Government of Karnataka
Department of Technical Education

C-25 Diploma in Mechanical Engineering

Scheme of Studies

(Effect from the AY 2025-26)

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Curriculum Structure

III Semester Scheme of Studies- Mechanical Engineering

	Teaching Department	Course Code	Course Name	Hours per week			Total Contact Hours/week	Credits	CIE Marks		Theory SEE Marks		Practice SEE Marks		Total Marks
				L	T	P			Max	Min	Max	Min	Max	Min	
Integrated Courses															
1	ME	25ME31I	Mechanics of Materials	4	0	4	8	6	50	20	50	20	-	-	100
2	ME	25ME32I	Thermal Engineering	4	0	4	8	6	50	20	50	20	-	-	100
3	ME	25ME33I	Fluid Power Engineering	3	0	4	7	5	50	20	-	-	50	20	100
4	ME	25ME34I	Programming Concepts in Mechanical Engineering	3	0	4	7	5	50	20	-	-	50	20	100
Audit Course															
5	KAN	25KA31T	Kannada –I (ಸಾಹಿತ್ಯ ಸಿಂಚನ-I/ಬಳಕೆ ಕನ್ನಡ-I)	2	0	0	2	2	50	20	-	-	-	-	50
			Total	16	0	16	32	24	250	-	100	-	100	-	450

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	III
Course Name	Mechanics of Materials	**Type of Course**	Integrated
Course Code	25ME31I	**Contact Hours**	8Hr/Week = 104 Hrs
Teaching Scheme	L: T:P 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale:

Mechanics of Materials is a fundamental subject in engineering that explores the behavior of materials under various loading conditions. It involves key concepts such as force analysis, stress and strain, material testing, shear force and bending moment diagrams, and the center of gravity and moment of inertia. These principles are critical for understanding how materials deform, how forces affect structures, and how to select materials for safe and efficient designs. By applying these concepts, engineers can design structures that are stable, durable, and capable of withstanding different types of loads, ensuring safety and performance in engineering applications.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Determine the Resultant force, Stress, Strain, Elastic Constants for a given problem.
CO-02	Identify the material properties by performing Tensile, Compression, Bending , Shear and Impact tests on a given specimen.
CO-03	Evaluate Shear force and Bending Moment problems using SFD, BMD and Bending equation.
CO-04	Calculate Centre of Gravity (C.G) & Moment of Inertia (M.I) for T, L, I and Channel sections.
CO-05	Validate the theoretical results with FEM software.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,3	**Force Analysis -** • Introduction to Force, Characteristics of a force, Effects of force & System of forces. • Concept of resultant, Resolution of forces & Composition of forces • Problems on Resolution of forces- Analytical Method • Finding Resultant Force by Graphical Method	• **Lami's Theorem** – Concept and validate using apparatus. • ASTM standards for tensile, compression, shear and bending.

2	1,2	1,2,3,4	**Stress and Strain -** • Concept of Stress & strain, types of Stresses-Normal stress (Tensile stress & Compressive stress), shear stress & Thermal stress. • Types of Strain-Longitudinal strain & Lateral Strain, Poisons ratio. • Stress-strain Curve for Ductile & brittle materials. • Hooks Law, Elastic Constants, Factor of safety.	**Tensile & Compression testing-** • Conduct Tensile test for the given Specimen and Determine Stress, Strain, Young's Modulus, Yield Stress, Maximum Stress, % increase in Length and % decrease in Area • Conduct Compression test for the given Specimen and Determine Stress, Strain, Young's Modulus, Yield Stress, Maximum Stress, % Reduction in Length and % Increase in Area.
3	1,2	1,2,3,4	**Problems on Stress and Strain -** • Simple problems to calculate stress, strain, deformation and Young's Modulus.	**Bending & Shear testing -** • Conduct Bending test for the given Specimen • Conduct Shear test for the given Specimen **Impact Testing** • Conduct the Impact Testing on a given material To determine the Impact strength for using Charpy / Izod testing machine
4	1,5	1,2,3,4	**Problems on Elastic Constants -** • Problems on Elastic constants to calculate Young's Modulus, Bulk Modulus & Rigidity Modulus.	**Introduction to FEM software** • Practice on FEM Software • Validate problems related to deformation and stress using FEM Software.
5	3,5	1,2,3,4	**Shear Force (SF) and Bending Moment (BM) -** • Introduction of Beam, Shear force, Bending moment & Types of Beams. • Types of Loads acting on a beam & Concept of sagging and Hogging bending moment. • Maximum bending moment, Point of contra flexure & Sign conventions for drawing Shear Force Diagram (SFD) & Bending Moment Diagram (BMD).	**Problem Validation using FEM** Validate problems related to deformation and stress using FEM Software.

6	3,5	1,2,3, 4	**Problems on Shear Force and Bending Moment** • Problems on Shear Force Diagram (SFD) & Bending Moment Diagram (BMD) for a cantilever beam subjected to point load & Uniformly Distributed load (UDL)	**SF and BM Validation using FEM** Validate Problems solved on Shear Force Diagram (SFD) & Bending Moment Diagram (BMD) using FEM Software.
7	3,5	1,2,3, 4	**Problems on Shear Force and Bending Moment** • Problems on Shear Force Diagram (SFD) & Bending Moment Diagram (BMD) for a Simply Supported beam subjected to point load & Uniformly Distributed load (UDL)	**SF and BM Validation using FEM** Validate Problems solved on Shear Force Diagram (SFD) & Bending Moment Diagram (BMD) using FEM Software.
8	3,5	1,2,3, 4	**Theory of Simple Bending:** • Introduction to Simple bending, Assumptions made in theory of simple bending & concept Bending stress. • Bending Equation (Without Proof), Moment of Inertia for different sections (rectangular, hollow rectangular, Circular & hollow circular sections), Modulus of section for different sections (rectangular, hollow rectangular, Circular & hollow circular sections).	**SF and BM Validation using FEM** Validate Problems solved on Shear Force Diagram (SFD)&Bending Moment Diagram (BMD) using FEM Software.
			Bending Moment for Different Sections- • Cantilever beam with point load at free end. • Cantilever beam with Uniformly Distributed load (UDL) throughout the length. • Simply Supported beam with point load at Centre. • Simply Supported beam with Uniformly Distributed load (UDL) throughout the length.	**Bending problem Validation using FEM** Demonstrate the validation of Problems on Bending Equation using FEM Software.
9	3,5	1,2,3, 4	**Problems on Bending Equation** • Cantilever beam with point load at free end. • Cantilever beam with Uniformly Distributed load (UDL) throughout the length.	**Bending problem Validation using FEM** Validate Problems solved on Bending Equation using FEM Software.

10	3,5	1,2,3, 4	**Problems on Bending Equation** • Simply Supported beam with point load acting at Centre. • Simply Supported beam with Uniformly Distributed load (UDL) throughout the length.	**Bending problem Validation using FEM -** Validate Problems solved on Bending Equation using FEM Software.
11	4,5	1,2,3, 4	**Centre of Gravity (C.G) and Moment of Inertia (M.I) -** • Concept of Centre of Gravity (C.G) & Moment of Inertia, Parallel & Perpendicular Axis Theorem. • Centre of Gravity (C.G) of Standard Sections (Rectangle, Triangle, Square, Circle, Semi-circle, Trapezium & Cone • Problems on Centre of Gravity (C.G) of T- Section and I- Section.	**C.G & M.I Problems Validation using FEM -** Validate Problems solved on Centre of Gravity (C.G) & Moment of Inertia (M.I) Using FEM Software.
12	4,5	1,2,3, 4	**Problems on C.G & M.I** • Problems on Centre of Gravity (C.G) of L- Section and Channel Section. • Moment of Inertia (M.I) of T-Section and L- Section about an XX & YY axis passing through Centre of Gravity (C.G).	**C.G & M.I Problems Validation using FEM -** Validate Problems solved on Centre of Gravity (C.G) & Moment of Inertia (M.I) Using FEM Software.
13	4,5	1,2,3, 4	**Problems on C.G & M.I** • Moment of Inertia (M.I) of I - Section and Channel section about an XX & YY axis passing through Centre of Gravity (C.G).	**C.G & M.I Problems Validation using FEM -** Validate Problems solved on Centre of Gravity (C.G) & Moment of Inertia (M.I)Using FEM Software.

4. References:

Sl. No.	Author	Title of Books	Publication/Year
1.	S Timoshenko	Engineering Mechanics	McGraw Hill Education, 5th edition, 2013
2.	M G James & S P Timoshenko	Mechanics of Materials	CBS publisher, 2nd Edition, 2004
3.	S S Bhavikatti	Strength of Materials	Vikas Publishing House, 4th edition, 2013
4.	S Ramamrutham	Strength of Materials	Dhanpat Rai Publishing Company (p) Ltd, 16th edition,
5.	Madhukar Vable	Mechanics of Materials	Second Edition
6.	Ferdinand P. Beer, E. Russell Johnston, Jr, John T. Dewolf	Mechanics of Materials	McGraw Hill Education, 6th edition, 2012
7.	Tirupathi R. Chandrupatla, Ashok D. Belegundu	Introduction to Finite Elements in Engineering	Cambridge University Press, 5th Edition

8.	P Seshu	Text book of Finite Element Analysis	Prentice Hall India Learning Private Limited, 1st edition, 2003
9.	https://www.vlab.co.in/participating-institute-nitk-surathkal		

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5.	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
Total					**50 Marks**

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	**Mechanical Engineering**			**Semester - III**	
Course Name	**Mechanics Of materials**			**Test**	**I/III**
Course Code	**25ME31I**	**Duration**	**90 min**	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q.No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a) The forces 20N, 30N, 40N, 50N & 60N are acting at one of the angular point of a regular hexagon towards the other five angular point taken in order. Find the magnitude and direction of the resultant force. b) A metal bar 50×50mm is subjected to an axial compression of 500kN. the reduction in length is 0.5mmover a gauge length of 200mm and increase in thickness is 0.04mm. find values of elastic constants.	Apply	CO1	10+15=25
2	a) The following forces act at a point i) 20N inclined at 30° towards the north of east ii) 25N towards north iii) 30N inclined at 45° towards north west	Apply	CO1	10+15=25

	iv) 35N inclined at 40° towards south of west Find the magnitude & direction of the resultant force. b) A rod of 30mm Diameter is subjected to a pull of 60kN.The measured extension on gauge length of 200mm is0.09mm. change in diameter is 0.0039mm calculate Elastic constants			
	Section - 2			
3	(a) Compare and contrast the stress-strain diagrams of the steel and ceramic materials, explaining the differences in terms of ductility and brittleness. b) A rod of 30mm diameter is subjected to an axial Pull of 80kN. The measured extension is 0.1 mm on a gauge length of 200mm and the change in diameter is 0.004mm. Calculate the poison's ratio and the values of young's Modulus, bulk modulus and Modulus of rigidity. c) A steel bar 50mm wide, 12mm thick and 300mm long is subjected to an axial pull of 100kN. find change in length, width & thickness of the bar. take E = 200 kN/mm^2,μ=0.32	Apply	CO1	5+10+ 10=25
4	a)In designing a bridge with steel cables, the cables are subjected to tensile forces due to the weight of the bridge and vehicles. Steel has a Young's Modulus of 200 GPa and Poisson's ratio of 0.3. How does the linear strain in the steel cables affect the total length of the cables when they are under load? Discuss how this deformation could impact the design of the bridge. b) A steel rod 30mm x 12.5mm and 500mm long is subjected to an axial pull of 75kN. Determine the changes in length, width and thickness and volume of bar. If young's modulus is 200kN/mm^2, μ=0.32 c) The young's modulus for a given material is 100kN/mm^{2}and its modulus of rigidity is 40kN/mm^2. Determine its bulk modulus and also its lateral contraction if the diameter is 50mm and length 2m and extension 2mm.	Apply	CO1	5+10+ 10=25
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	**Mechanical Engineering**			**Semester**	**III**
Course Name	**Mechanics Of Materials**			**Test**	**II/IV**
Course Code	**25ME31I**	**Duration**	**180 min**	**Marks**	**50**
Name of the Course Coordinator:					

Questions	**CO**	**Marks**
1.The forces 20N, 30N, 40N, 50N & 60N are acting at one of the angular point of a regular hexagon towards the other five angular point taken in order. Find the magnitude of the resultant force by graphical method.	CO1	10+40= 50
2. Conduct Tensile test for the given Specimen and Determine Stress, Strain, Young's Modulus, Yield Stress, Maximum Stress, % increase in Length and % decrease in Area **OR** Conduct Compression test for the given Specimen and Determine Stress, Strain, Young's Modulus, Yield Stress, Maximum Stress, % Reduction in Length and % Increase	CO2	

in Area.		
Scheme of Evaluation		
Q. No 1 a) Drawing Regular hexagon = 4 Marks Finding Magnitude = 2 Marks, Finding Direction = 2 Marks, **Q.No, 2** Writing Observation & Tabular Column=10 Marks Conduction of an Experiment = 20Marks Calculation & result = 10 Marks	CO1 CO2	10 40
	Total Marks	**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Find Centre of Gravity (C.G) of flywheel.
02	Stress concentration analysis on a Plate with circular hole (Varying diameter) using FEM Software.
03	Stress concentration analysis on a Plate with circular hole (Varying position) using FEM Software

10. Rubrics for Assessment of Experiments (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Preparation	Not prepared at all	Lacks several important materials or tools	Adequately prepared but missing key items	Mostly prepared with minor omissions	Fully prepared with all necessary materials and tools	40
2	Execution/ Implementation	Task not executed	Major errors affecting results or functionality	Some inconsistencies or inaccuracies present	Minor errors in execution, but overall effective	Test or task performed flawlessly with precision and accuracy	40
3	Quality of Work	No quality demonstrated	Poor quality, major flaws impacting functionality	Acceptable quality with noticeable defects	Good quality with minor flaws	High-quality output, meets or exceeds standards	30
4	Use of Tools/ Techniques	No proper tool use demonstrated	Weak use of tools, significant risks noted	Basic use of tools, some inefficiencies	Good use of tools, minor issues with technique	Mastery of tools and techniques demonstrated safely and effectively	40

5	Practical Record submission	Major sections are not addressed.	Major sections are missing or poorly addressed.	Some sections are included, but lack detail.	Most sections are complete with minor omissions.	All required sections are included and thoroughly detailed.	50
	Average Marks=(40+40+30+40+50)/5=40						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment / software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Quantity
01	FEM Software	-	30 Users
02	Computer	Latest Configuration	30
03	UTM	40 ton	01
04	Impact Testing machine		01

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	MECHANICAL ENGG	**Semester**	III
Course Name	Thermal Engineering	**Type of Course**	Integrated
Course Code	25ME32I	**Contact Hours**	104 Hrs/Sem
Teaching Scheme	L: T:P: 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale:

Thermal Engineering is a vital discipline that covers key concepts in thermodynamics, heat transfer, and energy systems, providing a strong foundation for engineering students. The course starts with basic thermodynamics and progressively advances to applications such as thermal power plants and gas turbines. A thorough understanding of heat transfer mechanisms—conduction, convection, and radiation—is essential for optimizing system efficiency. Additionally, the study of fuels and combustion offers insights into energy sources, their properties, and their environmental impacts, which are crucial for addressing modern engineering challenges.

The curriculum also emphasizes renewable energy, particularly solar technologies, to encourage sustainable engineering practices. By integrating these concepts, the course prepares students to contribute to the transition toward greener solutions. Overall, the syllabus is designed to develop the analytical skills and practical knowledge necessary for solving real-world engineering problems, equipping students to meet industry demands and excel in the field of Thermal Engineering

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Interpret basic thermodynamic concepts, laws, and cycles, and apply them to engineering applications.
CO-02	Evaluate conduction, convection, and radiation heat transfer and their engineering applications through experiments and simulations.
CO-03	Assess the fuel properties and combustion processes for different fuels.
CO-04	Evaluate the performance of Internal Combustion engines, Refrigeration systems and air conditioning system, focusing on efficiency, sustainability, and environmental impact.
CO-05	Analyze power generation systems in thermal and renewable power plants.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,2,5	**Introduction to Thermodynamics** • Definition of Volume, Pressure, Temperature, Absolute Temperature, Heat,, Specific Heat, Universal Gas Constant. Boyle's law, Charle's Law and Gay Lussac's law with expressions. • Basic Concepts: System, boundary, Surroundings. • Laws of Thermodynamics, Thermodynamic Properties. • Applications of Thermodynamics in Engineering. • Simple problems on different laws **Using Real-World Examples as Teaching Aids for Different Thermodynamic Systems* ***Closed System:*** *A pressure cooker trapping steam, a sealed can of soda at room temperature, and a car engine cylinder during compression.* ***Open System:*** *A kitchen faucet with water flow, an air compressor taking in and expelling air, and a radiator transferring heat as fluid flows.* ***Isolated System:*** *A thermos bottle keeping coffee hot, an insulated ice chest preserving cold items, and a sealed insulated lab container.* ***Identification of system boundaries in industrial setups*** *- Power plant, Refrigeration, AC unit, IC Engine.*	● Illustration of system and surrounding using simple experiments / Virtual simulations. ● Illustration of Thermodynamic equilibrium using simple experiments/ Virtual simulations. ● Demonstrate the Boyles law, Charle's Law, Gay-Lussac law using an online simulation. ● Demonstrate the Laws of thermodynamics using simple experiments or virtual simulations [14,15].
2	1	1,2,5	**Thermodynamic Processes** • Introduction to Thermodynamic Processes- Isochoric Process, Isobaric Process, Isothermal Process, Adiabatic Process Polytropic Process, Throttling Process, Combined Processes, and Real-World Applications • Simple problems on different processes **Using Real-World Examples as Teaching Aids for Different Thermodynamic Systems.* **Isothermal Process:** *Boiling water in an open pot at a constant temperature, compression in a pressure cooker, and ice melting in water without temperature*	● Conduct an experiment to study the behavior of isochoric process, isobaric process, Isothermal process, Isentropic process using computer simulations. [15]

			change. **Isobaric Process:** *Heating water in an open pot, inflating a balloon, and baking a cake in the oven at constant atmospheric pressure.* **Isochoric Process:** *Pressure changes in sealed aerosol cans or bottles in a refrigerator, heating a closed container, and filament heating in a light bulb with fixed volume.* **Adiabatic Process:** *Rapid compression in a bicycle pump, fire syringe demonstration, and gas expansion from an aerosol can showing temperature changes without heat exchange.*	
3	1	1,2,5	**Carnot Cycle** • Introduction to the Carnot Cycle, Ideal Gas, Assumptions, Four Processes of the Carnot Cycle, Efficiency of the Carnot Cycle, • Applications and Limitations of the Carnot Cycle • Simple problem on Carnot efficiency	• Conduct the experiment to study the behavior of Carnot Cycle using computer simulations [15].
4	2	3,4,6	**Heat Transfer** • Introduction to Heat Transfer • **Conduction -** Introduction to Heat Conduction, Fourier's Law of Heat Conduction, Thermal Conductivity, One-Dimensional Steady-State Conduction, Factors affecting thermal conductivity. • Applications of Heat Conduction in Engineering **Using Real-World Examples as Teaching Aids for Understanding Conduction in Cooling and Heating.* *Metal cooking pans transferring heat to food, heat spreaders in electronics dissipating heat, thermal pads connecting processors to heat sinks, and ice packs cooling skin through direct contact.*	• Conduct the experiment to determine the thermal conductivity of a metal rod/thin slab/ thick slab/ cylindrical/ fins and identify the factors influencing thermal conductivity.
5	2	3,4,6	**Convection** • Introduction to Heat Convection, • Types of Convection: Natural and Forced Convection. • Newton's Law of Cooling, Heat Transfer Coefficient, Factors affecting Heat Transfer Coefficient, • Applications of Convection in Engineering.	● Conduct the experiment to study heat transfer in free convection and forced convection, and identify the factors influencing heat transfer in each case.

			**Using Real-World Examples as Teaching Aids for Understanding Convection in Cooling* *Radiators dissipating engine heat, heat sinks cooling electronics, ceiling fans enhancing air circulation, and air conditioners circulating cool air to lower room temperature.*	
6	2	3,4,6	**Radiation** • Introduction to Heat Radiation. • Fundamental Concepts of Radiation. • Stefan-Boltzmann Law, Factors affecting Radiation and Emissivity, Blackbody and Gray Body Radiation. • Applications of Radiation in Engineering. **Using Real-World Examples as Teaching Aids for Understanding Radiation in Cooling and Heating* *Sunlight warming surfaces, infrared heaters radiating warmth in a room, cooling of hot engine parts by radiating heat into the air, and solar panels absorbing sunlight to generate electricity.*	● Perform the experiment to verify the Stefan-Boltzmann Law by measuring the radiant energy emitted from a blackbody surface and identify the factors affecting radiation ● Conduct the experiment to study heat transfer between surfaces with different emissivity's and identify the factors affecting emissivity.
7	3	1,2,7	**Fuels and Combustion** ● Types of fuels (fossil and renewable), Properties of fuel Green fuels: hydrogen and alternatives (biofuels, ethanol, biodiesel). ● Applications and future trends in hydrogen and green fuel technologies.	● Conduct the experiment to measure the calorific value of fuel using a Bomb Calorimeter or Boy's Calorimeter. ● Perform the experiment to determine the flash and fire points of the given fuel.
8	4	1,2,7	**Internal Combustion Engines** ● Introduction to IC Engines, Types of IC Engines, Working Principle of IC Engines - Two-Stroke and Four-Stroke Engines. ● Sustainability issues of using IC Engine. ● Introduction to Hybrid Vehicles, Electrical Vehicles. **Identification of type of IC engines used in various applications -* ***Spark Ignition (SI) Engines-*** *Passenger*	● Examine and identify the parts of IC engine cut-section models, and draw the valve timing diagram for a 4-stroke diesel and petrol engine. ● Conduct the performance study of a single/multi-cylinder petrol or diesel engine. and analyze the key parameters.

			Cars, Motorcycles, Small Generators. ***Compression Ignition (CI) Engines-*** *Diesel Trucks, Agricultural Tractors, Power Plants* ***Two-Stroke Engines-****Lawn Mowers, Chainsaws, Motorboats.* ***Four-Stroke Engines-*** *Passenger Cars, Agricultural Tractors, Generators.*	
9	4	5,6,7	**Turbines** ● Concept, Classification of turbines. ● **Steam turbines** – Concept, Classification, Applications. ● **Gas Turbines-** Concept**,** Classification, Brayton Cycle, Applications. Intercooling, Reheating in Gas turbines. ● Aero jet Engines, Rocket Engines	● Conduct a virtual tour or simulation-based experiment on a gas turbine system to observe efficiency improvement methods. ● Virtual Tour /Lab in Aero and Rocket Engine Studies
10	4	2,4,6	**Refrigeration** ● Concept, Terminologies. ● Refrigerant –Types, Properties of Refrigerants, Demerits of Freon series Refrigerants, Alternative Refrigerants. ● Coefficient of Performance (COP) ● Types of refrigeration system - Vapour Compression Refrigeration System, Vapour Absorption Refrigeration System **Identification of Refrigeration Systems in various applications* ***Vapour Compression Refrigeration System-*** *Domestic Refrigerators, Commercial Freezers, Supermarkets, Walk-in Coolers, Ice Makers, Air Conditioners, Wine Coolers* ***Vapour Absorption Refrigeration System*** *Large-Scale Cooling Systems (Hotels, Hospitals), Gas-Fired Refrigerators, Refrigeration in Remote Areas, RV Refrigerators, Absorption Chillers in Industrial Applications*	● Conduct the experiment to find the COP (Coefficient of Performance) of a given refrigeration system and identify the key components involved. ● Examine and Identify the Parts of a Domestic Refrigeration Unit and Perform Service and Maintenance Procedures.
11	4	2,4,6	**Air Conditioning** ● Psychometric terms ● Air Conditioning – Introduction. Types of Air Conditioning Systems - Window Air Conditioner ● Applications of Air Conditioning system	● Conduct the performance study on an air conditioning unit, focusing on cooling, humidification, and dehumidification processes. ● Examine and identify the key components of a window air

				conditioning unit and Perform the service and maintenance of window air conditioning unit.
12	5	5,6,7	**Thermal Power Plant** ● Introduction to Steam Generation. ● Types of Boilers. ● Babcock and Wilcox Boiler – its Mountings and Accessories Steam Cycle (Rankine Cycle). ● Layout of Thermal Power Plant.	● Conduct the study of a simple steam boiler model and identify the key components. ● Participate in a visit or virtual tour of a thermal power plant and conduct a case study on its operations.
13	5	5,6,7	**Solar Energy** ● Introduction to Solar Energy. ● Solar Photovoltaic Systems, Solar Thermal Systems (Solar plants). ● Applications of Solar Energy. ● Demonstration of a simple solar thermal system to heat water or fluids.	● Build a solar photovoltaic system using a solar panel and measure its output. ● Conduct the visit to assess the carbon footprint reduction achieved by solar panels and identify the key components involved in the solar energy generation process ● Perform the case study of solar thermal power plants including solar towers and examine the critical components that contribute to the overall system performance.

4. References

Sl. No.	Author	Title of Books	Publication/Year
1	R.K. Rajput	Thermal Engineering	Laxmi Publications, 2010
2	R.N. Bahl	Thermal Engineering	Khanna Publishers, 2016
3	Enrico Fermi	Thermodynamics	Dover Publications, 1956
4	Hendrick C. Van Ness	Understanding Thermodynamics	Dover Publications, 1983
5	Peter Atkins	Laws of Thermodynamics	Oxford University Press, 2010
6	Onkar Singh	Applied Thermodynamics	New Age International Publishers, 2014
7	Reccab Manyala	Solar Collectors and Panels,	InTechOpen, 2010

		Theory and Applications	
8	Dipak Sarkar	Thermal Power Plant	Elsevier, 2015
9	J.G. Rau, D.C	Environmental Impact Analysis Handbook	McGraw-Hill, 1980
10	J.A. Duffie& W.A. Beckman	Solar Engineering of Thermal Process	Wiley Publications; 3rd edition, 2006
11	Werner Vogel and Henry Kalb	Large-Scale Solar Thermal Power Technologies, Costs, and Development	WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010
12	Merala C. Pother, Craig W. Somerton	Thermodynamics for Engineers	Schaum Outline Series, Tata McGraw-Hill, New Delhi, 2004
13	P.K. Nag	Engineering Thermodynamics	Tata McGraw-Hill, New Delhi, 1998
14	Gas Properties Simulation Web Link:https://phet.colorado.edu/en/simulations/gas-properties		
15	Simulation of Thermodynamics First Law, Isothermal process and Carnot cycle Web Link: 1. https://physicsmonster.org/content/simulation/simulation_thermodynamics_first 2. https://physicsmonster.org/content/simulation/simulation_thermodynamics_first/index.html#id_section_thermodynamics_gas_isothermal 3. https://physicsmonster.org/content/simulation/simulation_thermodynamics_second/index.html#id_section_thermodynamics_carnot		

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and activities through Rubrics	1-13	-	50	
			Total		

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** III	
Course Name	Thermal Engineering			**Test**	I
Course Code	25ME32I	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Identify the thermodynamic system in a pressure cooker and analyze the heat transfer involved in steam generation.	Apply	CO1	5
	b. A gas is compressed isothermally from an initial volume of 2 m^3 to a final volume of 1 m^3. The initial pressure is 100 kPa. Calculate the final pressure and work done.	Apply	CO1	5
	c. Identify the First Law of Thermodynamics in a steam turbine and analyze its energy transformation during operation	Apply	CO1	5
	d. Analyze the thermodynamic process of heat exchange in an air conditioning system. Identify whether it is an isothermal or adiabatic process.	Apply	CO1	5
	e. Identify Gay-Lussac's Law in a heated sealed container and analyze how pressure changes with temperature increase.	Apply	CO1	5
2	a. Identify an process in boiling water and analyze heat transfer at constant temperature.	Apply	CO1	5
	b. A gas at 100 kPa and 300 K is heated at constant volume until the pressure reaches 400 kPa. Calculate the final temperature	Apply	CO1	5
	c. Identify the process during balloon inflation and analyze the constant pressure as volume increases.	Apply	CO1	5
	d. Identify the process in an aerosol can and analyze the pressure change at constant volume when cooled.	Apply	CO1	5
	e. Apply Gay-Lussac's Law to a pressure cooker. Explain how temperature and pressure inside the cooker are related during heating.	Apply	CO1	5
	Section – 2			
3	a. Identify the Law in a gas cylinder compression process and analyze how pressure and volume change during compression.	Apply	CO1	5
	b. A gas is heated at constant volume. The initial pressure is 500 kPa at 400 K. If the final temperature is 600 K, find the final pressure.	Apply	CO1	5

	c. Identify the concept of specific heat in heating materials and analyze how it affects energy absorption.	Apply	CO1	5
	d. A gas expands adiabatically. The initial pressure is 300 kPa, and the final pressure is 150 kPa. The initial volume is 1 m^3, and the adiabatic index γ is 1.4. Calculate the final volume.	Apply	CO1	5
	e. Identify process in a gas expansion valve and analyze the temperature change during the expansion process	Apply	CO1	5
4	a. A gas is heated at constant pressure. The mass of the gas is 2 kg, and its specific heat capacity at constant pressure is 1.0 kJ/kg·K. The temperature increases from 350 K to 450 K. Calculate the heat added.	Apply	CO1	5
	b. Identify the process in a bicycle pump and analyze the temperature rise due to rapid compression.	Apply	CO1	5
	c. In an isochoric process, the initial pressure is 100 kPa at a temperature of 300 K. If the final pressure is 400 kPa, calculate the final temperature.	Apply	CO1	5
	d. A gas is compressed isothermally from a volume of 2 m^3 to 1 m^3. The initial pressure is 100 kPa. Calculate the final pressure and the work done during the compression.	Apply	CO1	5
	e. A Carnot engine absorbs 1000 kJ of heat from the high-temperature reservoir and rejects 400 kJ to the low-temperature reservoir. Calculate the work done and efficiency.	Apply	CO1	5
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	III
Course Name	Thermal Engineering			**Test**	IV
Course Code	25ME32I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					
Questions				**CO**	**Marks**
Section-I					
1.	• Build a solar photovoltaic system using a solar panel and measure its output. **OR** • Conduct the experiment to find the COP (Coefficient of Performance) of a given refrigeration system and identify the key components involved.			CO4, CO5	25
Section-II					

2.	• Conduct the performance study on an air conditioning unit, focusing on cooling, humidification, and dehumidification processes. **OR** • Examine and identify parts of IC engine cut-section models. Draw the valve timing diagram for a 4-stroke diesel or petrol engine.	CO4	25
Scheme of Assessment Safety Measures & Conduction - 10 Marks Identification of Parts - 10 Marks Observation & Recording - 10 Marks Calculation & Analysis - 10 Marks Interpretation of Results - 10 Marks **Total Marks - 50 Marks**			**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities.
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Hybrid Engines **Activity**: Conduct a case study on hybrid engine technology, focusing on the combination of IC engines with electric motors. **Task**: Create a PowerPoint presentation covering the design, working principles, advantages, and future trends of hybrid engines. Ensure at least 10 slides are included.
02	Study of a Refrigeration System in a Local Repair Shop **Activity:** Visit a refrigerator service shop and study the internal components of a refrigeration unit. Record a video showing the compressor, condenser, evaporator, expansion valve, and refrigerant flow. **Task:** Create a PowerPoint presentation with a block diagram illustrating the system's layout, focusing on the refrigeration cycle and how each component contributes to the heat transfer process.
03	Thermal Power Plant Visit **Activity:** Visit a thermal power plant and document the overall power generation process, from fuel combustion to electricity generation. **Task:** Create a PowerPoint presentation focusing on the steam cycle, boilers, turbines, and cooling towers. Include a detailed report on the control systems used, such as SCADA and DCS.
04	Solar Power Plant **Activity:** Visit a renewable energy or a solar power plant that utilizes CSP technologies. **Task:** Prepare a PowerPoint presentation on Concentrated Solar Thermal Power Technologies: Status of Concentrated Solar Thermal Power Plants in India.
05	study of IC Engine **Activity:** Visit a automobile service station and study the components of a IC Engine. **Task:** Create a PowerPoint presentation focusing on the IC Engine and how each component contributes to the performance of IC engine.

10. Rubrics for Assessment of Graded Exercises (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Preparation	Not prepared, lacks basic materials or tools.	Missing several key items, limited understanding.	Adequately prepared, missing minor items.	Mostly prepared with all essential tools.	Fully prepared, complete understanding and tools.	40
2	Conduction / Execution	Task not performed or incomplete.	Major errors, significant impact on results.	Some minor inconsistencies, mostly correct.	Well executed, minor errors only.	Flawlessly executed, accurate and precise results.	40
3	Quality of Work	No quality evident, significant issues present.	Poor quality, major issues affecting results.	Acceptable quality with some defects.	Good quality, minor flaws only.	High-quality output, fully meets standards.	30
4	Use of Lab Equipment	No effective use of lab tools.	Ineffective use, risk of misuse.	Basic use, with some inefficiencies.	Good use of tools, safe and mostly accurate.	Excellent tool usage, safe and efficient.	40
5	Lab Report Submission	Major sections missing or incomplete.	Key sections missing, poorly detailed.	Adequate, but lacks some detail.	Mostly complete with minor omissions.	Fully detailed report with thorough explanations.	50
	Average Marks=(40+40+30+40+50)/5=40 Marks						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the exercises

11. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars Required	Purpose/Experiment	Quantity
1	Thermal Conductivity Apparatus (Metal Rod/Slab/Thin Slab/Cylindrical)	Measure thermal conductivity	1 set
2	Convection Heat Transfer Apparatus	Study heat transfer in convection	1 set
3	Stefan-Boltzmann Apparatus	Verify Stefan-Boltzmann Law	1 set
4	Emissivity Measurement Apparatus	Measure heat transfer with different emissivity's	1 set
5	Bomb Calorimeter or Boy's Calorimeter	Measure calorific value of fuel	1 set
6	Flash/Fire Point Apparatus	Determine flash and fire points	1 set
7	IC Engine Cut-section Models	Identify parts and draw valve timing diagram	1 set
8	IC Engine Performance Test Rig	Conduct performance study of IC engine	1 set
9	Refrigeration System Test Apparatus	Measure COP of refrigeration system	1 set
10	Air Conditioning Unit	Study performance of air conditioning unit	1 set
11	Simple Steam Boiler Model	Study simple steam boiler operation	1 model
12	Solar Photovoltaic System Kit	Build and measure output of solar panel	1 kit
13	Contactless (infrared) thermometer	Educational / laboratory use	1

	Temp. range = -50°C to 550°C		
14	Non-contact (laser/infrared) tachometer RPM range = 10 RPM to 99,999 RPM	to measure the rotational speed of machines or engines	1

Program	Mechanical Engineering	**Semester**	III
Course Name	Fluid Power Engineering	**Type of Course**	Integrated
Course Code	25ME33I	**Contact Hours**	7Hr/Week =91 Hrs
Teaching Scheme	L: T:P 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale: Fluid power is a term that describes the generation, control, and application of smooth, effective power of pumped or compressed fluids (either liquids or gases) to provide force and motion to mechanisms. With hydraulics, the fluid is a liquid (usually oil), whereas pneumatic uses a gas (usually compressed air). This force and motion may be in the form of pushing, pulling, rotating, regulating, or driving.

Students learn about the fundamental concepts important to fluid power, which includes both pneumatic (gas) and hydraulic (liquid) systems. Students learn background information about fluid power—both pneumatic and hydraulic systems—including everyday applications in our world (bulldozers, front-end loaders, excavators, chair height lever adjusters, door closer dampers, dental drills, vehicle brakes) and related natural laws.

The students are given exposure to building fluid power circuits and hence, on completing this course, will be able to build Pneumatic and Hydraulic Fluid power system for various applications.

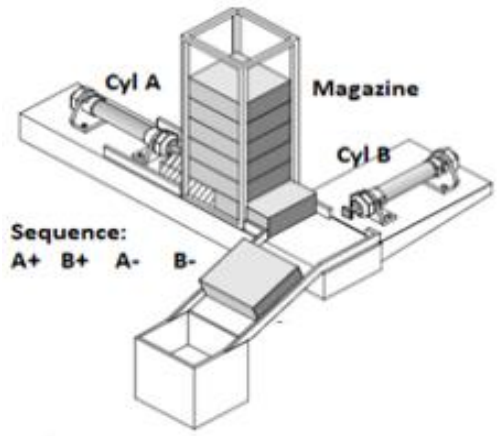
2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Interpret the Concepts, Industry relevance and Applications of Hydraulic and Pneumatic systems
CO-02	Evaluate fluid properties, pressure, and energy laws
CO-03	Analyze Pumps, Turbines, and Power Plant of Hydraulic machinery and measure their efficiency.
CO-04	Recognize the key components and their functions in a fluid power system
CO-05	Implement and troubleshoot real-time hydraulic and pneumatic circuits for industrial and automation applications using simulators and hardware kits.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,2,3&7	**Introduction to Fluid power** • Concept of Fluid power • Advantages and Disadvantages of Fluid power • Application of Fluid Power • Components of Fluid Power System- Hydraulic Power System, Pneumatic power System • Advantages, Disadvantages and Applications of Hydraulic power systems and pneumatic power system • Fluid power Industry- Size and scope, Future outlook • Hydraulic Fluids- Functions, Properties, Classification-Liquid and Gases	Study the following Fluid power system and identify the components and their functions • Hydraulic lift truck. • Excavator • Hydraulically powered robot Study the following Fluid power system and identify the components and their functions • Bicycle Pumps • Pneumatic Brakes • Pneumatic torque wrench
2	1,2	1,2,3&7	**Fluid Mechanics:** • Physical Properties of Hydraulic Fluids and Units-Specific Weight, Density, Specific Gravity • Pressure (Atmospheric, Gage and Absolute pressure), Pressure measuring Devices • Various types of energy present in Fluids, Total head • Bulk Modulus, Viscosity and its effect (Absolute and Kinematic) • Surface Tension and its effect on Fluids, Flow rate • Pascal's Law and its Application, Conservation of Energy	• Conduct an experiment to Measure the Gage pressure using Manometer/Pressure gage. ***Note:*** *Real time situations can also be considered- Tire Pressure Monitoringg, Engine Oil Pressure, gage pressure in hydraulic cylinders, Monitoring air pressure in compressors.* • Determine Viscosity of Fluid using Redwood / Saybolt's Viscometer.
3	1,2	1,2,3&7	• Continuity Equation- Simple problems (Contd). • Bernoulli's Equation – Application - Simple problems	• Verify Pascal's Law using hand operated Hydraulic Jack/ Bernoulli's Apparatus. • Verify Bernoulli's Equation using Venturimeter.
4	1,2	1,2,3&7	**Frictional Losses in Hydraulic Pipelines** (No Derivations) • Types of Flow, Dimensionless number, Reynolds Number, Darcy's Equation, Frictional Losses in pipes, Water Hammer in Pipes and its prevention • Simple Problems on Frictional	• Conduct experiment to determine the losses in Pipe **Note:** Real time situations can also be considered

			losses in pipes	
5	3	1,2,4&7	**Hydraulic Machineries Pumps** • Concept, Pumping theory • Positive displacement - Principle, Types • Non Positive Displacement - Principle, Types • Selection of Pumps • Pump Efficiencies- Volumetric, Mechanical, Overall Efficiency • Centrifugal Pump and Submersible Pump- Working principle and Application • Pump Cavitation	• Conduct experiment to measure the performance of Reciprocating Pump and Centrifugal Pump • Servicing of Centrifugal Pump and Submersible Pump
6	3	1,2,4&7	**Turbines** • Classification, Types, Hydraulic Turbines- Impulse and Reaction Turbines, Working, Applications, Selection of Turbines **Hydro-Electric Power Plant** • Explain the Layout of a Hydroelectric Power plant • Explain thecomponents of Hydro- Electric Power Plants & their functions	• Conduct experiment to determine the efficiency of a Turbine (Pelton Wheel, Francis Turbine, Kaplan Turbine) • **Note:** Can also use Virtual Lab
7	4	1,2,4&7	**Pneumatic Fluid Systems:** **Identify the basic components of Pneumatic Power Systems with Symbols and Application** • Air compressor • Air Drier • FRL Unit • Reciprocating Compressor and Vane Compressor • Pressure Relief valve and Pressure Regulating Valve (Pressure control Valve- Pressure Reducing Valve, Pressure Intensifier • Direction control Valves - 3/2 , 5/2, (Solenoid operated , Lever/Push button operated) • Flow control Valve • Check Valve • Pneumatic Actuators- Linear, Rotary • Shuttle Valve and its application in pneumatic circuit • Quick Exhaust Valve and its application in pneumatic circuit	

			• Time Delay Valve and its application in pneumatic circuit
8	5	1,2,3,4& 7	**Build and Execute the following Pneumatic circuits** • Operation of a Single Acting cylinder using three-way valve • Directional control of a double-acting cylinder using four-way /Five-way valve. • Control Forward and Return speed of a double-acting cylinder using two Non-return type flow control valves • Continuous TO and FRO motion of a Double acting cylinder using 3/2 Roller operated valves
9	5	1,2,3,4 & 7	**Build and Execute the following Pneumatic circuit** • Double-acting cylinder remotely operated through the use of an air pilot-actuated DCV. (For Automatic Opening and Closing of Door by using double Acting Cylinder being controlled by 4/2 or 5/2 double pilot DC Valve) • Double-acting cylinder operated through the use of an air-pilot-actuated DCV for stamping operation. (5/2 Single pilot DCV) • To press fit a pin to a hole with a precondition that while actuating the cylinder, both the hands of the operator should be engaged • Using limit switches to provide a timed cylinder extend and retract cycle with the help of solenoid DCV
10	5	1,2,3,4 & 7	**Build and execute the following Pneumatic circuit** • Design the pneumatic circuit diagram based on task given. A double-acting cylinder is used to clamp components on a drill machine. Upon operation of a push button and it's in start position, the clamping cylinder extends. Once the fully advanced position is reached and finish button is pressed, the cylinder is then immediately retracting to the initial position. The cylinder retraction is to be adjustable. A new start cycle is only possible after the cylinder has fully retracted. • Two cylinders (Fig) are used to transfer parts from a magazine onto a chute. When a push button is pressed, the first cylinder extends, pushing the part from the magazine and positions it in preparation for transfer by the second cylinder onto the out feed chute. Once the part is transferred, the first cylinder retracts, followed by the second. 

			• A clamping system (double acting cylinder, (A) and drilling (double acting cylinder, B) function as follows. When the switch is pressed, the clamps will clamp and drill the work piece. Once completed, the drill will have stopped and reversed. Finally, the clamps will release the work piece. The limit of start and extend position of the clamps and drills are determined by the limit switch a0 and a1 for clamping system and b0 and b1 for drilling respectively.
11	4	1,2,3,4 & 7	**Hydraulic Fluid systems:** **Identify the basic components of Hydraulic Power Systems with Symbols and Application** • Hydraulic Fluid • Hydraulic pump- Gear Pump, Vane Pump, Lobe Pump • Reservoir for hydraulic fluid • Actuator- Cylinders and Hydraulic Motors • Accumulator • Directional control valve • Seals
12	5	1,2,3,4 & 7	**Build and Execute the following Hydraulic circuit using Hydraulic kit/Simulator** • Design of hydraulic circuit for a drilling machine (regenerative cylinder circuit for machine tool applications), (hydraulic circuit for quick-return motion in machine tools) • Application of intensifier in punching press hydraulic circuit • Hydraulic circuit for forklift application • Hydraulic circuit for a surface grinding machine
13	5	1,2,3,4 & 7	**Build and Execute Hydraulic/ Pneumatic fluid circuit for any one Real Time Application** **Ref:** Suggestive Activities

4. References:

Sl No	Author	Title of Book	Publication/Year
1	Anthony Esposito	Fluid Power with applications	7th Edition, Pearson New international Publication
2	DrMohd Elias Daud	Pneumatic Circuit Design	1st Edition, Unit Penerbitan Publication, 2021
3	M GalalRabie	Fluid Power Engineering	McGraw-Hill Professional Publication, 2009
4	R K Hegde and Niranjan Murthy	Fluid Power Engineering	Sapna book House
5	Ram Srivatsav	Fluid Power Technology	2nd Edition, Standard Book House
6	George Croydon Marks	Hydraulic Power Engineering; A Practical Manual On The Concentration And Transmission Of Power By Hydraulic Machinery	Forgotten Books Publication, 2018

7	Sadhu Singh	Fluid Machinery: Hydraulic Machines	Khanna Publication House
8	S Majumdar	Pneumatic Systems (Principles And Maintenance)	McGraw Hill Education

5. CIE Assessment Methodologies

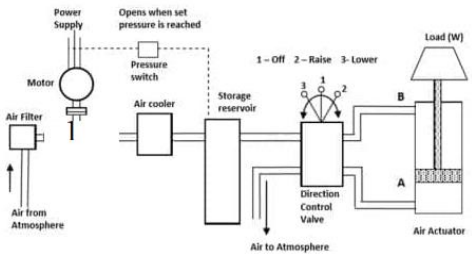
Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

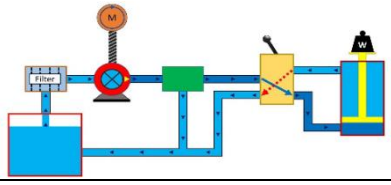
6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** III	
Course Name	Fluid Power Engineering			**Test**	I
Course Code	25ME33I	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Which Fluid Power system is used in heavy Machinery? Justify your statement.	Apply	CO1	5
	b. Identify the components required and point 1of a Pneumatic Power Systems. What is the function of this component? Write the role played by Direction control valve. 	Apply	CO1, CO3	5

	c. Which property of fluid helps in selection of good power transmission oil? Justify your statement.	Apply	CO1	5
	d. A Glass bottle filled with liquid will break at the bottom if a stopper is forced into its open end. Which law is applied here? Why does the bottle break at the bottom?	Apply	CO1	5
	e. How can air chambers or water hammer arrestors be used to reduce the effects of water hammer in residential plumbing systems?	Apply	CO1	5
2	a. Which fluid power system is used in small robots? Justify your statement.	Apply	CO1	5
	b. Identify all the components of any hydraulic power Systems and write their functions. 	Apply	CO1, CO3	5
	c. What happens to the viscosity when the temperature acts upon it and why?	Apply	CO1	5
	d. On what principle does the syringe work? Discuss the process of working.	Apply	CO1	5
	e. Explain how adjusting the valve closure speed can minimize the risk of water hammer in industrial pipelines.	Apply	CO1	5
Section – 2				
3	a. Water flows through a horizontal pipe with two sections. In the wide section of the pipe, the velocity of water is 2 m/s, and the pressure is 150 kPa. The narrow section has half the diameter of the wide section. Find the velocity and pressure in the narrow section.	Apply	CO1	10
	b. Water flows out of a hole at the bottom of a large tank. The water level is 5 m above the hole. Find the velocity of water exiting the hole. Assume no energy loss due to friction.	Apply	CO1	10
	c. A 50 m long pipe with a diameter of 0.2 m carries water at a velocity of 3 m/s. The friction factor f=0.02. Find the head loss due to friction.	Apply	CO1	05
4	a. Water flows through a pipe with a change in elevation. At point A, the velocity is 3m/s, the pressure is 200kPa, and the elevation is 5m. At point B, the velocity is 6m/s, and the elevation is 10m. Find the pressure at point B. Assume ρ=1000kg/m3.	Apply	CO1	10
	b. A water jet exits a nozzle with a pressure of 200kPa. The atmospheric pressure is 100kPa. Assuming no height difference and negligible friction, find the velocity of the jet.	Apply	CO1	10
	c. A pipe is 150 m long and has a diameter of 0.15 m. Water flows through it at a velocity of 1.5 m/s. The Darcy friction factor f=0.025. Calculate the head loss due to friction.	Apply	CO1	05
Note for the Course coordinator: *Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	**III**
Course Name	Fluid Power Engineering			**Test**	**II**
Course Code	**25ME33I**	**Duration**	**180 min**	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					

	Questions	**CO**	**Marks**
	Section-I		
1.	a. Why is oil often preferred over water in specific manometer applications? Conduct an experiment to Measure the Gage pressure using Manometer b. What is the absolute pressure of the oil in the hydraulic press? Conduct experiment to Measure the Gage pressure using Pressure gage? c. How to determine whether the flow is laminar or turbulent? Conduct experiment to determine the viscosity of the given oil. d. How can Pascal's Law be demonstrated using a hand-operated hydraulic jack, and how does the relationship between force, pressure, and area validate the law in this setup?	CO1, CO2	25
	Section-II		
2.	a. An hydroelectric power plant for a river has a net head of 50 meters. Select the type of turbine (Pelton, Francis, or Kaplan) that would be most appropriate for this scenario. Conduct an experiment to determine the efficiency of that turbine. b. A water treatment plant needs to pump water from a river to a filtration system. The required flow rate is 200 liters per second. Select the appropriate type of pump (centrifugal, reciprocating, etc.) based on the given parameter. Conduct an experiment to determine the performance of that Pump	CO3	25
	Scheme of Assessment for Section I & II	**CO**	
a	Selection of appropriate machinery /Answer to the appropriate Question **Note**: Includes Aim of the practical, List of Components Required	CO1	10 x 2
b	Conduction of experiment **Note**: Includes Procedure writing, Observation, Tabular and formulas used, Execution and Result writing.	CO2	15 x 2
		Total Marks	**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Food industry uses for pneumatic systems include equipment for chopping, cutting, slicing and dicing machines where pneumatic cylinders provide precise control of pressure and motion to reduce damage to food items. Pneumatic-based cutting systems can be easily adapted to process a variety of sizes, thicknesses and angles and are precise enough to encourage uniformity.
02	Various segments of the manufacturing industry, robotic arms utilizing pneumatically operated end of arm tooling (EOAT) can be applied to assembly, pick and place, machine tending, and material handling tasks. The simple, lightweight design of pneumatic systems is easier, often cheaper and less time consuming to maintain than electronic systems.
03	Automotive manufacturing relies on pneumatics for many operations, but one of the most important is the painting and finishing process. Using compressed air as the power source, the paint is sprayed though guns, robots or paint sprayers onto the prepared car body. In these operations, the pneumatic system provides high-quality, moisture-free compressed air that helps achieve a smooth, even factory finish.
04	Jet blast deflectors (JBDs) onboard aircraft carriers are raised and lowered by hydraulic cylinders through mechanical linkage. Two hydraulic cylinders are attached to each JBD panel shaft by crank assemblies. The shaft is rotated by the push and pull operation of the hydraulic cylinders. Shaft rotation extends or retracts the linkage to raise or lower the JBD panels. This operation is designed so that in the event of a failure of one of the hydraulic cylinders, the other one will raise or lower the panels.
05	Pneumatic filling systems are used to dispense free-flowing materials or products such as grains, weigh them and discharge them into packaging or process equipment.
06	Hydraulic circuit of dumpers
07	Hydraulic power steeringg
08	Hydraulic braking for automobiles

10 Rubrics for Assessment of Activity (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Students Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Component Selection & Sizing	Components are poorly selected or incompatible with the system.	Some components are incorrectly sized or incompatible.	Some Components are compatible, with minor sizing issues	Components are mostly compatible, with minor sizing issues.	Components are perfectly selected, well-sized	50
2	System Design & Layout	No system design or layout diagram is provided.	The system layout is incomplete, unclear.	The design is satisfactory but has errors.	The design is mostly clear, with minor details missing or errors.	The system design is clear, detailed, and accurate, with a well-documented layout	40

3	System Testing & Performance	No testing conducted, or system performs poorly	System performance is below expectations, with several issues identified.	The system performs well, meeting basic expectations but with some issues	The system performs well, meeting basic expectations with some room for improvement.	Comprehensive testing is conducted, and good performance expectations for efficiency and reliability.	40
4	Documentation & Reporting	No documentation or very poor quality documentation	Documentation is incomplete, unclear	Documentation is mostly clear, But has some key data missing	Documentation is mostly clear, but some details or phases are missing or unclear.	Detailed and clear documentation	30
	Average Marks = (50+40+40+30)/4 = 40 Marks						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE- Model Practice Question Paper

Program	Diploma in Mechanical Engineering		**Semester**	IV
Course Name	Fluid Power Engineering	**Course Code:** 25ME33I	**Duration**	180 min
Note: Answer any one question from each section				
Questions			**CO**	**Marks**
Section I				
1. An hydroelectric power plant for a river has a net head of 50 meters. Select the type of turbine (Pelton, Francis, or Kaplan) that would be most appropriate for this scenario. Conduct an experiment to determine the efficiency of that turbine. 2. A water treatment plant needs to pump water from a river to a filtration system. The required flow rate is 200 liters per second. Select the appropriate type of pump (centrifugal, reciprocating, etc.) based on the given parameter. Conduct an experiment the performance of the selected pump.			CO3	25
Section II				
1. For the given Application, Identify the components and Build and Execute a Pneumatic Power system. 2. For the given Application, Identify the components and Build and Execute an Hydraulic Power system.			CO4,CO5	25
Scheme of Assessment			**CO**	**Marks**
a Selection of appropriate machinery/Identify the component			CO3,CO4	5*2
b Tabular column with formula/ Build the circuit			CO3,CO5	10*2

c Execute + Result/Inference	CO3,CO5	10*2
	Total Marks	**50**

1. Signature of the Examiner **2) Signature of the Examiner**

12. Equipment list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Qty.
01	Manometer setup to measure Pressure	U-tube manometer with mercury as the working fluid, Measurement range: 0-500 mm Hg, Tubing material: PVC for gas flow compatibility, Connection: 1/8-inch barbed fittings for tight sealing, Environment: Controlled at 25°C to ensure stable readings.	02
02	Bourdon's tube pressure gauge set up to measure Pressure	**Type**: Bourdon's tube pressure gauge, **Range**: 0–10 bar (0–145 psi), **Accuracy**: ±1.0% of full scale, **Dial Size**: 100 mm for easy readability, **Material-** Tube: Stainless steel (316L), Case: IP67-rated stainless steel, **Connection**: 1/4" NPT bottom-mounted, **Filling**: Glycerin for vibration damping, **Temperature Range**: -20°C to 60°C (-4°F to 140°F).	02
03	Hand operated Hydraulic Jack	**Type**: Hand-operated hydraulic bottle jack, **Load Capacity**: 10 tons, **Stroke**: 150 mm, **Material**: Steel frame with a chrome-plated piston rod, **Hydraulic Fluid**: ISO VG 46 oil, **Pressure Rating**: Up to 700 bar, **Base Size**: 200 mm x 150 mm, **Safety Features**: Overload protection, pressure relief valve, and locking mechanism, **Accessories**: Integrated pressure gauge, extension rods, and carrying handle.	02
04	Redwood Viscometer	For light oils (low viscosity), 20–2,000 Redwood seconds, Standard small orifice (1.62 mm diameter),Ambient to 100°C (standard) or up to 150°C (extended range), 1: 50 ml, Electrically heated with temperature control, Two calibrated thermometers: one for bath and one for oil sample,220–240 V AC, 50/60Hz,Accessories: Stop watch, Brass or stainless steel flow cup.	02

05	Saybolt's Viscometer	Meets ASTM D88, ASTM D244, and IP 71 standards for Saybolt viscosity tests, Suitable for light and heavy oils, with viscosity ranging from 30 to 20,000 Saybolt Universal Seconds (SUS),Material: Stainless steel bath with corrosion resistance, Capacity: Typically 5–10 liters for uniform heating, Finish: Polished or powder-coated for durability,Ambient to 100°C,Electrically heated, equipped with an immersion heater and digital temperature controller, Accuracy: ±0.1°C, 60 mL for a single test run, 220–240 V AC, 50/60 Hz	02
06	Bernoulli's Apparatus	**Venturi Tube**: Transparent acrylic, **Pressure Tapping**: Multiple measurement points, **Manometer**: Vertical tubes for pressure readings, **Flow Measurement**: Rotameter, **Water Supply**: Reservoir with flow control, **Dimensions**: ~1000 mm (L) × 300 mm (W) × 600 mm (H), **Fluid**: Clean water, **Flow Range**: 0.1–2 L/min, **Base**: Steel or aluminum frame.	02
07	Venturimeter setup	Venturi Tube: Transparent, with converging and diverging sections, Pressure Tapping: Multiple points before, at and after the throat for pressure readings., Manometer: U-tube or digital for pressure measurement, Flow Measurement: Rotameter (0.1–2 L/min), Water Supply: Reservoir with flow control, Dimensions: Venturi tube ~500–1000 mm, overall system ~1000 mm (L) × 300 mm (W) × 600 mm (H), Fluid: Clean water, Flow Range: 0.1–2	01
08	Friction in pipes setup	**Pipe**: Transparent, 10–30 mm diameter, 1–2 meters long, **Flow Control**: Adjustable valve/pump, **Pressure Measurement**: Manometers at key points, **Flow Measurement**: Rotameter (0.1–2 L/min), **Fluid**: Clean water, **Flow Range**: 0.1–2 L/min, **Base**: Steel or	01

09	Pelton Wheel	**Pelton Wheel**: With multiple cups (buckets), made of durable material (e.g., aluminum or acrylic), **Nozzles**: Adjustable to control water flow and direct jets to the wheel, **Flow Control**: Valve for regulating water flow, **Flow Measurement**: Rotameter or flow meter, **Speed Measurement**: Tachometer to measure wheel rotation speed, **Wheel Diameter**: 100–300 mm, **Flow Rate**: 0.1–2 L/min (adjustable), **Base**: Steel or aluminum frame for stability and	01
10	Francis Turbine	**Turbine Runner Diameter**: 100–300 mm, **Flow Rate**: 0.1–5 L/s (adjustable), **Power Output**: 0.1–2 kW, **Water Supply**: Reservoir with controlled pump, **Speed Control**: Adjustable for load testing, **Dimensions**: 1–2 meters long	01
11	Kaplan Turbine	**Turbine Runner Diameter**: 100–300 mm, **Flow Rate**: 0.1–5 L/s (adjustable), **Power Output**: 0.1–2 kW, **Water Supply**: Reservoir with controlled pump, **Speed Control**: Adjustable for load testing, **Dimensions**: 1–2 meters long (bench-mounted setup), **Adjustable Blades**: To control water flow and	01
12	Reciprocating Pump	**Discharge Rate**: 0.1–2 L/min (adjustable), **Pressure Range**: 0–10 bar, **Stroke Length**: 50–150 mm, **Pump Speed**: Adjustable (manual or motorized), **Power**: Typically, 0.1–0.5 kW, **Material**: Stainless steel or durable plastic for easy maintenance, **Dimensions**: Compact, typically 400–600 mm in length, **Water Supply**: Reservoir or tank with controlled flow	01
13	Centrifugal Pump	**Flow Rate**: 0.1–5 L/s (adjustable), **Head**: 1–10 meters, **Power Output**: 0.1–2 kW, **Inlet/Outlet Diameter**: 20–50 mm, **Water Supply**: Reservoir with controlled pump, **Speed Control**: Adjustable for varying load conditions, **Dimensions**: Compact, typically 0.5–1 meter in length, **Material**: Durable plastic or stainless	01

14	Pneumatic Kit	**Air Pressure Range**: 0–8 bar, **Flow Rate**: 0.1–2 L/s (adjustable), **Compressor Power**: 0.1–1 kW, **Components**: Air compressor, Pneumatic cylinders (single and double-acting), Control valves (directional and flow control), Pressure regulators and gauges, **Dimensions**: Compact, typically 1–2 meters in length, **Power Supply**:	01
15	Hydraulic Kit	**Pressure Range**: 0–10 bar (adjustable), **Flow Rate**: 0.1–5 L/min (adjustable), **Reservoir Capacity**: 5–10 liter, **Components:** Hydraulic pump (manual/electric), Pressure relief valve, Flow control valve, Cylinders and actuators, **Power Source**: Electric motor or hand pump, **Dimensions**: Compact, typically 1–2	01

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	MECHANICAL ENGG	**Semester**	IV
Course Name	Programming Concepts in Mechanical Engineering	**Type of Course**	Integrated
Course Code	25ME34I	**Contact Hours**	91 Hrs/Sem
Teaching Scheme	L: T:P	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale:

Incorporating programming into the mechanical engineering curriculum prepares students for careers in emerging fields such as robotics, automation, and mechatronics. Students will gain hands-on experience, enabling them to apply theoretical concepts to real-world challenges. Understanding programming concepts fosters critical thinking and analytical skills, essential for any engineer. Furthermore, proficiency in programming enhances collaboration with software engineers and data scientists in multidisciplinary projects. As industries increasingly rely on data-driven decision-making, programming becomes a key competency for mechanical engineers. Ultimately, this course equips students with the necessary tools to innovate and excel in a technology-driven engineering landscape.

2. Course Outcomes: At the end of the Course, the student twill be able to:

CO-01	Apply appropriate programming syntax while writing Python programs
CO-02	Utilize and apply engineering data between programming environments and spreadsheet applications for various engineering problems.
CO-03	Apply python programming to solve various quality control and Finite Element problems in the field of mechanical engineering.
CO-04	Integrate Raspberry Pi hardware with Python programming for automation, robotics, control systems, and data acquisition in engineering applications.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,2	**Algorithms and Flow Charts** • The Importance of Programming in Solving Engineering Problems • Importance of Python in Problem Solving over other programing languages. • Algorithms – Steps/Procedures • Flowcharts – Symbols and Methodology	Write the Algorithm and flow Chart for the following • Convert Fahrenheit to Centigrade • Efficiency of and simple machine • To generate the multiplication table for the number 5. (Control Loop) • Finding the Max of three forces (Decision)
2	1	1,2	**Introduction to Python and Basic Constructs** • Introduction to Python and its environment (e.g., Anaconda, Jupyter Notebook, IDEs like PyCharm) • Basic syntax, variables, and data types (int, float, string, boolean) • Input/ Output operations (input(), print()) • Type conversions (int(), float(), str()) • Basic arithmetic and assignment operators.	• Write a Python program to accept user input and perform arithmetic operations (addition, subtraction, etc.) • Calculate the output speed and torque in a gear system based on user-inputted values for input speed, input torque, and gear ratio using basic operators. • Practice problems on type conversions and working with variables.
3	1	1,2,4	**Control Structures (Conditional Statements and Loops)** • If-else conditions, elif statements • Nested if statements • for loop and while loop • Loop control statements (break, continue, pass)	• Write a Python program to determine if a number is even or odd. • Create a program that uses a for loop to print multiplication tables. • Write a Python program to calculate the factorial of a number using a while loop. • Practice problems using if-else and loops.
4	1	1,2,4	**Functions and Modules** • Function definition, parameters, and return values • Scope of variables (local vs global) • Lambda functions • Built-in functions vs. user-defined functions • Importing and using modules (math, random, etc.)	• Write a Python program that defines a function to calculate the area of a circle. • Create a program to find the greatest common divisor (GCD) of two numbers using a function. • Explore lambda functions by creating small one-liners for tasks like squaring a number. • Write a Python program to use the math module for trigonometric

				calculations.
5	1	1,2,4	**Data Structures (Lists, Tuples, and Dictionaries)** • Lists: creation, indexing, slicing, adding/removing elements • List methods (append(), remove(), sort (), etc.) • Tuples: definition and immutability • Dictionaries: creation, accessing, adding, and removing key-value pairs • Iterating over lists, tuples, and dictionaries	• Create a Python program that stores names of students in a list and performs operations like adding, removing, and sorting. • Write a program that converts a list of temperatures from Celsius to Fahrenheit. • Create a Python dictionary for storing student records (name, age, and grade) and write functions to add and remove entries. • Write a program that uses tuples to store and display coordinates in 2D space.
6	2	1,2,4	**File Handling and Exception Handling** • File operations: reading from and writing to files (open(), read(), write(), close()) • Working with text files and CSV files • Exception handling: try, except, finally • Common exceptions and error handling techniques	• Write a Python program to read from a file and count the number of words in it. • Create a Python program that writes a list of random numbers to a file and reads them back. • Write a program to handle division by zero using try-except blocks. • Write a Python program to read data from a CSV file and perform basic operations like counting the number of rows.
7	2	1,2,4	**Object-Oriented Programming (OOP)** • Introduction to OOP concepts: classes and objects • Class attributes, methods, and the __init__ method • Inheritance and method overriding • Encapsulation, abstraction, and polymorphism	• Write a Python class to represent a Car with attributes like model, year, and color. Include methods to start, stop, and display car details. • Create a program that implements inheritance with a base class Animal and derived classes Dog and Cat. • Write a Python program that demonstrates method overriding. • Develop a Python class for a bank account that supports deposit, withdrawal, and balance inquiry.
8	4	1,2,4	**Integration of Python Programming with Raspberry Pi** **Introduction to Raspberry Pi and Setup** • Overview of Raspberry Pi hardware (Model types, GPIO pins)	**Practice - Motor Control and Automation** **Motor Driver Circuits** • Controlling DC motors using L298N motor driver with Raspberry Pi

			• Setting up Raspberry Pi (OS installation, booting up, network setup) • Raspberry Pi GPIO (General Purpose Input/Output) pins • Using breadboards, jump wires, and sensors with Raspberry Pi	• Building simple automated systems like a fan or water pump controller
9	4	1,2,4	**Sensor Integration and Data Collection** • Interfacing sensors like temperature, humidity, pressure, and motion with Raspberry Pi. • Using common sensors such as DHT11 (humidity/temperature), BMP180 (pressure), PIR (motion).	• Building a simple robot using Raspberry Pi, motors, and sensors
10	2,3	,2,4	**Applications of Python Programming in Quality Control and FEM**	
			Statistical Quality Control (SQC) Basic Concepts • The Role of Quality Control in Modern Manufacturing • Advantages of Python in Quality Analysis and Control • Introduction to SQC, Benefits of SQC • Techniques of SQC – Process control and Product control • Control Charts – for variables (X bar and R Charts), Fraction defective (p-Chart), Number of defects per unit (C-Chart)	• Develop the Python program to calculate Sample Average ($\bar{X}$) & Sample Range (R) for the given data and Plot X bar and R Charts for the given data using Matplotlib.
11	2,3	1,2,4	**Introduction to Statistical Quality Control (SQC)**: • Calculate the Sample Average ($\bar{X}$), Average of Average ($\bar{\bar{X}}$), • Sample Range (R), Average of Range ($\bar{R}$), • Standard Deviation (σ) • Process Capability (Cp), Process Capability Index (Cpk)for ongoing process study.	• Calculate mean, variance, and standard deviation using Python. • Generate X-bar and R control charts from sample data using Matplotlib. • Identify in-control and out-of-control points.
12	3	1,2,4	**Hypothesis Testing and TQM -**	• Generate python code to plot different Quality control tools for

			• Hypothesis Testing- t-test, ANOVA • Design of Experiments (DOE) • Quality Improvement Tools - Pareto Chart, Fishbone Diagram, Flowchart. • Continuous Improvement- Lean, Six Sigma, and Total Quality Management (TQM)	the given data.
13	3	1,2,4	**Finite Element Methods (FEM) –** • Introduction to Finite Element Method. • General steps of the finite element method. • Engineering applications of finite element method. • Advantages of the Finite Element Method. • Stiffness Matrix of a Bar Element - Global Stiffness Matrix, Properties of stiffness matrix.	• Write a python code to plot the stress distribution in the plate at various lengths along the bar • Write a python code to compare and plot the stress distribution in the plate with and without hole.

4. References:

Sl. No.	Author	Title of Books	Publication/Year
1.	Dr.Abhinav , Dr. S. Bhargavi	Fundamentals of Python Programming	Shashwat Publication, 2023
2.	Alex Kenan	Python for Mechanical and Aerospace Engineering	2020
3.	Sinan Kalkan, Onur T. Sehitoglu, Gktrkoluk	Programming With Python for Engineers	Springer-Nature New York Inc, 2024
4.	Luciano Ramalho	Fluent Python	O'Reilly Media, Inc, USA, 2015
5.	Wesley J. Chun	Core python programming	Prentice Hall PTR, 2006
6.	Alex Bradbury and Ben Everard	Learning Python with Raspberry Pi	John Wiley & Sons Inc, 2014
7.	Matt Richardson	Getting Started With Raspberry Pi	O'Reilly Media, Incorporated, 2012

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	

5.	CIE-5 Portfolio evaluation of all practices and activities through Rubrics	1-13	-	50	
Total					**50 Marks**

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practical Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practical	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering		**Semester- III**	
Course Name	Programming Concepts in Mechanical Engineering		**Test**	I
Course Code	25ME34I	**Duration**- 90 min	**Marks-**50	
Name of the Course Coordinator:				
Note: Answer any one full question from each section. Each question carries equal marks.				

Q. No	Questions	CL	CO	Marks
	Section - 1			
1	a) Draw a flowchart to represent the algorithm for checking if a given number is a prime number. Include decision points and the necessary steps for input, process, and output. b) Discuss the importance of breaking down a problem into smaller steps when creating an algorithm. How does this help in developing efficient and clear solutions to engineering challenges? c) In Python, how do you declare a variable to store a person's name and their age? What data types would be appropriate for these variables, and why? d) Enumerate the purpose of the `input ()` function in Python? Provide an example of how it can be used in a simple engineering program to get user input	Apply	CO1	**7+6+6 +6 = 25**
2	a) Draw a flowchart to find the maximum of three forces (F1, F2, F3), we compare the values step by step. b) Compare how Python, with its libraries, would be more advantageous compared to other programming languages like C++ or Java. c) Discuss the boolean variable in Python. In which type of engineering problem would you use a boolean data type, and how would it help in decision-making? d) In Python, if a user enters a decimal number as input, but the program requires an integer for further calculations, how would you handle this situation using type conversion? Provide a simple code example.	Apply	CO1	**7+6+6 +6 = 25**
	Section - 2			
3	a) In an engineering application where the user inputs a product's weight, you need to determine if the weight is acceptable for transport. Write an `if-else` condition to check if the weight is within an acceptable range. b) Differentiate between the `break`, `continue`, and `pass` statements in Python? Explain with examples how you would use each one in an engineering program that processes a list of machine components to check for faults. c) Describe the role of function parameters and return values. Provide an example where a function takes different parameters to calculate the cost of	Apply	CO1	**7+6+6 +6 = 25**

	various materials. d) Differentiate between **built-in functions** and **user-defined functions** in Python? Provide an example where a built-in function is more efficient than writing a custom user-defined function			
4	a) You are programming a system that checks the pressure in a pipeline and outputs warnings based on low, medium, or high-pressure readings. How would you use `elif` to handle these multiple conditions? b) Differentiate between a `for` loop and a `while` loop in Python? Provide an example of when you would use a `for` loop versus a `while` loop in an engineering context. c) Explain why **user-defined functions** are often necessary in programming, even when built-in functions are available. d) Differentiate between **local** and **global** variables? Provide an example of when you would use a global variable and when a local variable would be more appropriate in an engineering application.	Apply	CO1	**7+6+6 +6 = 25**
Note for the Course coordinator: Each question may have two, three, four and five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

7. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	III
Course Name	Programming Concepts in Mechanical Engineering			**Test**	II
Course Code	25ME34I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator: **Note:** Answer any one full question from the following					

Questions	**CO**	**Marks**
1. a. Write the Algorithm and flow Chart to Convert Fahrenheit to Centigrade b. Write a Python program to determine if a number is even or odd. c. Create a Python program that uses a for loop to print multiplication tables. d. Create a Python program that writes a list of random numbers to a file and reads them back. e. Create a program to find the greatest common divisor (GCD) of two numbers using a function.	CO1 C01 CO1 CO1 CO2	5+5+10 +15+15 = **50 Marks**
2. a. Write the Algorithm and flow Chart to find out Efficiency of and simple machine b. Write a Python program to use the math module for trigonometric calculations. c. Create a Python dictionary for storing student records (name, age, and grade) and write functions to add and remove entries. d. Write a Python class to represent a Car with attributes like model, year, and color. Include methods to start, stop, and display car details. e. Write a Python program to read data from a CSV file and perform basic operations like counting the number of rows.	CO1 CO1 CO1 CO2 CO2	5+5+10+ 15+15= **50 Marks**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl.No.	Suggestive Activities for Tutorials
01	Using Python to Plot the stress-strain curve for a given material, based on data provided from tensile testing.
02	Create a simple robot that avoids obstacles using an ultrasonic distance sensor using Raspberry Pi and Python.
03	Design a real-time monitoring of motor speed for a mechanical system using Raspberry Pi and Python.
04	Build a simple smart home automation system that controls mechanical devices like lights, fans, or a security camera using Raspberry Pi and Python

10. Rubrics for Assessment of Practices and Activities (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Preparation	Not prepared at all	Lacks several important materials or tools	Adequately prepared but missing key items	Mostly prepared with minor omissions	Fully prepared with all necessary materials and tools	40
2	Execution/ Implementation	Task not executed	Major errors affecting results or functionality	Some inconsistencies or inaccuracies present	Minor errors in execution, but overall effective	Test or task performed flawlessly with precision and accuracy	40
3	Quality of Work	No quality demonstrated	Poor quality, major flaws impacting functionality	Acceptable quality with noticeable defects	Good quality with minor flaws	High-quality output, meets or exceeds standards	30
4	Use of Tools/ Techniques	No proper tool use demonstrated	Weak use of tools, significant risks noted	Basic use of tools, some inefficiencies	Good use of tools, minor issues with technique	Mastery of tools and techniques demonstrated safely and effectively	40
5	Practical Record submission	Major sections are not addressed.	Major sections are missing or poorly addressed.	Some sections are included, but lack detail.	Most sections are complete with minor omissions.	All required sections are included and thoroughly detailed.	50
	Average Marks=(40+40+30+40+50)/5=40						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE–Model Practical Question Paper

Program	Mechanical Engineering	**Semester**	III
Course Name	Programming Concepts in Mechanical Engineering	**Marks**	50
Course Code	25ME34I	**Duration**	180 Min

Note: Answer any one full question. Each full question carries equal marks.

Q No	Questions	Cognitive Levels	Course Outcomes	Marks
	Section -1			
1	a. Write a Python class to represent a Car with attributes like model, year, and color. Include methods to start, stop, and display car details. b. Develop the Python program to calculate Sample Average ($\bar{X}$) & Sample Range (R) for the given data and Plot X bar and R Charts for the given data using Matplotlib. c. Write a program to Build automated water pump controller using Raspberry Pi.	Apply	CO2 CO3 CO4	10 20 20
2	a. Create a Python program that stores names of students in a list and performs operations like adding, removing, and sorting. b. Calculate mean, variance, and standard deviation using Python and Generate X-bar and R control charts from sample data using Matplotlib. c. Write a program to Control DC motors using L298N motor driver using Raspberry Pi.	Apply	CO2 CO3 CO4	10 20 20

12. Equipment/software list with Specification for a batch of 30 students

Sl.No.	Particulars	Specification	Quantity
01	Python Editors	iPython, Jupyter, spider, PyCharm , googleCoLab	20
02	Desktop Computers	Latest	30
03	Raspberry Pi OS	(Raspberry Pi OS Lite or Desktop version)	30
04	Breadboards and Electronic Components (1 set per group of 2	-	30

	students) – • Breadboard (15 units) → Size: Full-size (830 points) → Connector Type: 0.1-inch spaced pins • Jumper Wires (30 sets) → Length: 10cm to 30cm → Type: Male-to-male, male-to-female, female-to-female • LEDs (30 units) → Type: 5mm standard → Colors: Red, Green, Blue • Resistors (Assorted Pack, 30 sets) → Resistance: Common values (220Ω, 330Ω, 1kΩ, 10kΩ) • Sensors (1 set per group of 2 students) → Temperature Sensors (e.g., DHT11 or DS18B20) → Motion Sensors (PIR Sensors) → Distance Sensors (Ultrasonic HC-SR04)		

Government of Karnataka

DEPARTMENT OF TECHNICAL EDUCATION

Curriculum Structure

IV Semester Scheme of Studies- Mechanical Engineering

Sl. No.	Teaching Department	Course Code	Course Name	Hours per week			Total Contact Hours/week	Credits	CIE Marks		Theory SEE Marks		Practice SEE Marks		Total Marks
				L	T	P			Max	Min	Max	Min	Max	Min	
Integrated Courses															
1	ME	25ME41I	Product design, Drawing and development	4	0	4	8	6	50	20	50	20	-	-	100
2	ME	25ME42I	Operations management	4	0	4	8	6	50	20	50	20	-	-	100
3	ME	25ME43I	Machine Tool Technology & CNC Programming	3	0	4	7	5	50	20	-	-	50	20	100
4	ME	25ME44I	Elements of Industrial Automation	3	0	4	7	5	50	20	-	-	50	20	100
Audit Course															
5	KA	24KA41T	Kannada –II (□□□□□□□ □□□□□-II/□□□□ □□□□□-II)	2	0	0	2	2	50	20	-	-	-	-	50
Total				**16**	**0**	**16**	**32**	**24**	**250**	**-**	**100**	**-**	**100**	**-**	**450**

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	MECHANICAL ENGG	**Semester**	IV
Course Name	Product Design, Drawing and Development	**Type of Course**	Integrated
Course Code	25ME41I	**Contact Hours**	104 Hours/Sem
Teaching Scheme	L: T:P 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale - This course provides a holistic view of **product design**, covering fundamental principles, methodologies, and contemporary trends. Students will gain insights into user-centered design, materials and manufacturing processes, and sustainability considerations.

Effective product design requires clear communication of ideas. This syllabus focuses on developing visualization skills, teaching students how to create **detailed sketches, technical drawings, and digital models** that effectively convey design intent to various stakeholders hence this course emphasizes the importance of fundamental drawing techniques and tools, enabling students to accurately communicate their ideas visually. Mastery of these skills is crucial for translating concepts into design specifications. By combining theoretical knowledge with practical application, the syllabus encourages students to engage in **hands-on drawing and prototyping activities**. This approach reinforces learning and fosters a deeper understanding of the design process.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Apply fundamental principles of product design by integrating strength, aesthetics, and ergonomics to develop efficient and user-centric engineering solutions.
CO-02	Design simple machine elements like fasteners, shafts, couplings and knuckle joints using design data inputs.
CO-03	Develop CAD part and assembly drawings for couplings and knuckle joints by applying design parameters and engineering standards.
CO-04	Identify and interpret Geometric Dimensioning and Tolerancing (GD&T) in machine drawings for precise manufacturing and quality control.

Note: Course Co-coordinators can redefine their Course Outcomes as per their TLP

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1	**Introduction to Machine / Product design** • Introduction to product design and development, stages of new product development. Product Life Cycle. • Types of design, necessity of design, Comparison of designed and undersigned work, Design procedure, Characteristics of a good designer • Design terminology: factor of safety, factors affecting factor of safety, stress concentration, methods to reduce stress concentration, fatigue, endurance limit.	• Interpret course related SI units and their conversions. • Understanding the normal values of ultimate tensile strength, yield strength, density, modulus of elasticity and Poisson's ratio of commonly used materials. • Identify the normal values of factor of safety for different situations.
2	1	1,2	**General Considerations in Machine Design** • Ergonomics of design-man-machine relationship, Design of controls - Design of equipment for control, environment and safety. • Aesthetic consideration regarding shape, size, color and surface finish. Design of display -Design of equipment for Display.	• Use of Design Data Hand Book, • Present a video on Ergonomic and Aesthetic consideration followed in Industries. • Discuss the case studies related to Ergonomic and Aesthetic consideration in Design.
3	2	3,4	**Design of Threaded Fasteners:** • Stresses in Screwed fasteners, bolts of Uniform Strength. • Initial tightening load – Tensile, Torsional shear stress, Shear stress across thread, crushing stress, Bending stress. • Stresses due to an external load • Combined effect of initial tightening load and external load • Leak Proof Joint and Joint separation • Numerical Examples.	**Practice -** • **Different screw thread profiles** - Metric, Acme, Square, Buttress, Knuckle, whit worth in sketch book/drawing sheet, • Conventional representation of threads. **Practice -** • Draw the front and top view of ISO threaded Square & Hexagonal bolt and Nut of 100 mm long* with a threaded length of 50mm*. The diameter of the bolt is 20 mm* across corner & side in Sketch book / Drawing sheet. • Create 3D model for the Square and Hexagonal Bolt and Nut.
4	2	3,4	**Design of Shafts:** • Type of shaft, shaft materials, Type of loading on shaft, standard sizes of shaft available • Shaft subjected to torsion only, determination of shaft diameter	**Practice –** • Determine the Angle of twist by using Torsion equipment.

			(hollow and solid shaft) on the basis of Strength criterion, & Rigidity criterion • Numerical Examples.	
5	2	3,4	**Design of Shafts:** • Shaft subjected to bending only - Determination of shaft diameter (hollow and solid shaft) subjected to bending • Shaft subjected to combined torsion & bending - Determination of shaft diameter (hollow and solid shaft) subjected to bending	**Practice –** • Determine the Angle of twist by using Torsion equipment.
6	2,3	3,4	**Design of Keys & Couplings** • Types of key, materials of key, functions of key, Failure of key (by Shearing and Crushing). • Design of key (Determination of key dimension) • Necessity of a coupling, advantages of a coupling, types of couplings, • Design of muff coupling	**Practice -** • Draw the Assembly of Muff coupling for the designed values in Drawing sheet. • Prepare the 3D Model of the Muff coupling using CAD software. • Develop the Muff coupling scaled model using 3D Printer.
7	2,3	3,4	**Design of Couplings-** • Design of Flange coupling for the given power transmission.	**Practice -** • Draw the Assembly of Flange coupling for the designed values in Drawing sheet.
8	2,3	3,4	**Design of Couplings-** • Design of Flange coupling for the given power transmission.	**Practice -** • Prepare the 3D Model of Flange coupling for the designed values using CAD software • Develop the Flange coupling scaled model using 3D Printer.
9	2,3	3,4	**Design of Knuckle Joint** • Design of Knuckle joint	**Practice –** • Draw the views of Knuckle joint in Drawing sheet. • Prepare the 3D Model of the Knuckle joint for the designed values using CAD software • Develop the Knuckle Joint scaled model using 3D Printer.
10	4	1,2	**Basic Geometric Dimensioning and** • **Tolerance symbols**. **- Form controls**– Straightness, Flatness, Circularity, Cylindricity. **- Profile controls** – Profile of a line, Profile of a surface - **Orientation controls** – Angularity, Parallelism, Perpendicularity. • Concept of limits, fits & allowances	**Practice – (Refer Annexure - A – Suggestive only)** Understand and Practice the symbols used in Production drawing.

			• Representation of the following: (i) Clearance fit (ii) Interference fit (iii) Transition fit.	
11	4	1,2	**Basic Geometric Dimensioning and** • **Tolerance symbols**. - **Location controls** –Position, Concentricity, Symmetry - **Runout controls** – Circular runout, Total runout • **Surface Finish symbols**. • **Production drawing** Need, Elements of Production drawing	**Practice – (Refer Annexure - A – Suggestive only)** Understand and Practice the symbols used in Production drawing
12	4	4	**Assembly drawings (Refer Annexure - B – Suggestive only)–**Draw the Assembled views of **any one from the following** in drawing sheet. Prepare 3D parts and assemble by using CAD software. • Engine Stuffing box of a steam engine • C- Clamp • Spring loaded relief valve	
13	4	4	**Assembly drawings (Refer Appendix - B – Suggestive Only)–** Draw the Assembled views of **any one from the following** in drawing sheet. Prepare 3D parts and assemble by using CAD software. • Screw Jack • V-Block with clamp • Cross Head	

4. References:

Sl. No.	Author	Title of Books	Publication/Year
1.	Robert L. Norton	Machine Design: An Integrated Approach	Pearson Education India, 5th Edition, 2013
2.	R.S. Khurmi &J.K.Gupta	A Text book of Machine Design	S. Chand publication
3.	S G Kulkarni	Machine Design	McGraw Hill Education Publications
4.	V B Bhandari	Introduction to Machine design	McGraw Hill Education Publications
5.	K Mahadevan & K Balaveera Reddy	Design Data Hand Book for Mechanical Engineers	CBS publications
6.	Dr K L Narayana, Dr P Anaiah,, K Venkareddy	Machine Design and Drawing	New Age International Limited, 3rd Edition
7.	Frederick Giesecke	Technical Drawing with Engineering Graphics	Peachpit Press, 15th Edition
8.	N D Bhatt	Machine Drawing	Charotar Publication, 2023

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5.	CIE-5 Portfolio evaluation of all practices and activities through Rubrics	1-13		50	
Total					**50 Marks**

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering		**Semester-** IV
Course Name	Product Design, Drawing and Development		**Test** I
Course Code	25ME41I	**Duration**- 90 min	**Marks-**50
Name of the Course Coordinator:			
Note: Answer any one full question from each section. Each question carries equal marks.			

Q. No	Questions	CL	CO	Marks
	Section - 1			
1	a) Apply the six stages of the new product development to a **Passenger Car design**. What insights did you gain at each stage? b) Identify which **product life-cycle stage**, is the most important? which stage is riskiest? which stage appears to hold the greatest profit potential? Be certain to explain the thinking behind each of your answer. c) Identify and analyze at least three factors that could influence the factor of safety in a **mechanical design.** d) In designing a new **automated assembly robot,** how would you integrate general considerations in machine design with adherence to BIS standards?	Apply	CO1	**5+5+5 +10 = 25**
2	a) Discuss why the **appearance of product** is often a major factor in attracting the customer. b) Analyze a specific **workplace setting of an assembly line**. How would you apply ergonomic principles to improve the man-machine relationship? What changes would you suggest to enhance user comfort and efficiency? c) Discuss how you would integrate **aesthetic considerations** with ergonomic principles in the design of office furniture. What trade-offs might you encounter, and how would you resolve them to create a product that is both visually appealing and comfortable? d) For designing a **control panel for an industrial machine**, what factors	Apply	CO1	**5+5+5 +10 = 25**

	would you consider when designing the layout and functionality of the controls?			
Section - 2				
3	a) Discuss the factors that influence the selection of materials for shafts in a high-performance **automotive application**. What materials would you recommend, and what properties make them suitable for this application? b) 12 M20 x 2.5C bolts are used to hold the cylinder head of a reciprocating air compressor in position. The air pressure is 7 MPa and the cylinder bore diameter is 100 mm. A soft copper gasket with long bolts is used for sealing. If the tensile yield stress of the bolt material is 500 MPa find the suitability of the bolt for the purpose. Check if the joint is leak proof and also if any joint separation may occur. c) A solid shaft needs to be designed for a maximum torsion of 150 N-m. Using a strength criterion, calculate the required diameter of the shaft if the allowable shear stress is 60 MPa.	Apply	CO2	**5+10+10 = 25**
4	a) Identify and describe the different **types of shafts** used in mechanical systems. In what applications would each type be most suitable, and why? b) In a steam engine the steam pressure is 2 MPa and the cylinder diameter is 250 mm. The contact surfaces of the head and cylinder are ground and no packing is required. **Choose a suitable bolt** so that the joint is leak proof. Assume number of bolts to be used is 12. c) An engineer is designing a hollow shaft that must maintain a maximum angle of twist of 2 degrees under a torsional load of 300 Nm. If the length of the shaft is 1 m and the shear modulus is 75 GPa, calculate the required outer diameter of the shaft based on the rigidity criterion. Assume the inner diameter is to be 20 mm.	Apply	CO2	**5+10+10 = 25**
Note for the Course coordinator: Each question may have two, three, four and five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	IV
Course Name	Product Design, Drawing and Development			**Test**	II
Course Code	25ME41I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator: **Note:** Answer any one full question from the following					
Questions				**CO**	**Marks**
1. a) Draw and label the following screw thread profiles: Metric, Acme, Square, Buttress and Whitworth. For each profile, discuss the typical applications where they would be most effective. **b)** Design a **muff coupling** which is used to connect two steel shafts transmitting 40 kW at 350 r.p.m. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa. Create the 3D model in CAD and Extract the Principle views.				CO2, CO3	10+40 = **50 Marks**
2. a) Draw the front and top view of **ISO threaded Hexagonal bolt and Nut** of 120 mm long with a threaded length of 60mm. The diameter of the bolt is 25 mm across side. Create the 3D model in CAD and Extract the Principle views. **b)** Design a **Cast Iron unprotected type flange coupling** to transmit 15kW at 800				CO2, CO3	10+40 = **50 Marks**

rpm. The maximum torque may be assumed 1.35 times the mean torque. The permissible shear stress for Shaft, bolt and key material is 40 MPa. The permissible crushing stress for bolt and key material is 80 MPa. The shear stress for Hub and flange is 12 MPa. Assume that material used for Shaft and Key is same. Create the 3D model in CAD and Extract the Principle views.		
Scheme of Evaluation		
Q. No 1		
a) Drawing and labelling = 1 x 5 = 5 Marks,	CO3	5
Each application = 1 x 5 = 5 Marks.	CO2	5
b) Design = 20 Marks,	CO2	20
3D Modelling = 10 Marks,	CO3	10
Extracting the views = 10 Marks	CO3	10
Q. No 2		
a) Drawing of front and side view = 5 + 5 = 10 Marks,	CO3	10
b) Design = 20 Marks,	CO2	20
3D Modelling = 10 Marks,	CO3	10
Extracting the views = 10 Marks	CO3	10

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Design the foundation bolts (Number & Diameter) used in Electrical pole installation.
02	Design a suitable Coupling for different motor ratings and different shaft materials.
03	Develop a product from Concept design to Prototyping (at least 4 products).
04	Write and execute the Python Program for design of shafts.

10. Rubrics for Assessment of Practical Exercises and Activities (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Preparation	Not prepared at all	Lacks several important materials or tools	Adequately prepared but missing key items	Mostly prepared with minor omissions	Fully prepared with all necessary materials and tools	40
2	Execution/ Implementation	Task not executed	Major errors affecting results or functionality	Some inconsistencies or inaccuracies present	Minor errors in execution, but overall effective	Test or task performed flawlessly with precision and accuracy	40

3	Quality of Work	No quality demonstrated	Poor quality, major flaws impacting functionality	Acceptable quality with noticeable defects	Good quality with minor flaws	High-quality output, meets or exceeds standards	30
4	Use of Tools/ Techniques	No proper tool use demonstrated	Weak use of tools, significant risks noted	Basic use of tools, some inefficiencies	Good use of tools, minor issues with technique	Mastery of tools and techniques demonstrated safely and effectively	40
5	Practical Record submission	Major sections are not addressed.	Major sections are missing or poorly addressed.	Some sections are included, but lack detail.	Most sections are complete with minor omissions.	All required sections are included and thoroughly detailed.	50
	Average Marks=(40+40+30+40+50)/5=40						**40**

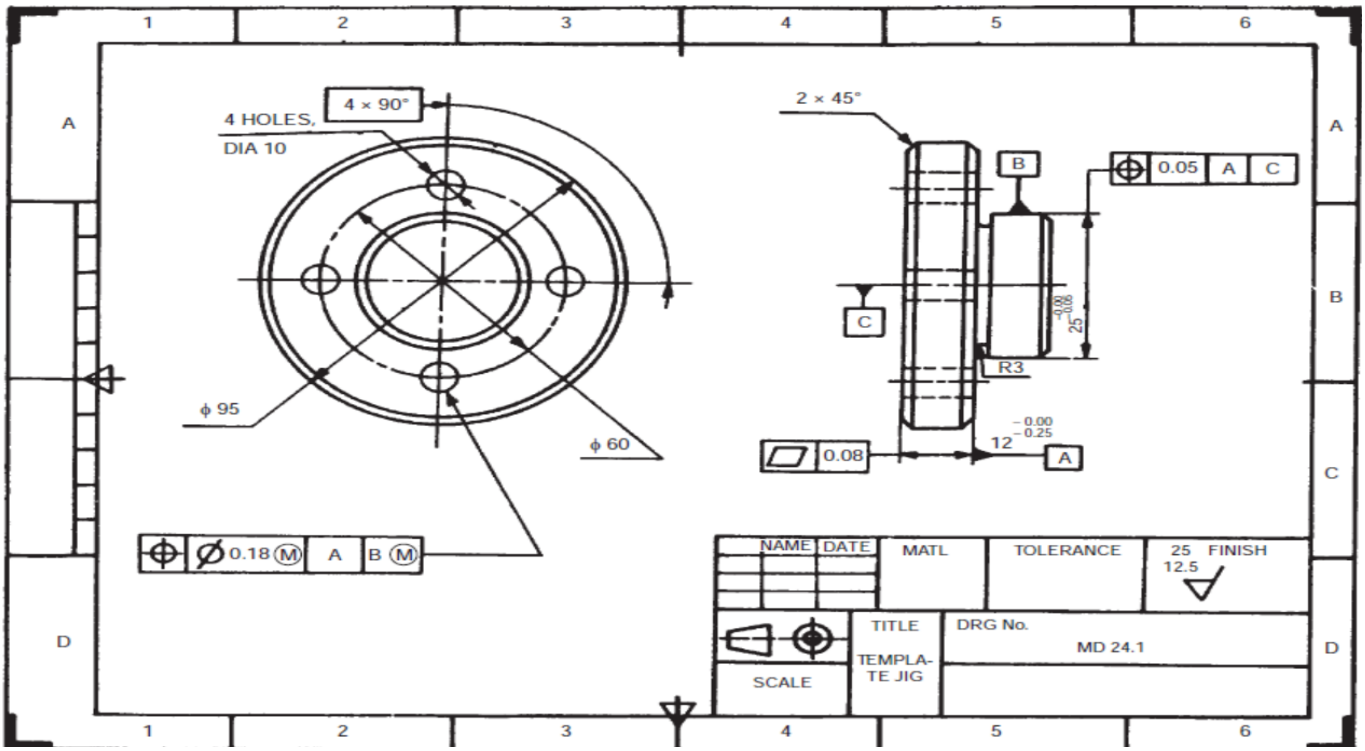
Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment/software list with Specification for a batch of 30 students

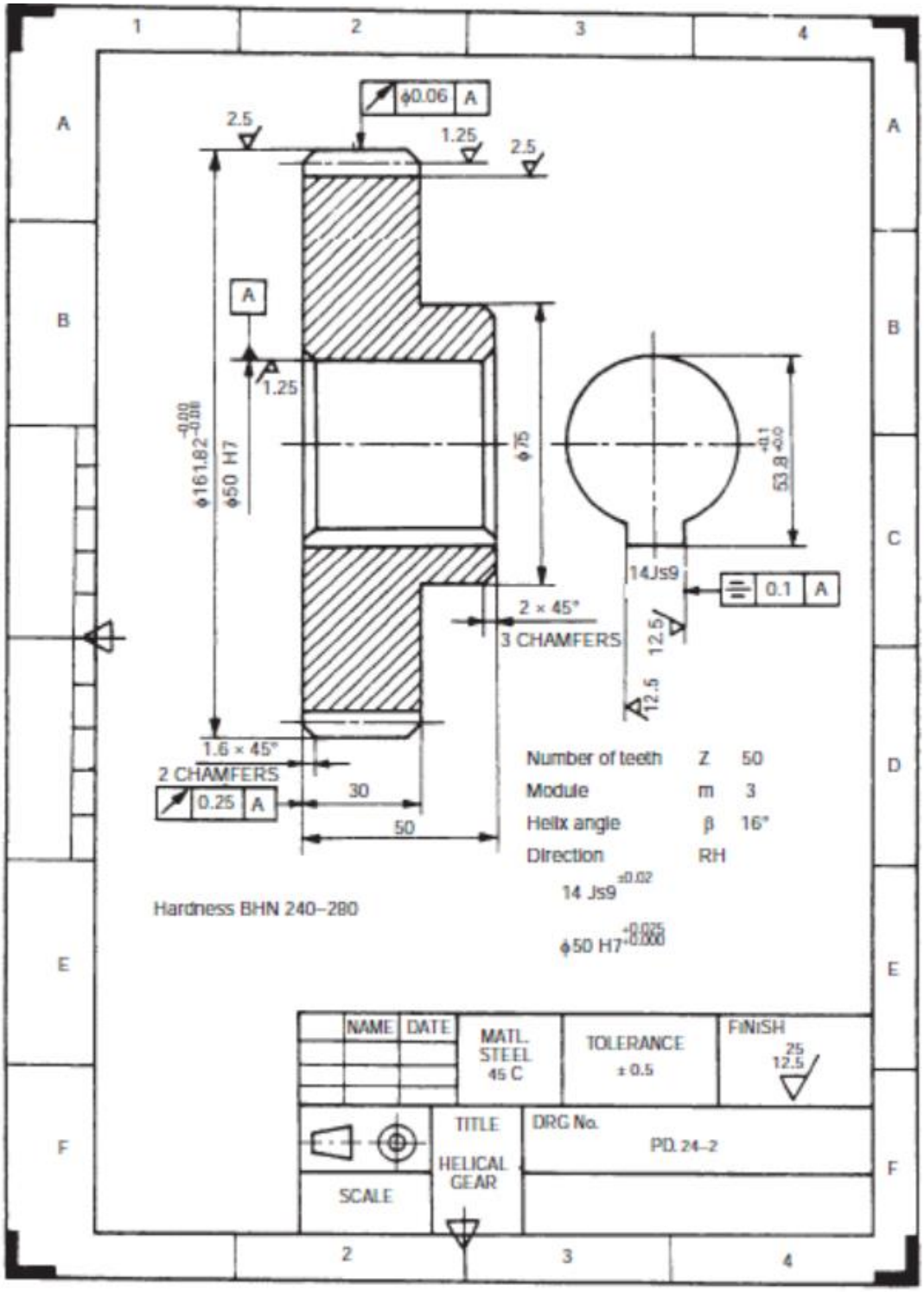
Sl. No.	Particulars	Specification	Quantity
01	Desk top computer	Latest Configuration	20
02	Latest version of CAD software	Any Licensed version	20
03	3-D Printing Machine	PLA/ABS 3D printer	02

Annexure – A (Suggestive Only)

1. Production Drawing – Template Jig

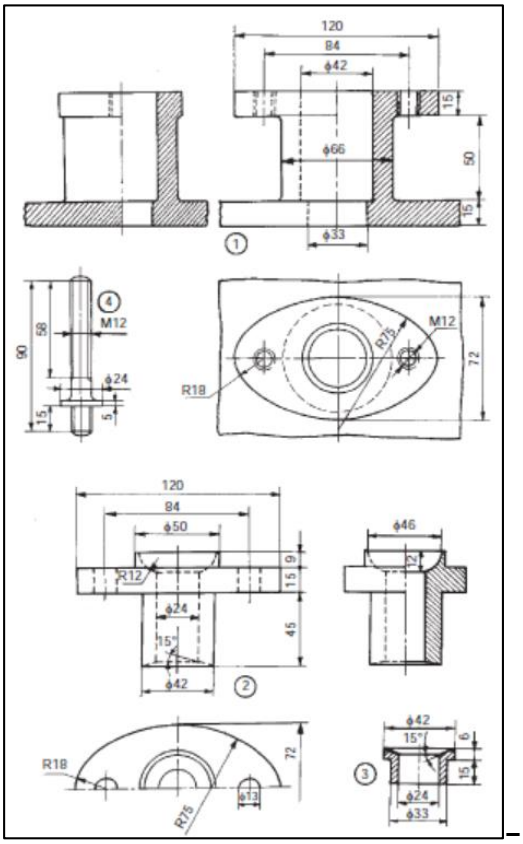


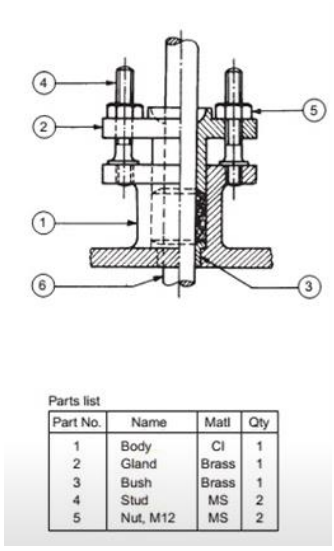
2. Production Drawing – Helical gear



Annexure– B (Suggestive Only)

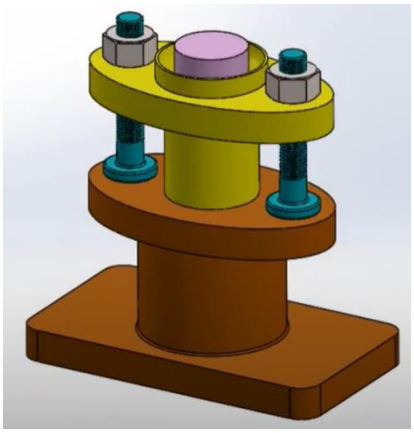
1. Stuffing Box of a Steam Engine



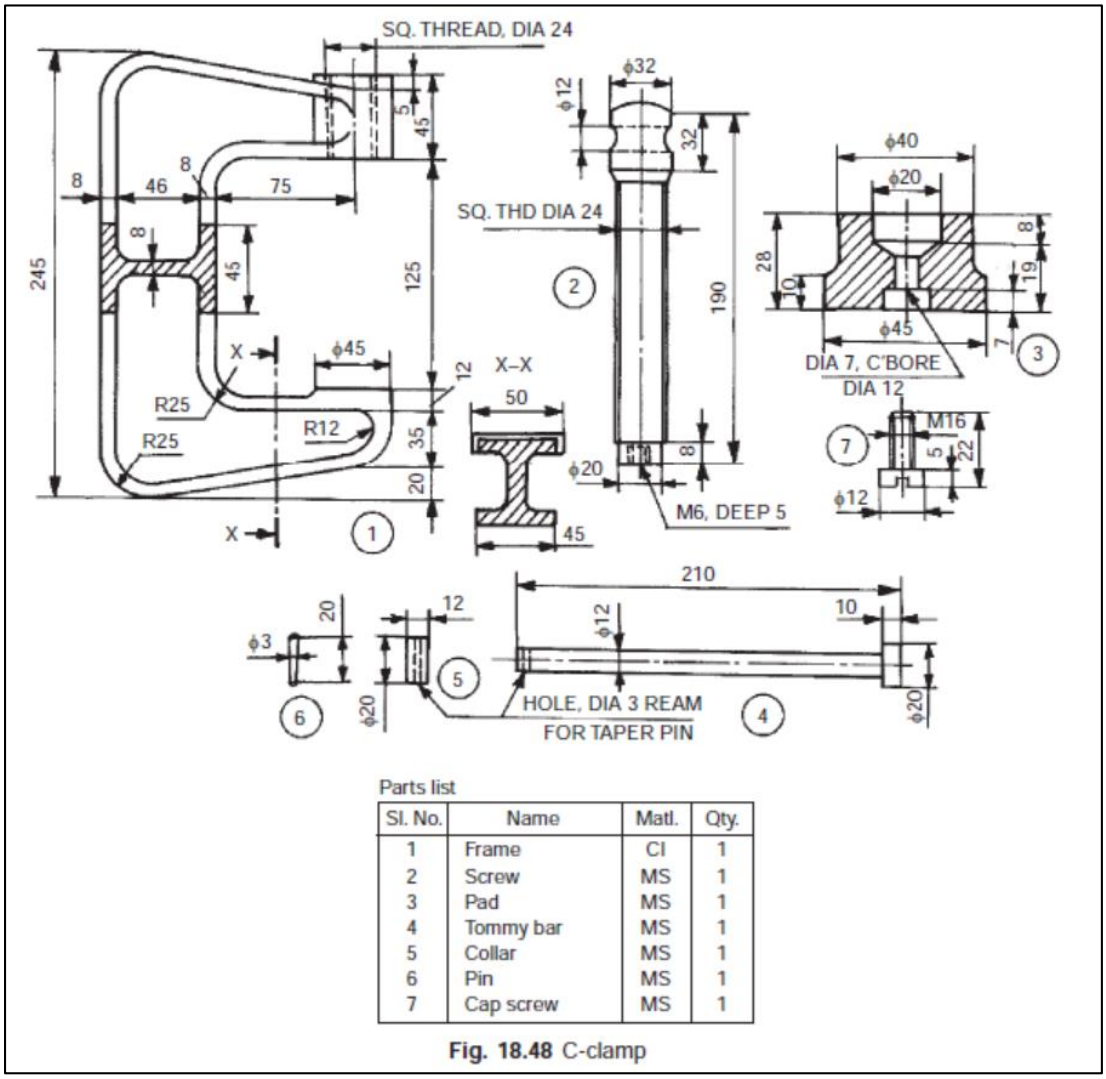


Parts list

Part No.	Name	Matl	Qty
1	Body	CI	1
2	Gland	Brass	1
3	Bush	Brass	1
4	Stud	MS	2
5	Nut, M12	MS	2



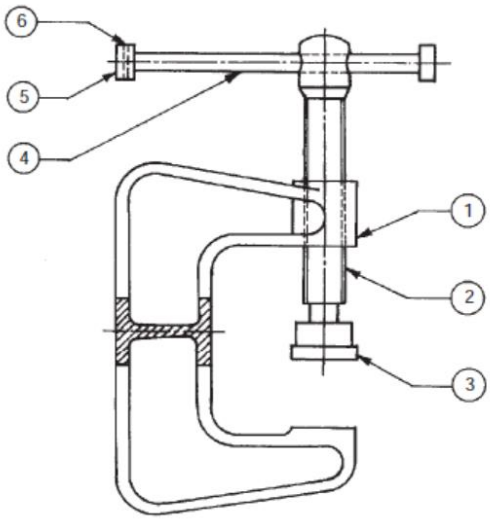
2. C - Clamp –

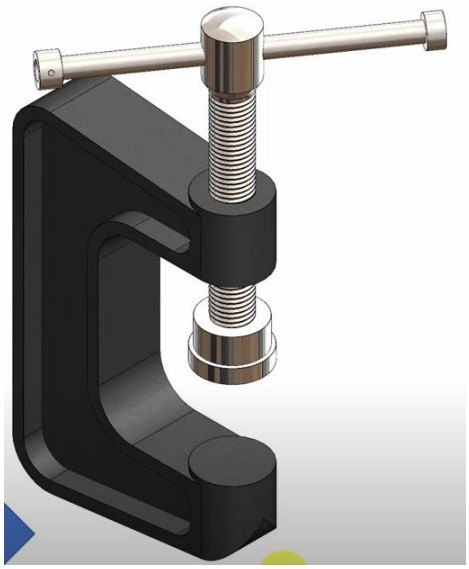


Parts list

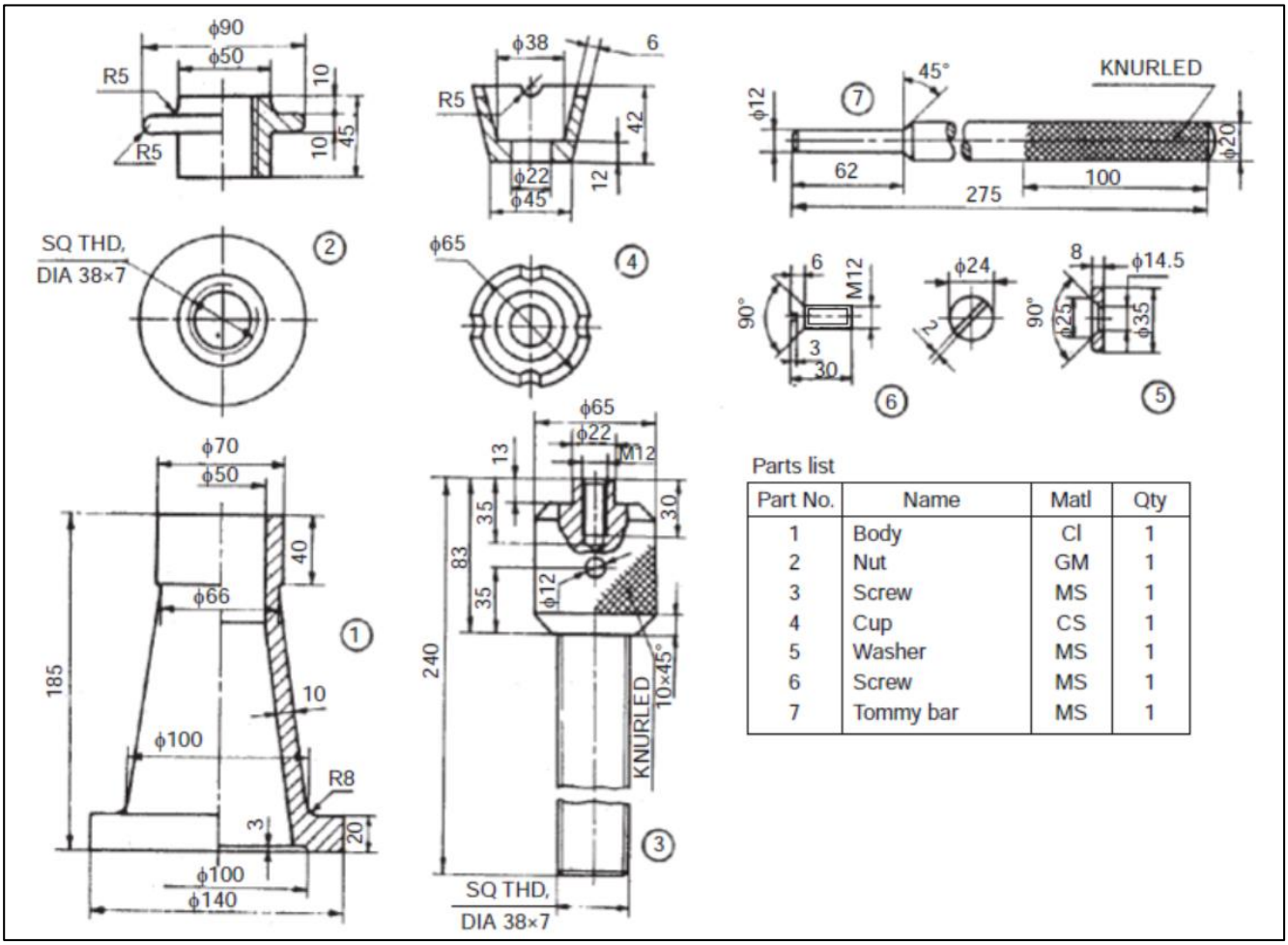
Sl. No.	Name	Matl.	Qty.
1	Frame	CI	1
2	Screw	MS	1
3	Pad	MS	1
4	Tommy bar	MS	1
5	Collar	MS	1
6	Pin	MS	1
7	Cap screw	MS	1

Fig. 18.48 C-clamp



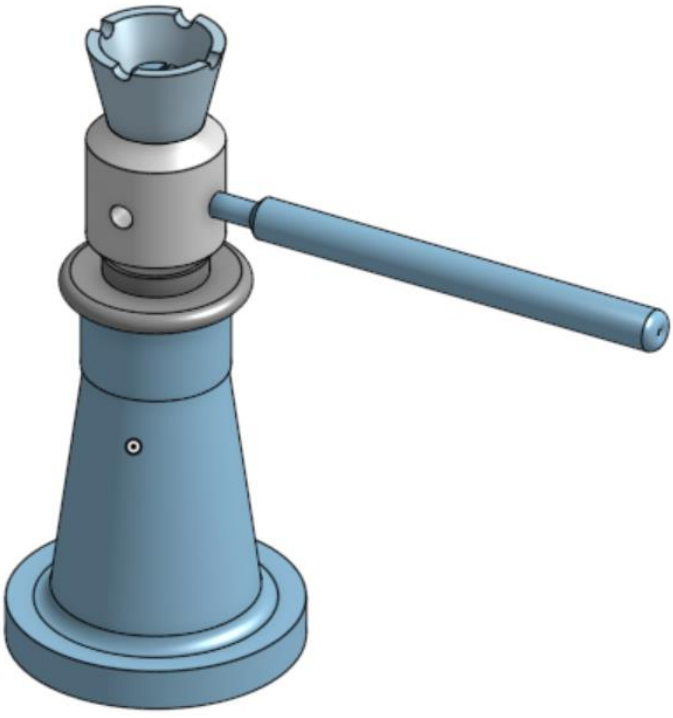


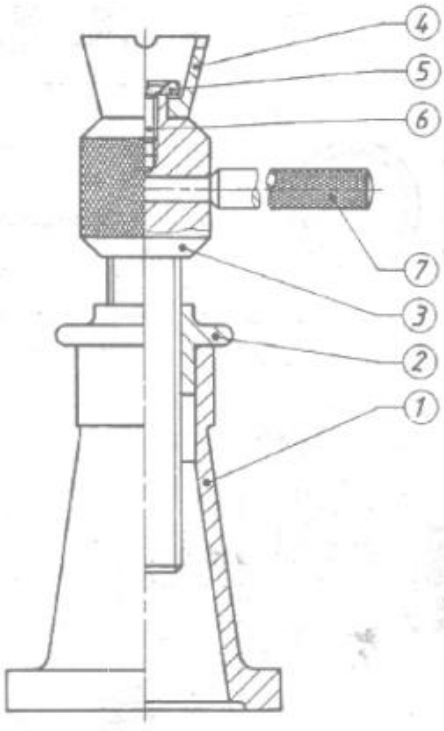
3. Screw Jack –



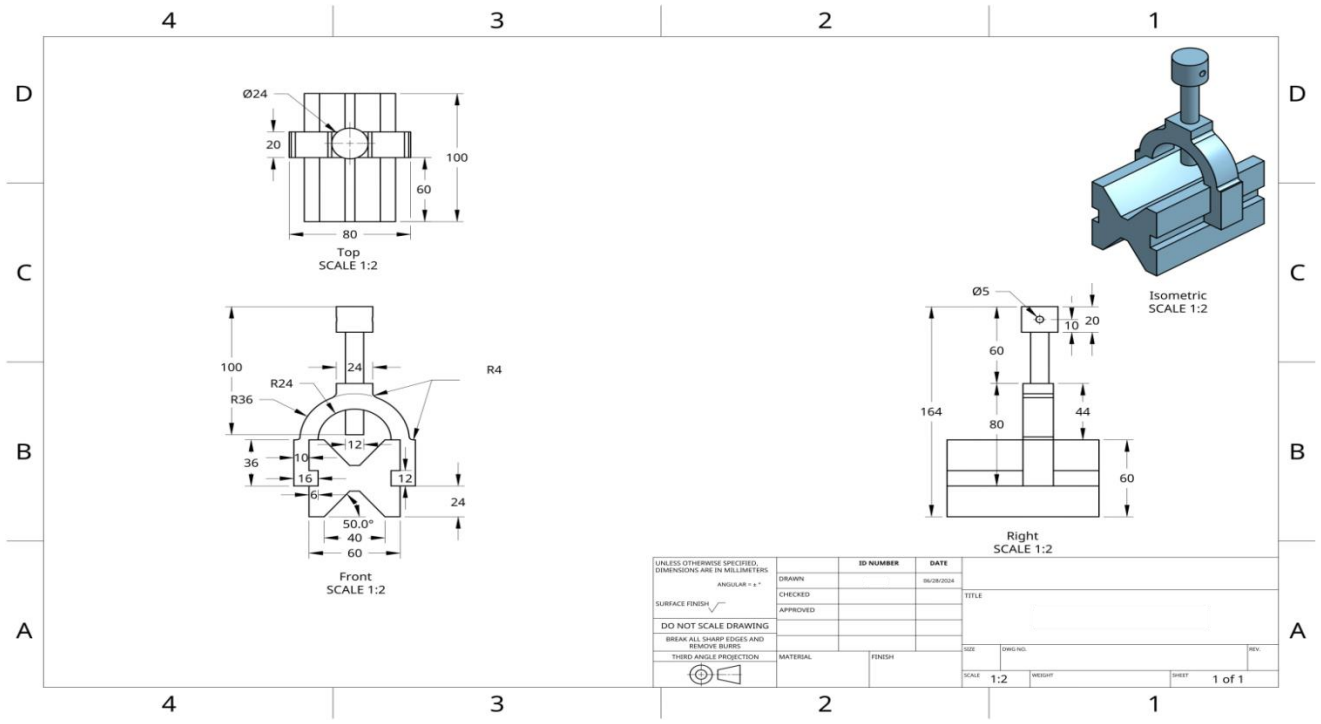
Parts list

Part No.	Name	Matl	Qty
1	Body	CI	1
2	Nut	GM	1
3	Screw	MS	1
4	Cup	CS	1
5	Washer	MS	1
6	Screw	MS	1
7	Tommy bar	MS	1

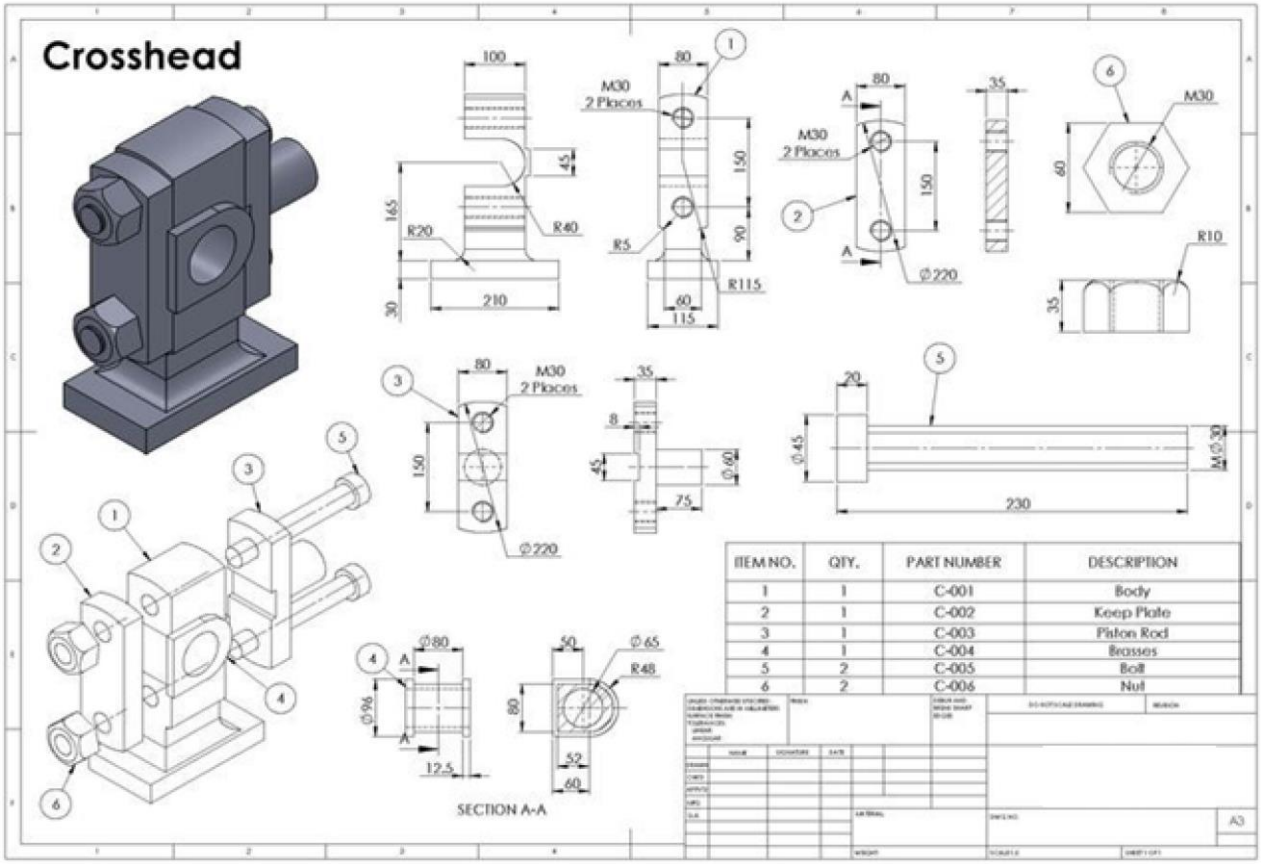




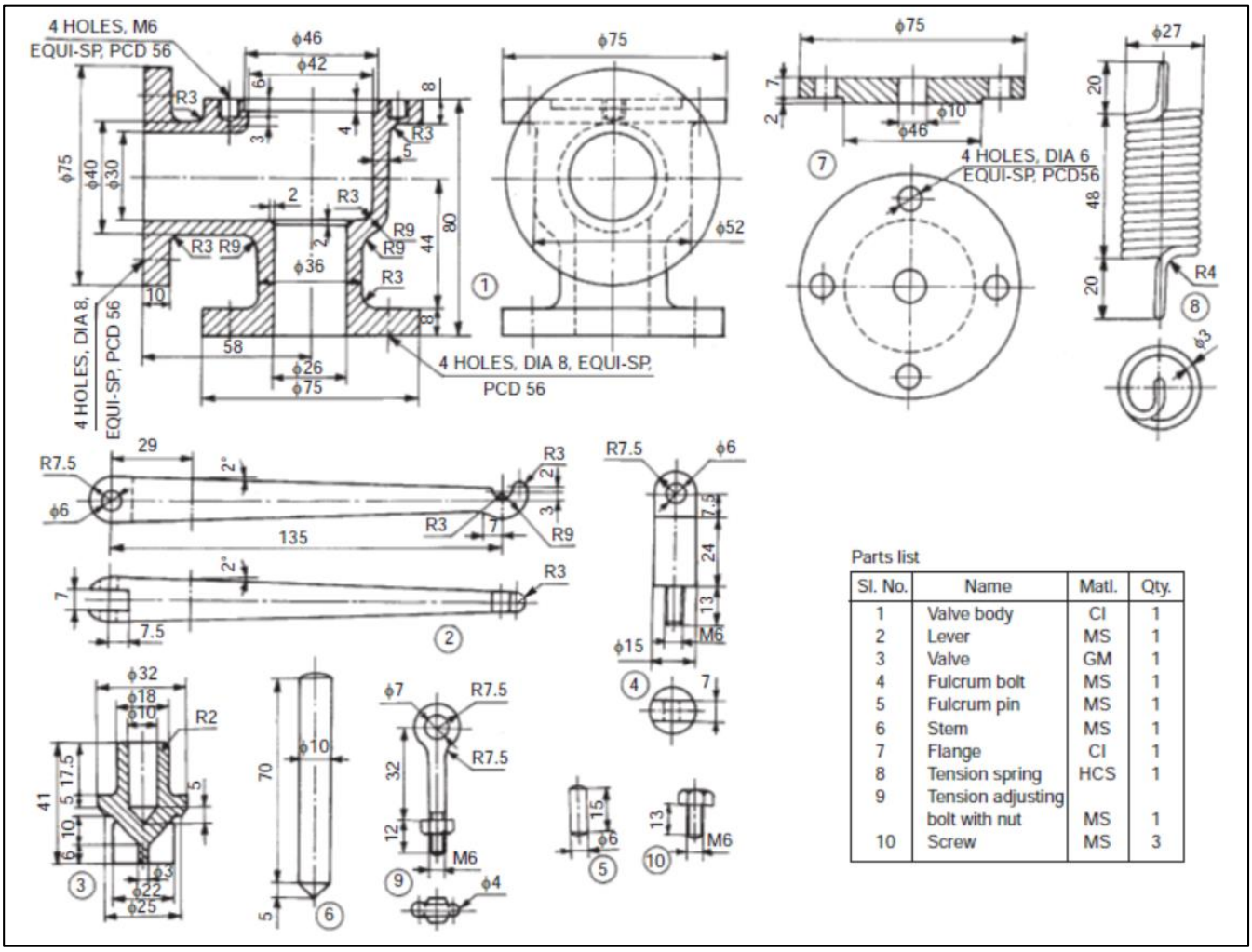
4. V-Block with Clamp –

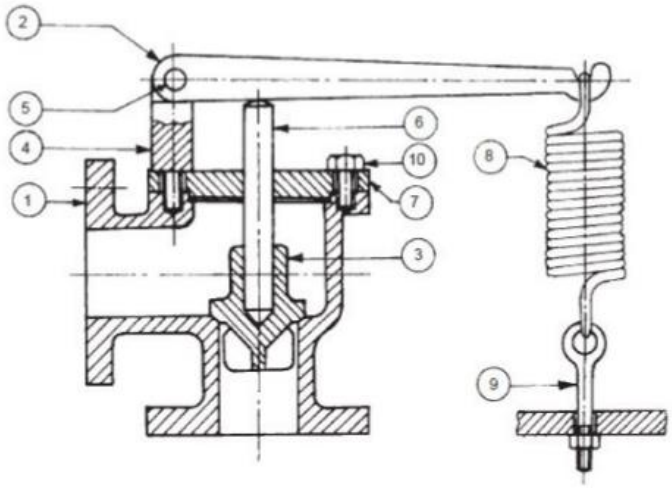


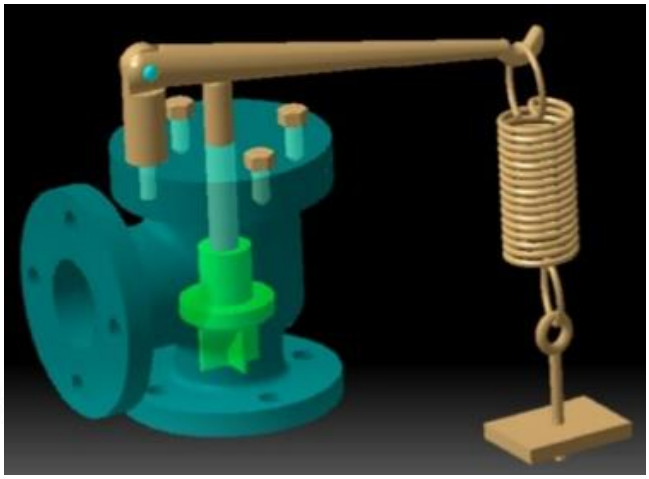
5. Cross Head –



6. Spring Loaded Relief Valve –







Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	**IV**
Course Name	Operations Management	**Type of Course**	Integrated
Course Code	20ME42I	**Contact Hours**	104hrs/ Sem
Teaching Scheme	L:T:P:: 4-0-4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale: This course in Operations Management provides a comprehensive understanding of manufacturing processes by integrating theoretical concepts with practical applications. It covers essential topics such as productivity, process planning, demand forecasting, scheduling, work study, inventory management, and quality control.

Students will explore advanced manufacturing techniques, decision-making strategies, and optimization methods, including Computer-Aided Process Planning (CAPP), Group Technology (GT), and Lean Manufacturing. Practical sessions include industry visits, case studies, route and operation sheet creation, plant layout design, and problem-solving in scheduling and forecasting. Additionally, key aspects of quality management, such as TQM, Six Sigma, Kaizen, and Quality Circles, are emphasized to enhance production efficiency. Through hands-on learning, students will develop analytical skills, decision-making capabilities, and technical expertise required to optimize operations and improve productivity in the manufacturing sector.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	**Interpret** fundamental concepts of Operations Management, including productivity and decision-making, to assess their impact on manufacturing industries.
CO-02	**Apply** planning, forecasting, and scheduling techniques to optimize operational efficiency in production systems.
CO-03	**Analyze** plant layouts, inventory management, and supply chain strategies to enhance productivity and resource utilization.
CO-04	**Evaluate** work study methods and time measurement techniques to improve process efficiency and labor utilization.
CO-05	**Implement** quality management tools such as TQM, Six Sigma, and Kaizen to ensure continuous improvement in manufacturing processes.

3. Details of Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,2	**Introduction to Operation Management** • Meaning, Key Concepts, Importance, Application • Production Management vs. Operation Management • Productivity- Concept, Types, Factors, Strategies • Competitiveness - Concept, Factors, Measure Competitiveness • Relationship Between Productivity and Competitiveness, simple numerical problem	• Visit an industry - Study the manufacturing process and calculate the productivity of the process using Labour and Machine Productivity. • Provide case study of the Production System - Analyse the system and identify key elements that contribute to productivity and competitiveness.
2	2	1,3	**Process Planning** • Process Planning - Steps in Process planning • Process planning Techniques –List, Meaning, Application in manufacturing, Benefits, Challenges • Different Tools used in Process planning • Purpose, Components, Challenges and application a) Route Sheets b) Operation Sheets	• Create a practical route sheet for a specific component, considering all necessary production aspects, tools, and resources. • Develop an Operation Sheet indicating Process Plan and Process flow chart for a given component.
3	1	1,2	• Make or Buy Decision- Concept, Factors, Steps involved- Simple problems • Outsourcing- Factors for Outsourcing, Risks • Production types –Batch, Mass, Job order – Applications - Factors Influencing Production type, Pro's and Con's • Plant Location-Factors Influencing Plant Location	• Consider a scenario in a Mechanical Industry. Decide whether to make a product or buy a product • Virtual Tour on Batch, Mass and continuous Process
4	2	1,4	**Plant Layout** • Types, Principles of a Good Plant Layout • Techniques for Improving Layout **Demand Forecasting** • Demand Forecasting • Demand Behavior-Trend Cycle, Seasonal Background • Steps in Forecasting Process • Methods of Forecasting	• Preparing plant layout of college machine shop • Provide a scenario to Analyse Trend Cycle
5	2	2,3	**Forecasting tools** • Qualitative approach- Delphi method,	• Provide a scenario to forecast demand by Delphi method and Market Research method

			Market Research method, Case Studies on Delphi method	
6	2	2,3	• Quantitative approach – Moving average method, Exponential smoothing method - Simple Problems	• Provide a scenario to forecast demand by Moving average method • Provide a scenario to forecast demand by Exponential smoothing
7	2,4	1,3	**Scheduling and Sequencing** • Scheduling: Types, Timing of operations to optimize production flow • Sequencing - Types, techniques to manage production order • Introduction to Critical Path Method (CPM) for efficient scheduling- Simple Problems on practical examples	• Provide a scenario for job sequencing • Problems on practical examples using CPM.
8	4	1,4	**Work Study and Time Management** • Work Study and its importance in productivity improvement • Method Study: Analyzing tasks for efficiency • Tools - Process Chart, Single handed and two Handed Process Chart - Simple Problems	• Develop single handed process chart with appropriate symbols • Develop two handed process chart with appropriate symbol
9	4	1,4	• Man-machine chart – Simple problems • Assignment problems – Simple problems • Work Measurement: Time study and setting standard times- Simple Problems • Applications of Time Allowances: Rest, personal, and process allowances	• Provide a scenario and analyse Man-machine activity for a given simple process • Provide a scenario and analyse a simple production assignment problem • Provide a scenario and analyse Time Study in a Practical Setting- calculate the standard time for the task and suggest improvements.
10	3	1,3	**Inventory Management** • Inventory Management- Objectives and Functions of Inventory management • Various inventory Costs • Key terms: Demand, Minimum Stock Level, Lead Time, Reorder time, Reorder Level • Inventory Classification: ABC Analysis- Problems • Economic Order Quantity (EOQ) - Simple Problems	Problems on • ABC Classification System of items • Economic Order Quantity (for Fixed order quantity system/ Model 1)

11	3	2,5	**Supply Chain Management (SCM)** • Introduction to SCM: Importance in production and delivery • Components of SCM: Sourcing, procurement, logistics, and distribution • Supply Chain Strategies: Just in Time (JIT) and Lean Manufacturing • Information Technology: Bar Codes, Radio Frequency Identification	Case study onInformation Technology- • Bar Codes • Radio Frequency Identification
12	5	1,3	**Quality Management** • Quality from The Customer's Perspective • Quality from The Producer's Perspective • Cost of Quality- Cost of Achieving Good Quality- Cost of Poor Quality- Quality Productivity Ratio • Quality Tools - Process Flowcharts, 5 Whys, Cause and Effect Diagrams, Check sheets, Histograms, Pareto Analysis, Scatter Diagrams	• Provide a scenario and analyse the problem using quality tools and interpret the results
13	5	1,3	• TQM and QMS, Quality Management - Customers • TPM (Total Productive Maintenance) in Quality Management. • The Role of Employees in Quality Improvement • Kaizen – Continuous Improvement • Quality Circles • Six Sigma • Breakthrough Strategy: DMAIC	Simple Practice problems on • Kaizen, • Quality Circles • Deming Wheel (PDCA Cycle)

4. References:

Sl No	Author	Title of Books	Publication/Year
1	Heizer, Jay	"Operations Management"	Pearson, 2021
2	Stevenson, W.J.	"Operations Management"	McGraw-Hill, 2020
3	Chase, R.B., Jacobs, F.R., & Aquilano, N.J.	"Operations Management for Competitive Advantage"	McGraw-Hill, 2021
4	Slack, N., Chambers, S., & Johnston, R.	"Operations Management"	Pearson, 2020
5	Buffa, E.S., & Sarin, R.K.	"Modern Production/Operations Management"	Wiley, 2020
6	Hill, T.	"Operations Management: An Integrated Approach"	Palgrave, 2019
7	Mahadevan, B.	"Operations Management"	Pearson, 2019

8	Russell, R.S., & Taylor, B.W.	"Operations Management: Creating Value along the Supply Chain"	Wiley, 2020
9	Baines, T., & Lightfoot, H.	"Sustainable Operations Management"	Routledge, 2019
10	Waters, D.	"Supply Chain Management: An Introduction to Logistics"	Palgrave, 2020
11	Schonberger, R.J.	"World Class Manufacturing: The Next Decade"	Free Press, 2020
12	Foster, S.T.	"Cost Accounting: Foundations and Evolutions"	Pearson, 2019

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max Marks	
1.	CIE-1TheoryTest	4	90	50	Average of all CIE=50Marks
2.	CIE-2 Practice Test	7	180	50	
3.	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation–all practices and Activities through Rubrics	1-13		50	
Total					**50 Marks**

6 SEE-Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** IV	
Course Name	Operations Management			**Test**	I
Course Code	25ME42I	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. A mechanical parts factory needs to allocate resources for a high-demand product while managing other operations. Compare how production management and operations management ensures balanced resource allocation across the organization.	Apply	CO1	10
	b. A manufacturing plant observes a consistent drop in output due to machine downtime and inefficient workflows. Suggest strategies to enhance productivity	Apply	CO1	05
	c. Discuss the risks involved in outsourcing a critical component of a product. How would you ease these risks if the decision is to "buy"?	Apply	CO1	05
2	a. A manufacturing company, wants to improve its overall productivity to meet increasing market demand and reduce production costs. The company produces precision metal parts for the automotive industry. Identify the key factors that affect productivity in the manufacturing process. Discuss how each factor can influence overall productivity.	Apply	CO1	10
	b. Your factory produces machine parts, and demand often fluctuates between large orders of standard parts and small orders of customized designs. What production type(s) would best suit this situation, and why?	Apply	CO1	05
	c. Your company needs a custom component for its new product. What factors would you evaluate to decide whether to manufacture it in-house or outsource it?	Apply	CO1	05
	Section – 2			
3	a. A mechanical engineering company, "Precision Tech," manufactures the following products: i) Custom-designed machine components for specific clients. ii) Standard bolts and nuts in large quantities. iii) Specialized automotive parts for a limited series of vehicles. Identify the most appropriate type of production for each of the above case. Justify your selections by explaining how each type of production aligns with factors like customization, production volume, and cost-efficiency in the mechanical sector.	Apply	CO1	10
	b. A global automotive parts manufacturer, needs to forecast the demand for a new car component—an advanced braking system—to plan production schedules and inventory levels effectively. Identify the factors that should be considered when forecasting the demand for the new braking system.	Apply	CO2	05
	c. A mid-sized automotive parts manufacturer, "Auto Gear Solutions," specializes in producing custom gearbox components for different car models. To improve efficiency and reduce manual errors, the company decides to implement a Computer-Aided Process Planning (CAPP) system. What are the likely challenges that the company has to overcome?	Apply	CO2	5
4	a. A manufacturing company, is in the process of implementing a new product line. The company produces precision-engineered components for the aerospace industry and requires detailed operation sheets for each part to ensure	Apply	CO2	10

	consistency and quality in production. Describe the purpose of an operation sheet in a manufacturing setting.			
	b. A manufacturing company, specializes in reverse engineering obsolete mechanical parts to refurbish and maintain aging machinery for industrial plants. The company often encounters challenges when attempting to replicate outdated or discontinued parts. Identify the primary challenges the Industry faces during the reverse engineering process.	Apply	CO2	05
	c. A company plans to manufacture a complex mechanical part requiring high precision. Which tools would you recommend for effective process planning, and why?	Apply	CO2	05
Note for the Course coordinator: *Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	IV
Course Name	Operations Management			**Test**	II
Course Code	25ME42I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					
	Questions			**CO**	**Marks**
	Section-I				
1. 2.	Provide case study of the Production System - Analyze the system and identify key elements that contribute to productivity and competitiveness. Provide a detailed report. Provide a scenario in a Mechanical Industry. Decide whether to make a product or buy a product. Provide a detailed report.			CO1	25
	Section-II				
1. 2.	Provide a scenario. Forecast the demand by Delphi method Provide a scenario to forecast demand by Exponential smoothing			CO2	25
	Scheme of Assessment for Section I & II			**CO**	
	a) Understanding of the System: 5 Marks b) Analysis: 10 Marks c) Factors Influencing: 5 Marks d) Recommendations and Conclusions : 5 Marks			01	25
	a) Understanding Forecast Demand: 5 Marks b) Selection of Forecast Demand: 5 Marks c) Applying Forecast Demand: 10 Marks d) Evaluation of Forecast Accuracy: 5 Marks			02	25
				Total Marks	**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Ssuggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	A mechanical manufacturer using batch production for shafts and bearings notices frequent downtime due to retooling between batches. Propose solutions to minimize production delays.
02	Employees in a mechanical assembly line lack the skills needed for operating advanced equipment. Design a strategy to improve their productivity through training and development programs.
03	A new product launch involves several unfamiliar manufacturing steps. How can tools like failure mode and effects analysis (FMEA) or simulation models be used to mitigate risks during process planning?
04	Compare the forecasted values to actual demand to evaluate the performance of Exponential Smoothing. Discuss if the chosen smoothing constant (α) provided an adequate balance between bias and responsiveness.
05	A company is evaluating its quality management practices and needs to understand the cost implications associated with achieving good quality and poor quality. Discuss how understanding these costs can help the company make informed decisions about its quality strategies and improvements.

10 Rubrics for Assessment of Practical Exercises and Activities (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Preparation	Not prepared at all	Lacks several important materials or tools	Adequately prepared but missing key items	Mostly prepared with minor omissions	Fully prepared with all necessary materials and tools	40
2	Execution/ Implementation	Task not executed	Major errors affecting results or functionality	Some inconsistencies or inaccuracies present	Minor errors in execution, but overall effective	Test or task performed flawlessly with precision and accuracy	40
3	Quality of Work	No quality demonstrated	Poor quality, major flaws impacting functionality	Acceptable quality with noticeable defects	Good quality with minor flaws	High-quality output, meets or exceeds standards	30
4	Use of Tools/ Techniques	No proper tool use demonstrated	Weak use of tools, significant risks noted	Basic use of tools, some inefficiencies	Good use of tools, minor issues with technique	Mastery of tools and techniques demonstrated safely and effectively	40

5	Practical Record submissio n	Major sections are not addressed.	Major sections are missing or poorly addressed.	Some sections are included, but lack detail.	Most sections are complete with minor omissions.	All required sections are included and thoroughly detailed.	50
	Average Marks=(40+40+30+40+50)/5=40						**40**

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	MECHANICAL ENGG.	**Semester**	IV
Course Name	Machine Tool Technology and CNC Programming	**Type of Course**	Integrated
Course Code	25ME43I	**Contact Hours**	91Hrs/Sem
Teaching Scheme	L: T:P 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. **Rationale**: This course helps students learn about machining processes, from basic metal cutting to advanced CNC programming. It covers both theory and hands-on practice to develop essential skills for manufacturing. Students will start with conventional machining techniques like turning and milling, understanding machine operations, cutting tools, and machining parameters. They will perform operations on lathes and milling machines, create process plans, estimate costs, and inspect finished parts using measuring tools. Safety practices and preventive maintenance are also emphasized. The course also introduces CNC machining, teaching students how to operate CNC machines, set tools, and write programs using G-codes, M-codes, and canned cycles. They will practice programming, simulating, and executing CNC turning and milling operations.

   By combining traditional and modern machining methods, this course prepares students for real-world manufacturing, helping them improve efficiency, reduce costs, and ensure high-quality production.

2. **Course Outcomes: At the end of the Course, the student will be able to:**

CO-01	Interpret the fundamental concepts of metal cutting, machining processes, and safety standards in conventional and CNC machining.
CO-02	Operate lathe and milling machines to perform various machining processes effectively.
CO-03	Develop process plans and estimate production costs based on given component drawings for lathe and milling operations.
CO-04	Generate CNC turning and milling part programs for a given production drawing and simulate/produce the model.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,2	**Theory of Metal Cutting** • Material Removal Process - Introduction, Classification, Mechanics of Metal Cutting • Types of Chips, Orthogonal & Oblique Cutting • Cutting Tool - Geometry of Single Point Cutting Tool, Cutting Tool Material - Selection, Cutting Fluids - Functions, Types, Properties • Safety Standards practiced in machine shop o Do's and Don'ts o Safety signs, Protection – PPE (Personnel Protective Equipment), Fire protection, Electrical & Chemical safety. o First aid o Machine shop layout	
2	2,3	1,2,4	**Turning** • Lathe - Introduction, Classification. • Demonstrate the various parts of lathe and their functions. • Explain the Lathe Terminologies - Feed, Speed, Depth of cut & Machining time • Demonstrate lathe Operations- facing, plain turning, step turning, taper turning (compound rest method), chamfering, knurling, grooving and threading operations (external) • **Inspection** – Demonstration of Measuring tools, Checking & documenting the dimensions and surface finish using various measuring tools.	
3	2,3	1,2	• Preparation of Process planning sheet for lathe - include component drawing, process list, machine used, tool selection, cutting parameters and selection of measuring tools for inspection • Estimation - Material costs, Labour costs, Overhead Costs, Machining Time & Cost, Total Cost, Selling price & Cost of Scrap • Estimation of production cost for lathe operations • Preventive Maintenance of Lathe - Inspection, Replace/Repairs, Cleaning, Lubrication	
4	2,3	1,2,4, 7	Students shall (as given in Annexure-A) • Prepare the process plan for the given component drawing • Estimate its production cost. • Prepare the model in lathe machine • Document dimensional checks.	
5	2,3	1,2,4	**Milling** • Milling - Introduction, Classification, Up milling & Down milling process • Explain Milling terminologies - Feed, Speed, Depth of cut & Machining time • Demonstrate various parts of milling machine with their functions. • Demonstrate Indexing - Index Head Parts, Methods of Indexing, Direct and Simple Indexing • Milling practice –demonstration on milling model incorporating facing and cutting operations • **Inspection** - Demonstration of Measuring tools , checking & documenting dimensions and surface finish using various measuring tools	
6	2,3	1,2	• Preparation of Process plan for milling - include component drawing,	

			process list, machine used, tool selection, cutting parameters and selection of measuring tools for inspection • Estimation of production cost for milling(cutting/facing) operations • Preventive Maintenance of Milling Machine- Inspection, Replace/Repairs, Cleaning, Lubrication
7	2,3	1,2,4, 7	Students shall (as given in Annexure-B) • Prepare the process plan for the given component drawing • Estimate its production cost. • Prepare the model in milling machine • Document dimensional checks
8	4	1	**CNC Machines** • Introduction, Advantages of CNC machines over conventional machines • Safety standards practiced in CNC machine shop • Illustrate various parts of CNC Turning & Milling machine with their functions. • Axis convention of CNC machines, Machine Zero & Work Zero • Compensation - Tool Length, Nose Radius, Wear & Offset Compensation • Work/Tool setting, Tool Offset, Tool Wear Offset, Modes (JOG/Edit/MDI/Single Block/Auto) in CNC Turning & Milling machine
9	4	1,2,4	**CNC Programming** • CNC Programming sequence & Format, Absolute and Incremental system • G Codes, M codes, Feed, Speed, Depth of cut • Develop CNC turning program and simulate/prepare the model – Illustration and Practice as given in Annexure-C
10	4	1,2,4	• Develop CNC milling program and simulate/prepare the model – Illustration and Practice as given in Annexure-D
11	4	1,2,4	• Canned cycles (CNC Turning Center) - G70, G71, G72, G75, G76 • Develop CNC turning program using canned cycles and simulate/prepare the model – Illustration and Practice
12	4	1,2,4	• Canned Cycles (CNC Milling Center) - G80, G81, G82, G83, G84 • Develop CNC milling program using canned cycles and simulate/prepare the model – Illustration and Practice
13	4	1,2,4	• Mirroring & Subroutines • Develop CNC turning/milling program for mirroring with subroutines and simulate/prepare the model – Illustration and Practice

4. References

Sl. No.	Author	Title of Books	Publication/Year
1.	P.N.Rao	Manufacturing Technology - Vol II	Mc Graw Hill, 2018
2.	Serope Kalpakjian Steven R. Schmid	Manufacturing Engineering and Technology	Pearson, 2021
3.	T.R.Banga S.C.Sharma	Mechanical Estimation and Costing	Khanna Publishers, 2001
4.	M.Adithan	Process Planning and Cost Estimation	New Age International Publishers, 2015
5.	R.Kesavan C.Elanchezhian	Process Planning and Cost Estimation	New Age International Publishers, 2017

	B.Vijaya Ramnath		
6.	P.N.Rao	CAD/CAM Principles and Applications	Mc Graw Hill, 2017
7.	Mikell P. Groover	Automation, Production Systems and Computer Aided Manufacturing	Pearson, 2024
8.	P.Radhakrishnan	Computer Numerical Control, Machines and Computed Aided Manufacture	New Academic Science, 2018

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max Marks	
1.	CIE-1TheoryTest	4	90	50	Average of all CIE=50 Marks
2.	CIE-2Practice Test	7	180	50	
3	CIE-3TheoryTest	10	90	50	
4.	CIE-4Practice Test	13	180	50	
5	CIE-5 Portfolio of all the practices and activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

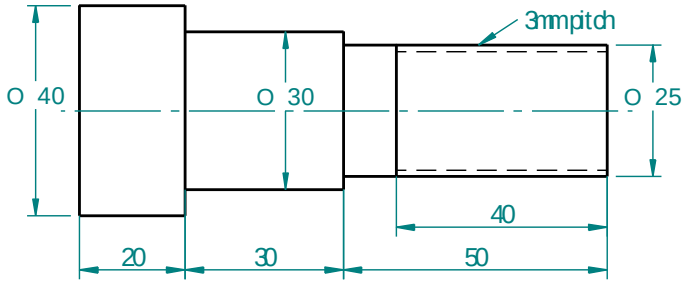
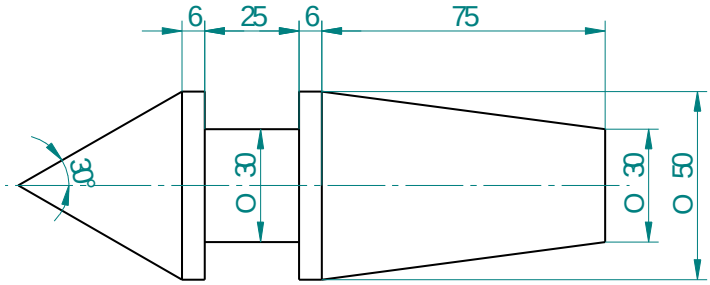
6. SEE – Practice Assessment Methodologies

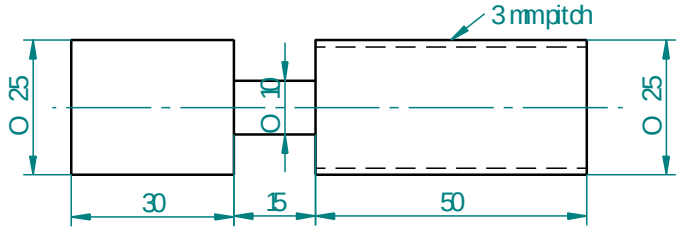
Sl.No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester** -IV	
Course Name	Machine Tool Technology & CNC Programming			**Test**	I/III
Course Code	25ME43I	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a) Select appropriate cutting tool material for machining cast iron work piece. Justify. b) Select appropriate cutting method whether oblique or orthogonal for turning operation and describe the observations made during the operation. c)Discontinuous chips were produced while machining operation, list the probable causes and corrections d) Make use of the sketch to explain the process of creating patterned/grip surface on the cylindrical component. e) Identify the cutting forces produced during i. tapping operation ii. threading operation	Apply Apply Apply Apply Apply	CO1	**5X5 = 25**

2	a) Select appropriate cutting fluid used while machining HSS workpiece. Justify. b) Select appropriate cutting method whether oblique or orthogonal for thread cutting operation and describe the observations made during the operation. c)Identify the chips formed for following cases ○ Brittle material ○ Ductile material ○ Titanium ○ Severe work hardened material ○ Metals with low thermal conductivity d) Make use of the sketch to explain the process of creating tapered surfaces on cylindrical component. e) Make use of the sketch to explain the process of creating helix on cylindrical component for fastening purposes.	Apply Apply Apply Apply Apply	CO1	**5X5 = 25**
	Section - 2			
3	a) Prepare the process planning sheet for the given component drawing. Assume missing data suitably. All dimensions in mm.  b) Estimate the cost of material of component made of C.I shown in figure below, if C.I weight 7.7 gm/cm^3 and material cost is Rs. 60/kg. All dimensions in mm.  	Apply Apply	CO3	**10+15 = 25**
4	a)A product is manufactured on lathe machine, determine the selling price of the product for the following conditions. ○ Material cost = Rs. 700 ○ Labour cost for Cutting and setting up = Rs. 150 ○ Labour cost for turning, threading = Rs. 160 ○ Machining time = 2.5 hours ○ Machining cost for Turning, threading = Rs. 50/hour ○ Cost of tools = Rs. 100 ○ Over head cost = 150% of total labour cost ○ Profit = 20% of selling price b)A rod of 30mm dia. 100mm long is to be machined on a lathe to make component as shown in figure. Calculate the machining cost. Take Cutting speed is 30m/min for turning/knurling and 10m/min for threading, feed as 3mm/rev. for turning/knurling and 1mm/rev. for threading. Depth of cut being 2.5 mm. All dimensions in mm.	Apply Apply	CO3	**10+15 = 25**

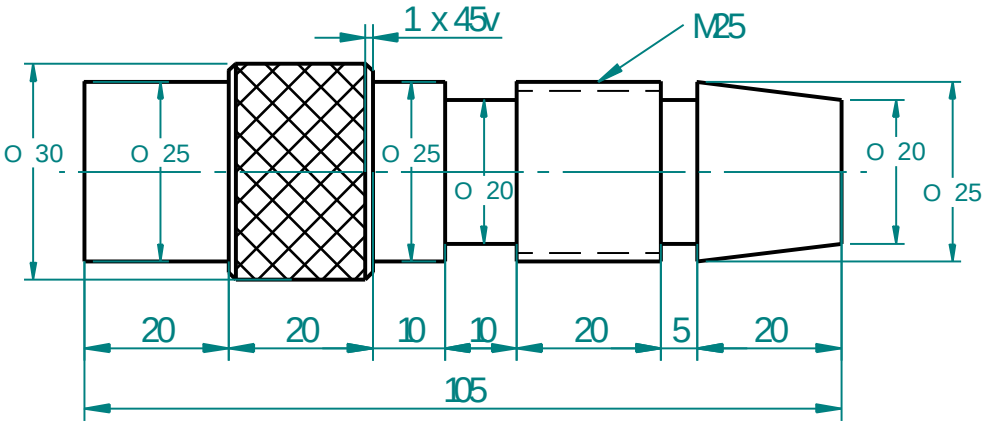
				

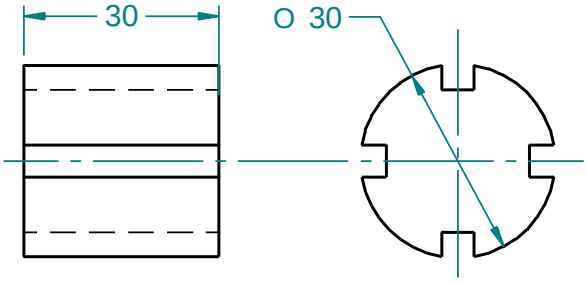
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE-2 Practice Test model question paper

Program	Mechanical Engineering			**Semester**	IV
Course Name	Machine Tool Technology & CNC Programming			**Test**	II
Course Code	20ME43I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					

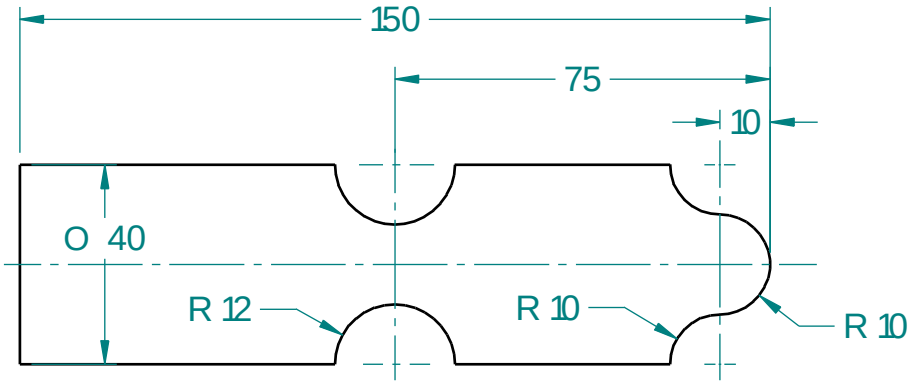
Questions	**CO**	**Marks**
1. Question on Lathe(Turning) Operations with process plan and determination of production cost of the product for given parameters Prepare the given model in lathe machine, with process plan and estimate the cost of production. Raw Material size = Ø32 × 110 *mm*. Material Cost = Rs. 55/kg. Density of raw material = 7.8 gm./cc. Labour Cost = 200% of Material Cost. For turning, cutting speed = 40 m/min., Feed = 0.4 mm/rev., Depth of cut = 2.5 mm/per pass and for Threading, cutting speed = 8 m/min. Machining Cost = Rs. 100/hr. Overhead charges = 20% of Material Cost. Consider missing data suitably.  All dimensions are in mm	CO2, CO3	**50**
OR		
Question on Milling Operations with process plan and determination of production cost of the product for given parameters { Mill Keyways on cylinder surface of Φ30 mm for length 30mm as per given sketch, with process plan and estimate the cost of production. The width and depth of keyway is 5 mm and 4 mm respectively. Raw Material Cost = Rs. 11/piece. Density of raw material = 7.9 gm./cc. Cost of Scrap = Rs. 20/kg. Labour Cost = Rs. 100/hour. For milling, Feed = 30 mm/min., Depth of cut = 1 mm/per cut. Overall setup and indexing time = 15 mins. Machining Cost = Rs. 200/hr. Overhead charges = 25% of Material Cost. Consider suitable missing data.	CO2,CO3	**50**

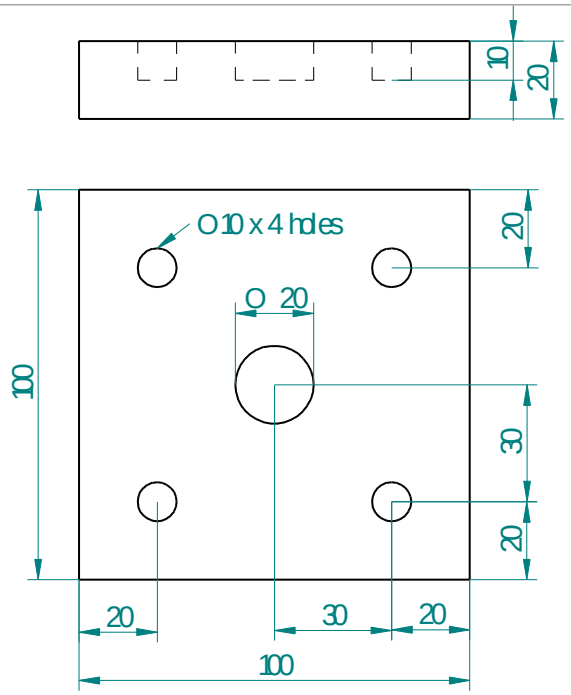
 All Dimensions are in mm}			
Scheme of assessment a. Process planning sheet b. Estimation of Production Cost c. Performing Operations on Machine d. Dimensional accuracy	 = 10 Marks = 10 Marks = 25 Marks = 05 Marks	 **3** **3** **2** **2**	
		Total Marks	**50**

Signature of the Course Coordinator **Signature of the HOD Chairman** **Signature of the IQAC**

8. CIE -4 Practice Test model question paper

Program	Mechanical Engineering			**Semester**	IV
Course Name	Machine Tool Technology & CNC Programming			**Test**	4
Course Code	20ME43I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					

Questions	**CO**	**Marks**
1. Question on writing CNC program for Turning model, Simulation / Preparation of model on CNC Machine {Develop a part program for circular interpolation utilize canned cycles and simulate/prepare. Blank size Φ42 mm x 152 mm.  All dimensions are in mm}	CO4	**50**
2. Question on writing CNC program for Milling model, Simulation / Preparation of model on CNC Machine {Develop CNC Milling part program for drilling using canned cycles and simulate / prepare. Blank size 100mm x 100mm x 20mm. Hole depth 10 mm.		

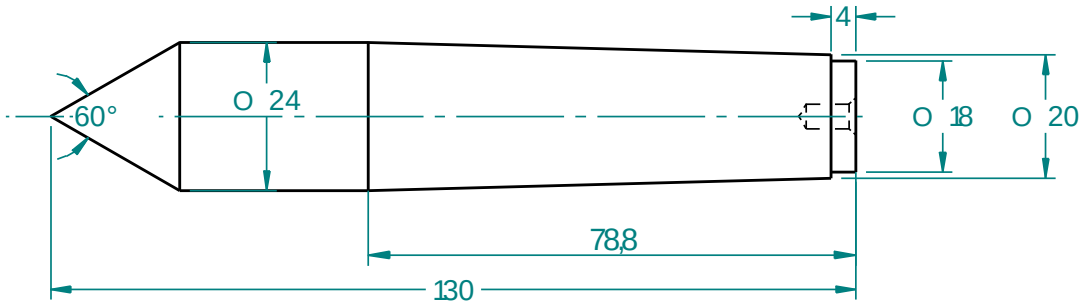


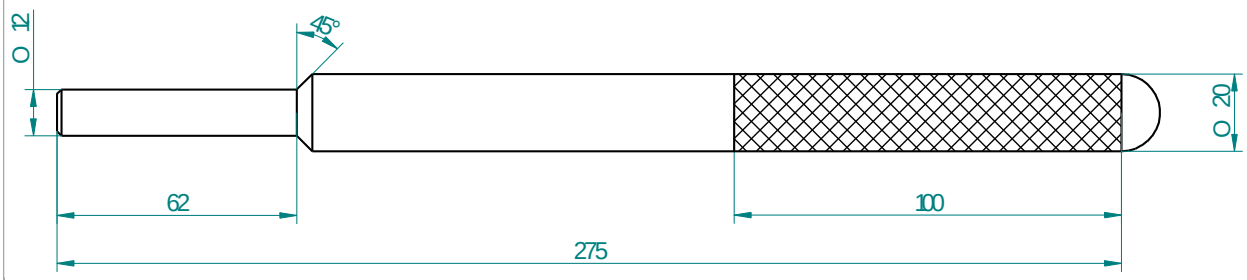
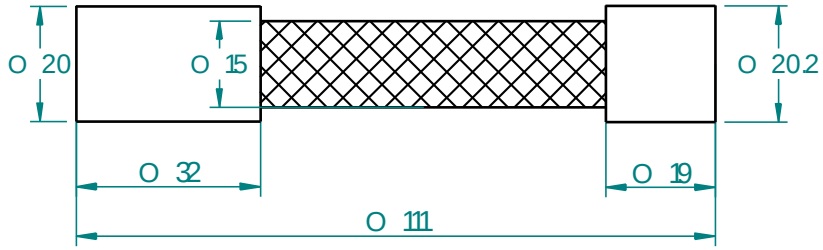
All Dimensions are in mm }

Scheme of assessment a. Writing CNC program for Turning model = 15 Marks b. Writing CNC program for Milling model = 15 Marks c. Simulation/Preparation of model on CNC machine (**Any 1**) = 20 Marks	CO4	
	Total Marks	**50**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
1	Prepare the given lathe dead center in Lathe machine. Flat end has countersink hole of dia. 4mm, depth 8mm and countersink dia. 6mm. Make a survey and collect the required missing data. Also, • Prepare Process Plan • Estimate Cost of Production • Document Dimensional Checks • Prepare the CNC part program • Simulate/Prepare the model in CNC Lathe with different material.  All dimensions are in mm.

2	Prepare the given Tommy Bar of Screw Jack in Lathe machine. Make a survey and collect the required missing data. Also, • Prepare Process Plan • Estimate Cost of Production • Document Dimensional Checks • Prepare the CNC part program (except knurling) • Simulate/Prepare the model in CNC Lathe with different material.  All dimensions are in mm.
3	Prepare the given Plug Gauge in Lathe machine. Make a survey and collect the required missing data. Also, • Prepare Process Plan • Estimate Cost of Production • Document Dimensional Checks • Prepare the CNC part program (except knurling) • Simulate/Prepare the model in CNC Lathe with different material.  All dimensions are in mm.
4	Prepare ¾" Square head pipe plug in lathe and milling machine, along with process plan, estimation of production cost, documentation of dimensional checks, CNC part program. Make a survey and collect the required missing data.
5	Carry out servicing of Lathe/Milling machine. Present and submit its report.
6.	Make a presentation on influence of coolant in CNC by explaining purpose, delivery methods of coolants, types of coolants, properties of coolants, health and safety issues, recycling and disposal of cutting lubricants. Also submit the report.
7.	Prepare M25 Bolt and Nut along with process plan, estimation of production cost, documentation of dimensional checks, CNC part program. Make a survey and collect the required missing data.
8.	Collect Manufacturers Catalog of Lathe/Milling/CNC machine and select the model required for the particular application. Present and submit the report on selection criteria adopted.
9.	Visit nearby Industries/Workshops having special purpose lathe/milling machines. Study its features and applications. Present and submit its report.

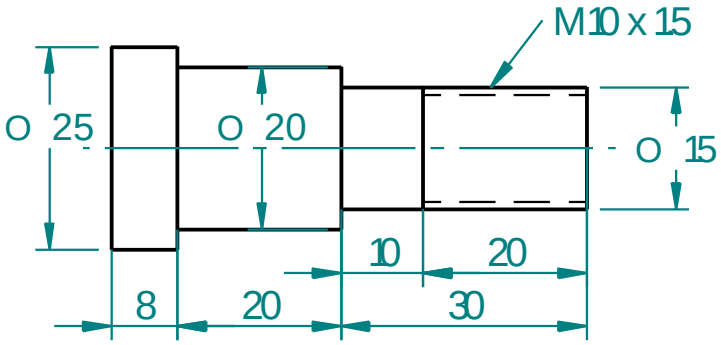
10. Rubrics for Assessment of Activity (Qualitative Assessment)

Sl. No.	Dimension	Needs Improvement	Basic	Competent	Proficient	Excellent	Students Score
		1-10	11-20	21-30	31-40	41-50	
1	Survey and Data Collection	Not collected or analyzed.	Incomplete or poorly organized, with little to no analysis	Adequate but lacks organization or clarity in some areas.	Mostly complete, with a clear structure, though some data may be less organized	Thoroughly collected & organized in a effective manner, with a well-structured analysis.	48
2	Operations / Task Carried	Not carried out properly	Partially carried, leading to some significant errors	Partially carried, but there is noticeable disorganization	Mostly carried correctly, with minor mistakes	Carefully followed, and is executed with high skill and accuracy.	36
3	Impact and Effectiveness of work/task	Fails to make an impact or is ineffective in achieving goals	Minimal impact and fall short of achieving its intended purpose	Moderate impact but could be more effective	Positive impact effectively achieving its purpose	Outstanding impact exceeding expectations	12
4	Presentation and Report submission	Missing critical information, incomplete, or unclear.	Incomplete, poorly organized, or lacks important components.	Includes some key elements but lacks clarity or detail in some areas.	Mostly complete, with minor omissions or organizational issues.	Comprehensive, well-organized, and includes all necessary details.	12
	Average Marks=(48+36+12+12)/4=27						**27**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE- Model Practice Question Paper

Program	**DIPLOMA IN MECHANICAL ENGINEERING**		**Semester**	**IV**
Course Name	**MACHINE TOOL TECHNOLOGY & CNC PROGRAMMING**	**Course Code : 25ME43I**	**Duration**	**180 min**
	Questions		**CO**	**Marks**
1.	Question on Lathe(Turning) Operations with process plan and determination of production cost of the product for given parameters (Minimum of 3 operations including either threading or taper turning) { Prepare the given model in lathe machine, with process plan and estimate the cost of production. Raw Material size = Ø25 × 60 *mm*.Material Cost = Rs. 55/kg. Density of raw material = 7.8 gm./cc. Labour Cost = 200% of Material Cost. For turning, Cutting speed = 40 m/min., Feed = 0.4 mm/rev., Depth of cut = 2.5 mm/per pass and for Threading, cutting speed = 8 m/min. Machining Cost = Rs. 100/hr. Overhead charges = 20% of Material Cost. Consider suitable missing data.		02,03	**30**

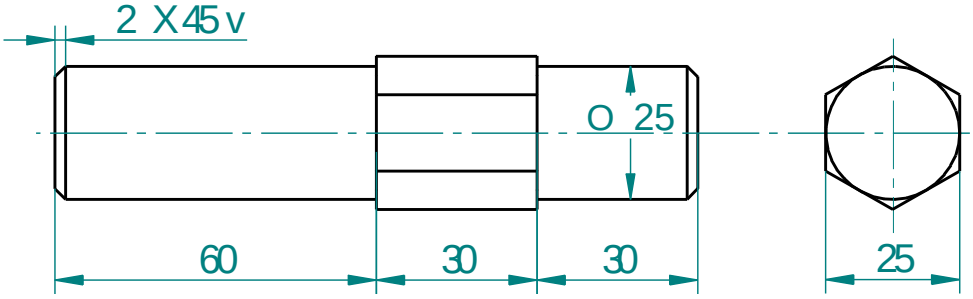


All dimensions are in mm. }

OR

Question on Milling Operations with process plan and determination of production cost of the product for given parameters

{ Mill Hexagon on cylinder surface of Φ30 mm for length 30mm as per given sketch, with process plan and estimate the cost of production. Raw Material Cost = Rs. 80/kg. Density of raw material = 8.0 gm./cc. Cost of Scrap = Rs. 20/kg. Labour Cost = Rs. 70/hour. For milling, Speed = 200 r.p.m., Feed = 0.25 mm/rev. Overall Setup and Indexing time = 21 mins. Machining Cost = Rs. 200/hr. Overhead charges = 20% of Material Cost. Consider suitable missing data.



All dimensions are in mm }

Scheme of assessment		
1. a. Process planning sheet	= 10 Marks	
b. Estimation of Production Cost	= 10 Marks	
c. Performing Operations on Machine	= 25 Marks	
d. Dimensional accuracy	= 05 Marks	
	Total Marks	**50**

2) Signature of the Examiner **2) Signature of the Examiner**

12. Equipment/Consumables/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Quantity
01	Center Lathe with all accessories and attachments (Gear Driven)	Approximate Swing Over bed: 450 mm Swing Over Carriage: 275 mm Admit between Centers: 550 mm Other Features Suitably Selected	30
02	Column and Knee type Vertical Milling machine with all attachments	Approximate Table Size 250 x 850 mm Arbor Diameter - Φ20 - Φ28 mm Other Features Suitably Selected	01
03	CNC Turning Centre (Tutor / Productive)	Approximate Turning Dia.: 100 mm Turning Length: 300 mm	01

		Turret head: 8 Stations Automatic Tool Changer Feature Controller: Fanuc Other Features Suitably Selected	
04	CNC Milling Centre (Tutor / Productive)	Approximate Working Size: 250 x250 mm Working thickness: 50 mm Automatic Tool Changer Feature Controller: Fanuc Other Features Suitably Selected	01
05	CNC Simulation Software	Turning/Milling Environment	30 User
06	HSS Cutting Tool for turning	Square tool 10 to 20 mm Shank length 50 to 165 mm	30
07	Cemented Carbide tippled tools with holder brazed	For Turning operation	30
08	Knurling tool – Rough	2 No. of Knurls -Standard size	15
09	Knurling tool - Smooth	2 No. of Knurls -Standard size	15
10	Threading tool	Standard	15
11	Vernier Calipers	Measuring Range - 0 to 300 mm	30
12	Outer Calipers	Measuring Range - 0 to 50 mm	30
13	Steel Scale	Measuring Range - 0 to 300 mm	20
14	Dial gauge for setting work	Graduation - 0.01 mm, Range - 10 mm	15
15	Counter sunk drill bit	Dia - 6mm, Tapered shank	30
16	Marking divider	Range - 200 mm	30
17	Marking punch	Standard	30
18	Combination set square	Standard	15
19	Surface plate	Size of plate - 400 mm * 400 mm	01
20			
21	Keyway / Slot cutter	Keyway/Slot cutter set Outer Diameter range - 20to200mm Thickness range - 0.5 to 10 mm	01
22	Gear cutter (Spur teeth)	Set of standard sizes	01
23	Concave Milling cutter	Set of Standard sizes	01
24	Convex milling cutter	Set of Standard sizes	01
25	End milling cutter	Set of Standard sizes	01
26	First Aid Kit	Workshop Standard	01

Annexure-A
Suggestive Model Drawings for Practice in lathe

Turning Models (All Dimensions are in mm)

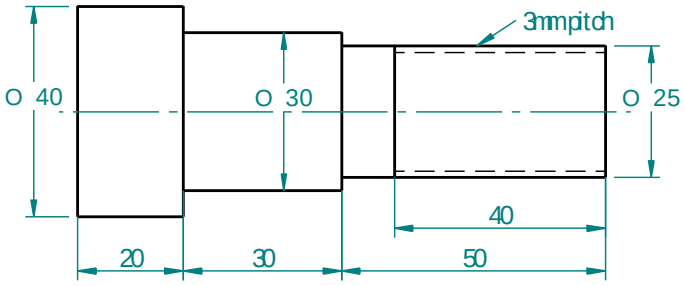


Figure 1

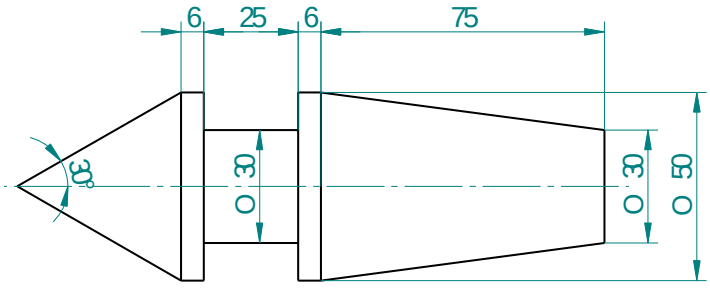


Figure 2

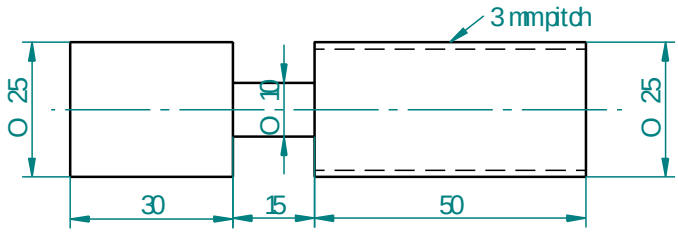


Figure 3

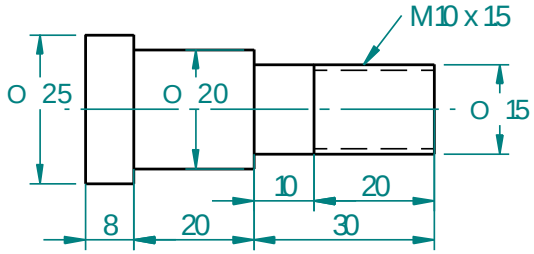


Figure 4

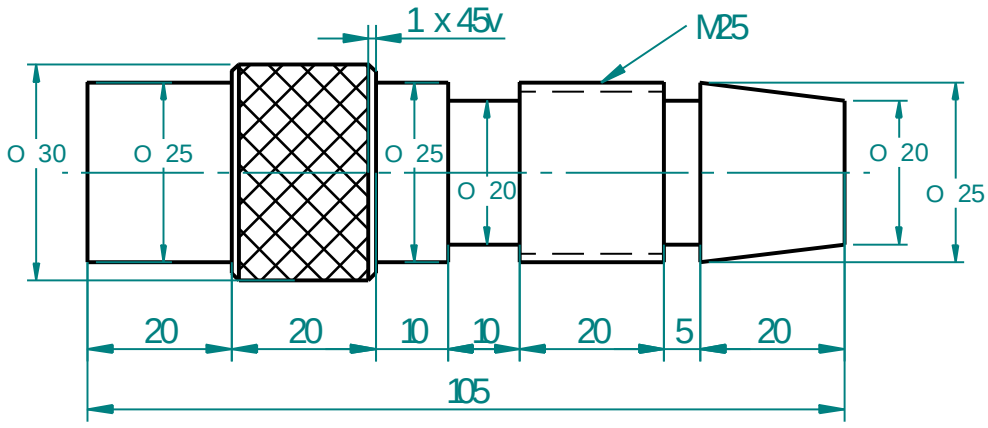
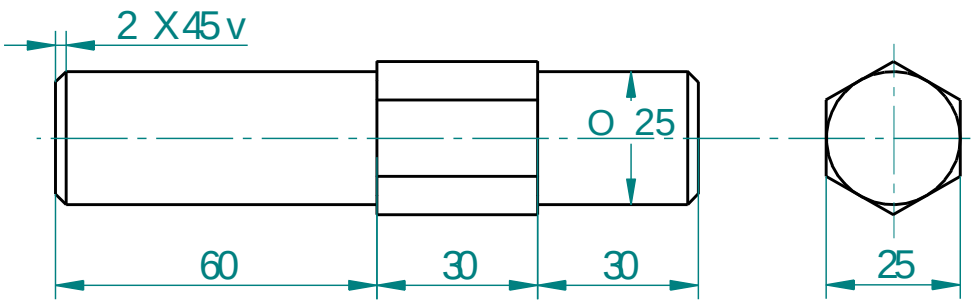


Figure 5

Annexure-B

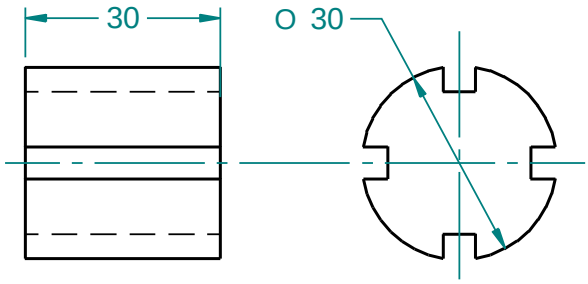
Suggestive Model Drawings for Practice in Milling machine

Hexagon Milling practice - Mill Hexagon on cylinder surface of Φ30 mm for length 30mm



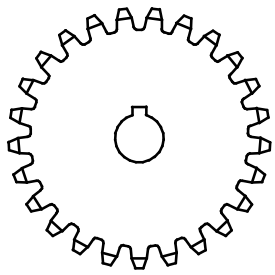
All Dimensions are in mm

Key way cutting practice – Keyway width = 5mm & depth = 4mm



All Dimensions are in mm

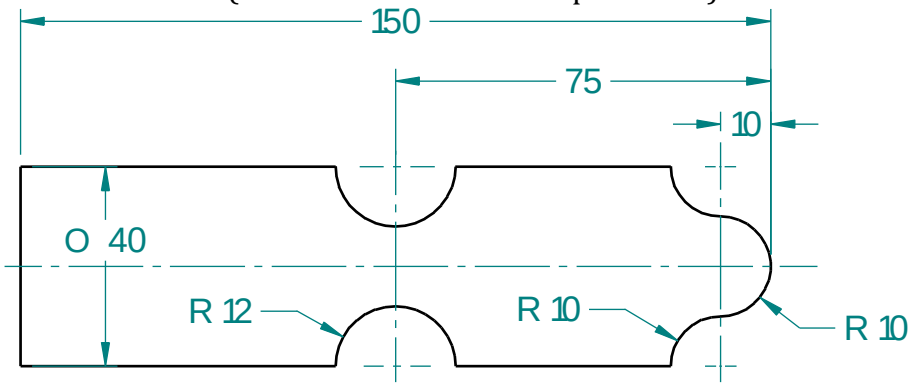
Spur Gear cutting practice - Machine Spur Gear having 25 numbers of teeth and module 1.5 mm/tooth.



Annexure-C

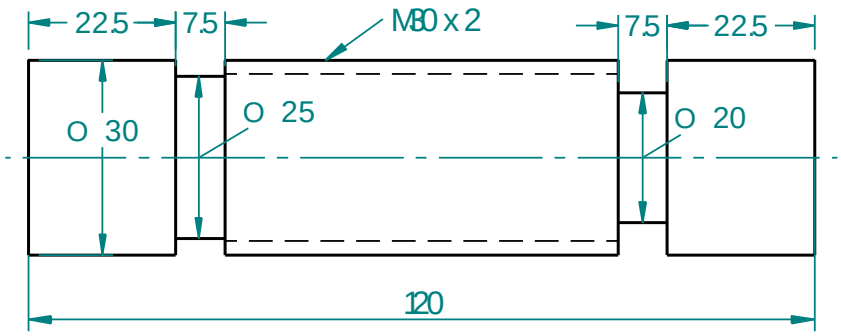
CNC Turning

Develop a part program for circular interpolation utilize canned cycles and simulate/prepare. Blank size Φ42 mm x 152 mm. (Hint use tool radius compensation)



All dimensions are in mm

Develop a part program for thread cutting, grooving and simulate/prepare. Blank size Φ102 x 100 mm.

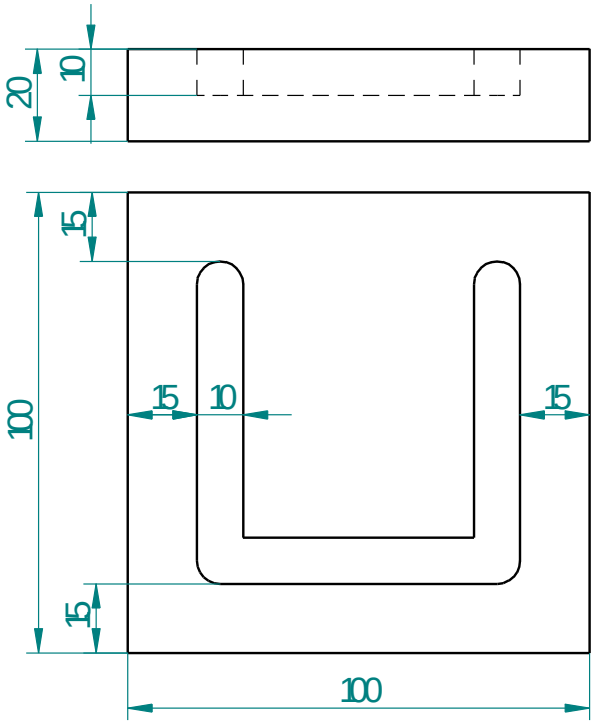


All dimensions are in mm

Annexure-D

CNC Milling

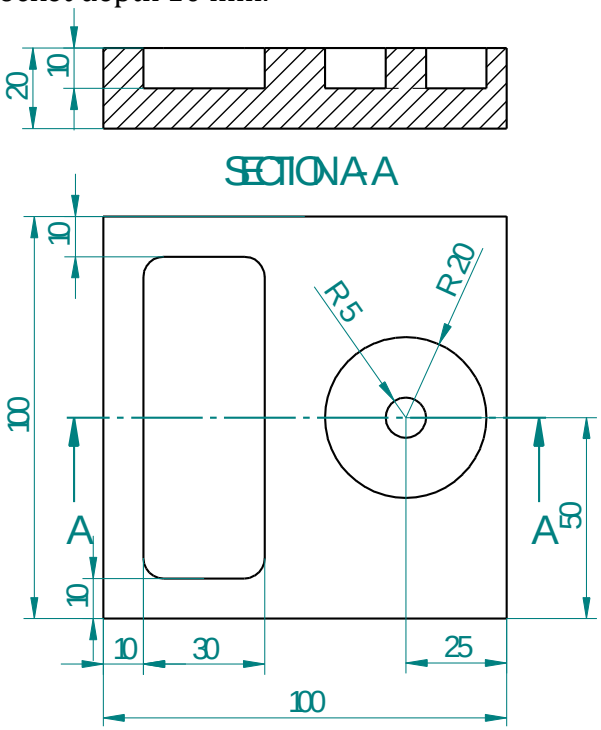
Develop part program to mill the groove and simulate/prepare. Blank size 100mm x 100mm x 20mm. Groove depth 10 mm.



All Dimensions are in mm

Figure 4.1

Develop CNC Milling part program for circular and rectangular pocketing and simulate / prepare. Blank size 100mm x 100mm x 20mm. Pocket depth 10 mm.

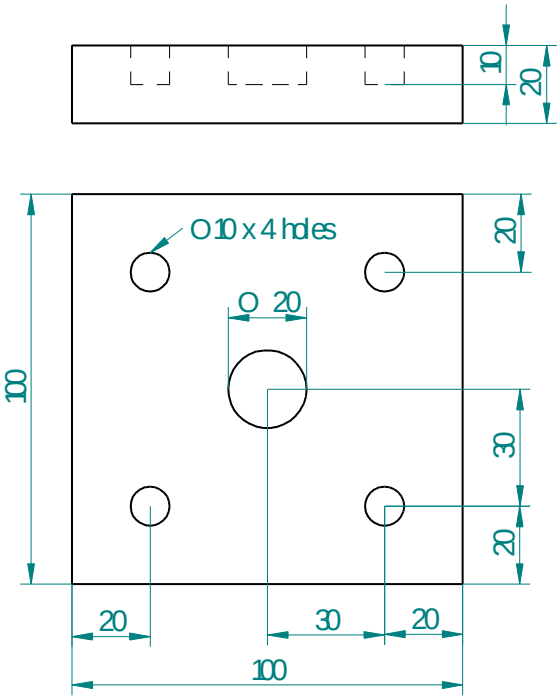


All Dimensions are in mm

Figure 4.2

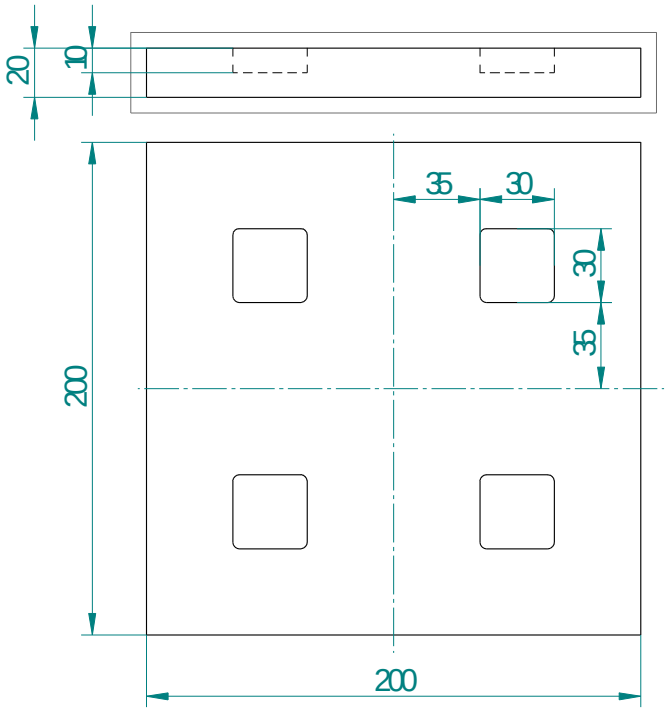
Develop CNC Milling part program for drilling using canned cycles and simulate / prepare. Blank size 100mm x 100mm x 20mm. Hole depth 10 mm.

Develop CNC Milling part program for mirroring with subroutines and simulate / prepare. Blank size 200mm x 200mm x 20mm. Hole depth 10 mm.



All Dimensions are in mm

Figure 4.3



All Dimensions are in mm

Figure 4.4

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	MECHANICAL ENGG	**Semester**	IV
Course Name	Elements of Industrial Automation	**Type of Course**	Integrated
Course Code	25ME44I	**Contact Hours**	91 Hrs/Sem
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale:

In today's manufacturing landscape, industries are rapidly transitioning towards complete automation. Small and medium-sized enterprises are increasingly adopting PLC (Programmable Logic Controller) and Human Machine Interface (HMI) technologies for data acquisition and process control. Industrial automation systems are used to monitor and control processes, machines, or devices in a computerized manner, typically handling repetitive tasks. These systems are designed to function autonomously, reducing the need for human intervention and improving efficiency across the industry. The benefits of this technology include higher production rates, increased productivity, more efficient material usage, better product quality, improved safety, shorter workweeks for labor, and reduced factory lead times. Automation engineers are responsible for designing, programming, simulating, and commissioning automated machinery and plant-wide processes to perform various functions. Depending on the size of the organization, the engineer may take on all or part of these responsibilities. It is essential for diploma engineers to acquire knowledge of both PLC and other automation technologies, as these are the backbone of industrial automation.

This course is designed to introduce the fundamental theoretical and practical concepts of automation technologies, helping students develop the operational competencies needed in this field. As a result, it serves as a foundational course for diploma engineers who wish to specialize in industrial automation.

2. Course Out comes: At the end of the course, the student will be able to:

CO-01	**Select** the appropriate sensor, actuator and hardware components for a given automation application.
CO-02	**Integrate** various hardware components to design and implement an automation system.
CO-03	**Develop** ladder logic program for simple automation applications.
CO-04	**Appreciate** the role of automation technologies in Industry 4.0 and their Industrial applications

3. Course Content

WEEK	CO	PO	Theory	Practice
1	4	1,2,4	**Introduction to Industrial Automation** • History of Industrial Automation (Industry 1.0 to Industry 4.0) • Benefits of Industrial Automation/Need of Automation in Industry • Types of Industrial Automation- fixed, programmable, flexible (*give at least one example for each.)* • Levels/ Hierarchy of Industrial Automation • Standards used in industrial automation (ISO, IEC, JIC) • Basic Components of Automation System with block diagram	Study the following appliances/ automation systems and identify various elements used and their function • Air conditioning System • Washing Machine • Automatic Bottling System • Automatic Packaging System Write the **Block Diagram** for each of the above application by highlighting the importance of sensor/actuator and controller used.
2	1, 2	1,2,4	**Sensors and Transducers** • Classification of Sensors • Analog and Digital Sensors • Performance Terminology of Sensors • IEC standard Symbols for Switches/Sensors ***Ref:*** *https://symbols.radicasoftware.com/230/layout* **Types of Sensors** -Working Principle & Industrial Applications with circuit for each of the following (Refer CIE QP) a. Switches and Push buttons b. Limit Switches c. Proximity Sensors d. Position/Displacement Sensor	Interfacing following **Industrial grade** switches with simple circuits for basic automation tasks • Push Buttons • Toggle Switches • Emergency Stop • Rotary Switches • Key Switch • Limit Switches **Note**: Give an industrial scenario for each of these where specific switches are essential.
3	1, 2	1,2,4	**Types of Sensors** (Refer CIE QP) e. Pressure Switches f. Liquid Level detectors g. Photoelectric Sensors/switches h. Encoders i. Temperature Sensors j. Strain Gauges k. Fluid Flow Measurement l. Smart Sensors m. Speed Sensors	Interfacing following sensors with simple circuits for basic automation tasks without using controller • Float Sensor • Proximity - Inductive, Capacitive and Optical (PNP & NPN) • Pneumatic Reed Switch(magnetic)
4	1,2	1,2,4	**Actuators**	Interfacing following Actuators

			• IEC standard Symbols for Actuators • Working Principle and Applications of Following devices • Solenoid Actuators – Water Solenoid, Pneumatic DCVs • Vacuum generators & Pneumatic Gripper • Relays-SPST, SPDT, DPST and DPDT	with simple circuits for basic automation tasks without using controller • Use Water Solenoids and Float switches to maintain Water Level • Actuate DAC using double solenoid 5/2 DCV (Electro-Pneumatic Circuit) • Run 12VDC Geared Motor forward/ reverse using two relays and Push buttons
5	1,2	1,2,4	**Electric Motors** • DC Motors & DC Servo Motors • Stepper Motor • Synchronous Motors • Servo Motors • Motor Drivers – Stepper Drivers, Servo Drivers, Variable Frequency Drives (VFDs)	Interfacing following Motors with motor Drivers for basic automation tasks without using controller • DC Geared Motors with Driver • Stepper Motor with Driver & Pulse Generator • AC Motors with VFD
6	3	1,2,4	**Programmable Logic Controller(PLC)** • History of PLC • Relay Logic Circuits • Need of PLC for Industrial Automation • PLC Block Diagram • Opto–Isolators • Need of Sink and Source type Wiring • Types of PLC based on outputs • Analog to Digital Converters (ADCs) & Digital to Analog Converter (DACs)	• Demonstrate Relay Logic Circuit • PLC Hardware & Architecture • Memory Organization • Familiarize with PLC - CPU, IO Modules, Power Supply, Communications, IO Devices • Wiring the PLC • Leading PLC manufacturers in global market
7	3	1,2,4	**PLC Programming Fundamentals** • Types of PLC Programming Languages • Ladder Programming • Standard IEC Symbols (Programming) • Basic Ladder Diagram –Rails, Rungs, Branch • NC, NO Contacts and Coil. • Need of Push Button for Industrial Application	Develop a Ladder diagram to switch ON/OFF light using following • AND, OR, NOT, NAND, NOR & XOR Logic. ***Note****: Construct the above logics using NO/NC contacts and Logical Instruction blocks* • To develop a ladder program for "automatic door opening" using optical sensor
8	3	1,2,4	**Programming Concepts** • Latching - Latching and Unlatching Instructions	Develop a ladder diagram for the following logic using Latching Circuit, Latching Instructions,

			• Internal Relays /Memory Bits– Variable Declaration • Interlocks and Trips – Types and Need of Interlocks (Demonstrate using three level alarm system) • Controlling Stepper Motor using PWM Instruction Block	Internal Relays/Bits • Three level Safety Alarm System • Develop a ladder diagram for Automation of two Pneumatics cylinders in sequence • Develop a ladder diagram to forward and Reverse stepper motor using Driver: Use PWM instruction block in Ladder Programming
9	3	1,2,4	**Programming Concepts** • Timer - TON, TOFF • Timer - Sequencing, Cascading • Counters – CTD, CTU, CTUD • Math Instructions- *,+,-,/, MOD, Neg etc. Subtract the current liquid level from the tank capacity to calculate available space- use level gauge. • Compare Instruction- <,>, <=,>=, =,<> etc. Compare the temperature of a process with a set point to control an output- use LM35 temperature sensor.	Develop PLC ladder diagram and interface the following Logics • Two tanks supplying liquids simultaneously to mixer based on requirement using timer instruction block • For counting the number of items moving on a conveyor belt • Car Parking Barrier using Up-Down Counter(CTUD)
10	3	1,2,4	**Programming Concept- Reading Analog inputs** • Instruction Blocks: Conversion of any variable to bool, int, real etc. • SCALER Instruction Block	• Develop a ladder diagram to measure the water level using Level Gauge (Analog Input): Use “Any to Real” and “SCALAR” instruction blocks • Lift for three floor • Traffic Light Programming
11	3	1,2,4	**PLC Pneumatics/ Hydraulics** • Importance of PLC Pneumatics/Hydraulics • Sensors & Actuators used in Pneumatic/ Hydraulics circuits • Functions and features of pneumatic drives- Guided cylinders, rod less linear drives and rotary drives. • Vacuum Generator and Gripper • Industrial Application of PLC pneumatics.	• Develop ladder diagram and operate pneumatic actuation for the following logics a. *Cylinder Sequencing Circuit using Reed Switches* b. *Clamp/unclamp* based on optical sensor input. • The develop PLC ladder diagram and interface hardware components to pneumatic gripper to pick up objects from a conveyor belt and place them in specific bins.
12	4	1,2,4	**Advanced Industrial Automation& Control Systems** • SCADA: Features, Typical SCADA Systems- Petroleum Refining, Water Purification, Chemical Plant.	**Case studies -** Visit any one of the following industries and prepare a concise report on their operations: • Milk Packing Unit • Paint Industry

			• HMI: Human-Machine Interface, Sample HMI Screens • PAC: Programmable Automation Controller- Benefits over PLC • RTU: Remote Terminal Unit • DCS: Distributed Control System	• Food Packing Industries • Drinking Water Bottling Unit **Note**: Collect information about SCADA, HMI, DCS, PAC, RTU or any other automation system used in the Industry. **Ref.**www.industrialautomation.us/case-studies/ as on 02/10/2024
13	4	1,2,4	**Technologies driving Industry 4.0** • IIoT, Cyber Security • Artificial Intelligence, Machine Learning • Big Data, Augmented Reality • Digital Twin, Block Chain	Demonstrate following IoT application using Arduino/ Raspberry-Pi board • Arduino IoT Program for Controlling an LED • Arduino IoT Program for Reading Temperature and Humidity using DHT11/DHT22 Sensor

4. References:

Sl. No.	Author	Title of Books	Publication/ Year
1	Mikell P. Groover	Automation, Production Systems and Computer - Integrated Manufacturing	4thEdition, Pearson Education, 2016
2	W. Bolton	Programmable logic Controllers	6th Edition, Newnes Publisher, 2015
3	Jacob Fraden	Hand book of Modern Sensors, Physics, Designs and Applications	4th ed. Springer-Verlag New York Inc., 2014
4	Austin Hughes And Bill Drury	Electric Motors and Drives	4thEdition, Newnes Publisher, 2013
5	Hugh Jack	Automating Manufacturing Systems with PLC	Publisher: Lulu, 2009
6	Shimon Y. N	Springer Handbook of Automation	Springer 2009
7	A_Boyer	SCADA: Supervisory Control and Data Acquisition	4thEd, International Society of Automation, 2016
8	Rajesh Mehra&Vikrant Vij	PLCs & SCADA - Theory and Practice	1stEd, Laxmi Publications Private Limited, 2019
9	Samuel Greengard	The Internet of things	The MIT Press, 2015
10	Web Link : www.industrialautomation.us/case-studies/ as on 02/10/2024		

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1TheoryTest	4	90	50	Average of all CIE=50 Marks
2.	CIE-2Practice Test	7	180	50	

3	CIE-3TheoryTest	10	90	50	
4.	CIE-4Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all the Practical Exercises and activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test Model Question Paper

Program	Mechanical Engineering			**Semester -** IV	
Course Name	Elements of Industrial Automation			**Test**	I/III
Course Code	25ME44I	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Describe how decisions are made at various levels of industrial automation. Give an example of how field-level systems and management-level systems work together to improve production efficiency.	Apply	CO4	5
	b. In an automatic beverage bottle-filling system, explain the functions of different sensors, actuators, and controllers employed, along with a block diagram.	Apply	CO4	5
	c. Discuss the advantages and disadvantages of fixed automation versus flexible automation in a manufacturing setting. Provide an example of a scenario where each type would be most beneficial.	Apply	CO4	5
	d. Discuss the role of limit switches in automated machinery. Identify a specific application where limit switches are critical and explain how they contribute to the overall functionality of the system.	Apply	CO1	5
	e. Give an industrial scenario for each of the following switches where specific switches are essential) Push Buttons ii) Key Switch	Apply	CO1	5
2	a. Describe how industrial automation improves quality control in the manufacturing process. Provide a case where automation has been successfully applied to reduce defects.	Apply	CO4	5
	b. In a simple automatic food packaging system, explain the functions of different sensors, actuators, and controllers employed, along with a block diagram.	Apply	CO4	5
	c. Discuss the benefits and drawbacks of fixed and programmable automation in manufacturing processes. Provide an example for each type that illustrates when it would be most advantageous to use.	Apply	CO4	5
	d. Discuss the importance of position or displacement sensors in an industrial automation setup. Provide a practical	Apply	CO1	5

	example where these sensors significantly impact the performance of a manufacturing process.			
	e. Give an industrial scenario for each of the following switches where specific switches are essential) Toggle Switch ii) Emergency Stop	Apply	CO1	5
Section –2				
3	a. In a hydraulic system, explain how a pressure switch can be used to monitor pressure levels. Design a simple circuit that activates an alarm if the pressure exceeds a specified threshold.	Apply	CO1	5
	b. In a water tank system, how can liquid level detectors be employed to maintain optimal water levels? Create a simple circuit that controls a pump to fill the tank when the water level is low and turns it off when the level is adequate.	Apply	CO1	5
	c. In a packaging line, describe the application of photoelectric sensors for detecting the presence of products. Design a circuit that triggers a conveyor belt when a product is detected, considering the need for timely operation.	Apply	CO1	5
	d. In a food processing plant, explain the role of temperature sensors in ensuring product safety. Design a circuit that activates a cooling system when temperatures exceed a certain level, considering the requirement for rapid response.	Apply	CO1	5
	e. In a sewage treatment plant, how can float sensors be implemented to manage waste levels? Create a simple circuit that activates a pump to remove waste when a certain level is detected, considering space and environmental constraints	Apply	CO1	5
4	a. In an automated assembly line, how can proximity sensors be used to detect the presence of parts? Create a circuit that triggers an action (e.g., starting a machine) when a part is detected, considering the need for quick cycle times.	Apply	CO1	5
	b. In an automated material handling system, how can proximity sensors improve safety? Design a circuit that stops machinery if a person is detected within a hazardous area, ensuring worker safety.	Apply	CO1	5
	c. In a conveyor belt system, explain how limit switches can prevent jamming. Create a circuit that stops the conveyor when a limit switch is triggered due to a blockage, focusing on operational continuity.	Apply	CO1	5
	d. In a water distribution system, how can fluid flow measurement ensure system integrity? Design a circuit that alerts operators when flow rates are outside acceptable limits, considering the need for real-time monitoring.	Apply	CO1	5
	e. In a refrigeration unit, describe the role of temperature sensors in maintaining optimal conditions. Design a circuit that turns on the compressor when the temperature rises above a set point	Apply	CO1	5

***Note for the Course coordinator**: Each question may have two or three or four or five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	**IV**
Course Name	Elements of Industrial Automation			**Test**	**II**
Course Code	25ME44I	**Duration**	**180 min**	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					

	Questions	**CO**	**Marks**
Section-I			
1.	a. Design a circuit using push buttons (Start/Stop) to control the operation of a conveyor belt. Use relays to handle the load without using a controller. b. Design a basic automation circuit using an inductive proximity sensor to detect metal objects. c. Create a circuit using a float sensor to control the water level in a tank. Use a water solenoid valve to automatically fill the tank when the level drops below a set point. d. Design a basic emergency stop switch circuit that shuts down a press machine upon pressing the button. e. Design a simple circuit using a float switch and a relay to automatically control the pump.	CO1, CO2	**25**
Section-II			
2.	a. Design a pneumatic circuit to automatically reverse a double-acting cylinder (DAC) using a magnetic reed switch, push button, 5/2 double solenoid valve, and other essential pneumatic components. b. Design a circuit using a VFD (Variable Frequency Drive) to control the speed of an AC motor driving the conveyor belt. c. Design a circuit that controls a stepper motor using a pulse generator for accurate positioning of items on a conveyor. d. Design a circuit using two relays and push buttons to control the forward and reverse operation of a DC motor. e. Develop a relay-based control circuit for a conveyor belt system that starts and stops based on input from a proximity sensor (Inductive). Include an emergency stop button to ensure safety during operation, simulating a scenario where metal objects are detected on the conveyor.	CO1, CO2	**25**

Scheme of Assessment for Section I & II	**CO**	
a. Select the appropriate sensor, actuator and other hardware components for a given automation application. ***Note**: Includes Aim of the practical, List of Components Required*	CO1	10x2
b. Integrate various hardware components to design and implement automation circuits. ***Note**: Includes Explanation, Procedure writing, Circuit diagram using IEC standard Symbols, Execution and Inference/Result writing*	CO2	15x2
Total Marks		**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Visit a nearby washing machine, refrigerator, or air conditioning repair shop. Observe and study the system's various components. Record a video showing the operation and components, and upload it to Google Classroom or any other platform as directed by the course coordinator. Additionally, prepare a handwritten report (maximum 200 words) that includes a block diagram of the system, illustrating how the components are interconnected, with a focus on sensors, actuators, and controllers.
02	Create a ladder logic program to automate a "Water Level Controller" using Open PLC software. Implement the program on an Arduino board and interface it with the necessary hardware components to demonstrate its operation. *Reference: Open PLC Project Guide*
03	Develop a simple relay circuit to switch ON/OFF an LED using Tinker CAD online simulation software. *Reference: TinkerCAD*
04	Design a ladder diagram to measure room temperature using an LM35 temperature sensor and demonstrate the interfacing process.
05	Prepare a PowerPoint presentation on a proximity sensor manufactured by a selected company. The presentation should include at least 10 slides. *Note: The course coordinator may assign each student a specific company and sensor type.*
06	Visit one of the following industries: Milk Packing Unit, Paint Industry, Food Packing Industry, or Drinking Water Bottling Unit. Prepare a concise report detailing the automation systems used, including SCADA, HMI, DCS, PAC, RTU, or any other system. **Note**: Collect information about SCADA, HMI, DCS, PAC and RTU or any other automation system used in the Industry. Reference.www.industrialautomation.us/case-studies/ as on 02/10/2024

10. Rubrics for Assessment of Practical exercises and Activity (Qualitative Assessment)

Sl. No	Dimension	Unsatisfactory	Satisfactory	Good	Very Good	Excellent	Student's Score
		1-10	11-20	21-30	31-40	41-50	
1	Understanding of Components/ Systems	Limited understanding of system components and their functions	Basic understanding with some key details missing	Clear understanding with proper explanation of components	In-depth understanding with ability to explain component relationships	Comprehensive understanding with deep insights into system operation	20
2	Technical Skills/ Implementation	Struggles with basic implementation of tasks	Able to implement tasks with some assistance or errors	Can complete tasks independently with minor errors	Completes tasks accurately with minimal assistance	Demonstrates advanced technical skills with flawless execution	30
3	Report/ Presentation Quality	Report/presentation lacks clarity and detail	Provides basic information, but lacks depth or organization	Well-organized report/presentation with clear details	Clear, concise, and in-depth with appropriate diagrams	Highly professional presentation with comprehensive details and	30

						critical insights	
4	Creativity and Problem Solving	Limited creativity or problem-solving in the approach	Shows some creativity but limited problem-solving skills	Demonstrates a creative approach with good problem-solving	Highly creative approach with strong problem-solving abilities	Exceptional creativity and innovative problem-solving, with original insights	40
	Average Marks=(20+30+30+40)/4=30						**30**

Note: *Dimension and Descriptor shall be defined by the respective course coordinator as per the activities*

11. SEE- Model Practice Question Paper

Program	Diploma in Mechanical Engineering		**Semester**	**IV**
Course Name	Elements of Industrial Automation	**Course Code:** 25ME44I	**Duration**	**180 min**

Note*: Answer any one question*

Questions	**CO**	**Marks**
Note*: During the SEE, All questions will be distributed among the group. Each student will be assigned one of the following questions by the examiner, without offering any choice.*	**1,2**	**50**
1. For an automatic door system using an optical sensor, select the appropriate sensor, actuator, and other necessary hardware components. Develop a ladder program that controls the door's opening and closing.		
2. Design a pneumatic system that automates the sequencing of two cylinders. Identify the suitable sensors and actuators for this application and integrate them into a functional system. Write a ladder program for cylinder sequencing.		
3. For a three-level safety alarm system, select the appropriate sensors and internal relays to trigger alarms based on certain conditions. Develop a ladder program using latching instructions.		
4. Select and interface the required components for a water level monitoring system using an analog level gauge. Write a ladder program using "Any to Real" and "SCALAR" instruction blocks to measure and display the water level.		
5. For a mixer system where two tanks supply liquids simultaneously, select the proper sensors, actuators, and timers to control the flow. Develop a ladder program using timers for this automation.		
6. Design an automation system for controlling a conveyor belt. Choose the appropriate hardware to count items moving on the belt and then develop a ladder program to manage the counting.		
7. For a lift system that operates between three floors, identify the necessary sensors, actuators, and other hardware. Develop a ladder program to control the lift's movement, including the detection of floor levels.		
8. Select the sensors and actuators for controlling a traffic light system at an intersection. Integrate the components and write a ladder program to manage the light sequencing based on a timer.		
9. For a car parking barrier system, identify the necessary sensors, actuators, and timer instruction blocks. Develop a ladder program to automate the opening and closing of the barrier.		
10. Develop an automation system for a pneumatic gripper that picks objects from a conveyor belt and places them in bins. Select and integrate the appropriate sensors, actuators, and		

hardware, then write a ladder program for the gripper's operation.		
Scheme of Assessment		
a. Select the appropriate sensor, actuator and other hardware components for a given automation application. ***Note:*** *Includes Aim of the practical, List of Components Required*	CO1	5
b. Integrate different hardware components with a Programmable Logic Controller (PLC) for a specified automation system. ***Note:*** *Includes Explanation, Procedure writing and Circuit diagram using IEC standard Symbols in addition to PLC integration with input and output components.*	CO2	15
c. Develop ladder program for given automation applications, download and automating the system ***Note:*** *Includes ladder programming and result writing in addition to automating the given problem.*	CO3	30
Total Marks		**50**

1) Signature of the Examiner **2) Signature of the Examiner**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Qty.
01	Computers	Latest Configuration	10
02	Programmable Logic Controller (PLC)	Minimum 12, 24V DC Inputs, 4 configurable analog input with thermistor voltage reference out, 7 24V DC Source Output, 1 Analog Output, Embedded Ethernet Port and RS-232/485 non-isolated Serial port, Embedded RTC, MicroSD Card support and minimum 2 Plug-In slots.	10
03	24 VDC Power Supply	24 V, 10A DIN Rail Mountable	10
04	12 VDC Power Supply	12 V, 5 A, DIN Rail Mountable	10
05	Push Button	Push Button Industrial Grade with NO and NC Elements- 22 mm diameter	50
06	Key Switch	Key Switch with NO and NC Elements - 22 mm diameter	5
07	Rotary Switch	2/3 Position Rotary Switches with NO Elements - 22 mm diameter	15 Each
08	Emergency Stop	Industrial Grade Mushroom Types switch with NC element -22 mm diameter	10
09	Toggle Switch	2/3 Position Toggle Switch	5 Each
10	Float Sensor	Float Sensor for Water Level detection	10
11	Buzzer	24VDC, 22mm	04
12	Level Gauge	Analog Water Level Gauge (minimum 30 cm Height)	02
13	Limit Switches	Industrial Grade Roller Type/lever operated Limit Switch (NO/NC)	10
14	Proximity Sensors (PNP Only)	Inductive, Capacitive and Optical Proximity Sensors (Available Size M8/M12/M18/M30 diameter)	20 Each

15	Pneumatic Reed Switch	Pneumatic Magnetic Reed Switch NO/NC, Used in Pneumatic Cylinder	10
15	Water Solenoids	24 VDC water Solenoid	10
16	Geared Motor	DC Geared Motor	10
17	Pneumatic Cylinder	20 mm bore 100/150 mm stroke	6
18	Twin Cylinder	Dual rod cylinder with guide function for pick & place applications, 10/12 mm rod diameter, 125 mm stroke length	2
19	Direction Control Valve (DCV)	5/2 Single Solenoid DCV	2
20	Direction Control Valve(DCV)	5/2 Double Solenoid DCV	2
21	Direction Control Valve(DCV)	3/2 single Solenoid DCV	2
22	Pneumatic vacuum Generator	0.5 to 10 BAR	2
23	Vacuum Suction Cup Gripper	Round, oval, and bellow shaped	2
24	Stepper Motor	NEMA 23 Stepper motor 10kg/cm, 4 wired	4
25	Stepper Driver	TB6600 Stepper Motor Driver Controller 4A 9~42V TTL 16 Micro-Step	4
26	Pulse Generator	Stepper Motor Driver Controller 8A Dual Mode Function Signal Generator, 1Hz-150KHz PWM Motor Speed Regulation/LCD Pulse Frequency Cycle Module Adjustable Driver Module Signal Generator	2
27	AC Motor	3 Phase AC Motors	1
28	Variable Frequency Drive(VFD)	AC drive which offer a power rating of 0.4...22 kW (0.5...30 Hp) with global voltage classes of 100...600V, provide a variety of motor control and flexible mounting options.	1
29	Lift Model	The trainer must be a miniature model of a three/four-layer elevator, fully replicating real elevator functions with easy PLC interfacing. It provides hands-on training in PLC programming, sensor integration, position control, and sequential logic control for elevator automation systems.	1
30	Conveyor Model	The trainer should feature a DC geared motor-operated flat belt conveyor, 3.5-inch width and minimum 2 feet length, easily interfaced with PLC. It provides hands-on training in PLC programming, motor control, and automation processes, simulating real-world conveyor operations.	1
31	Car Parking Barrier	The trainer should be a miniature model of a car parking barrier system with functional entry and exit arms, similar to those at toll plazas, easily interfaced with PLC. It should also include car full indicators that activate when parking capacity is reached.	1
32	Automatic Door Open Close System	The trainer should be a miniature model of an Automatic Door Open-Close System powered by a DC-geared motor, incorporating optical sensors and limit switches for accurate motion detection and control. The model should be easily interfaced with a PLC, providing hands-on training in motor control, sensor integration, and sequential logic operations.	1
33	Mixer Model	The trainer should be a miniature model of an industrial Mixer System with water solenoids for precise control in each jar. It should feature PLC-interfaced controls for automatic or manual operation of the mixing cycles.	1

V-VI SEMESTER

Government of Karnataka
DEPARTMENT OFTECHNICAL EDUCATION

Curriculum Structure

V Semester Scheme of Studies – Mechanical Engineering

	Teaching Department	Course Code	Course Name	Hours per week			Total Contact Hours/week	Credits	CIE Marks		Theory SEE Marks		Practice SEE Marks		Total Marks
				L	T	P			Max	Min	Max	Min	Max	Min	
Integrated Courses															
1	ME	SP-1	Specialization Pathway-I	4	0	4	8	6	50	20	50	20	-	-	100
2	ME	SP-2	Specialization Pathway-II	3	0	4	7	5	50	20	-	-	50	20	100
3	ME	SP-3	Specialization Pathway-III	3	0	4	7	5	50	20	-	-	50	20	100
4	ME	25ME54I	Project Management and Entrepreneurship	4	0	4	8	6	50	20	50	20	-	-	100
Total				**14**	**0**	**16**	**30**	**22**	**225**		**100**	**-**	**100**	**-**	**400**

SP	Course Code	Course Name	SP	Course Code	Course Name	SP	Course Code	Course Name
SP-1	25ME51IA	Industry 4.0	SP-2	25ME52IA	PLC, HMI and SCADA	SP-3	25ME53IA	Industrial Internet of Things
	25ME51IB	Advanced Manufacturing		25ME52IB	Computer Aided Manufacturing		25ME53IB	Artificial Intelligence and Machine Learning
	25ME51IC	Power Plant Engineering		25ME52IC	Refrigeration and Air Conditioning		25ME53IC	Heating Ventilation and Air Conditioning
	25ME51ID	Product Design		25ME52ID	Design For Manufacturing & Assembly		25ME53ID	Finite Element Analysis
	25ME51IE	Automobile Engineering		25ME52IE	Electric Vehicle Technology		25ME53IE	Drone Technology

Government of Karnataka
DEPARTMENT OFTECHNICAL EDUCATION

Curriculum Structure

VI Semester Scheme of Studies – Mechanical Engineering

Sl. No.	Department	Course Code	Course Name	Hours per week	No. of Weeks	Credits	CIE Marks		Practice SEE Marks		Total Marks
							Max	Min	Max	Min	
1	ME	25ME61I	Internship/Capstone Project	40	13	13	50	20	50	20	100
Total				**40**	**13**	**13**	**50**	**20**	**50**	**20**	**100**

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Industry 4.0	**Type of Course**	Integrated
Course Code	25ME51IA	**Contact Hours**	104 Hrs./Sem. 8Hrs/Week
Teaching Scheme	L: T:P: 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. **Rationale:** Industry 4.0 represents the fourth industrial revolution, characterized by the integration of advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), robotics, and big data analytics into manufacturing and industrial processes. This course aims to equip students with the knowledge and skills necessary to understand and implement Industry 4.0 technologies in mechanical engineering and manufacturing contexts. By exploring the evolution, core technologies, and applications of Industry 4.0, students will gain insights into how these innovations can enhance productivity, efficiency, and sustainability in modern industries. The course also emphasizes hands-on learning through practical projects, enabling students to apply theoretical concepts to real-world scenarios. Ultimately, this course prepares students to be industry-ready professionals capable of driving digital transformation in manufacturing and related sectors.

2. **Course Outcomes:** At the end of the Course, the student will be able to:

CO-01	**Appreciate** the importance of Industry 4.0 technologies such as IoT, AI, and robotics in design and optimizing of smart manufacturing systems.
CO-02	**Apply** predictive maintenance strategies using machine learning and data analytics to enhance equipment reliability and reduce downtime.
CO-03	**Develop** and **simulate** smart factory layouts using software tools to improve production efficiency and resource utilization.
CO-04	**Design** and **execute** IoT-based projects for real-time monitoring and control of industrial processes.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,3,4	**Introduction** • Evolution of Industry 4.0. • Historical context: From Industry 1.0 to Industry 4.0. • Key drivers and benefits of Industry 4.0. • Applications in mechanical engineering and manufacturing.	• Case studies on implementation of Industry 4.0 to increase Vehicle production Audi, Mercedes etc. • Prepare a short report on how Industry 4.0 can transform traditional manufacturing. *(Refer Annexure- Exercise No.1)*
2	1,3	1,2,3,4	**Core Technologies of Industry 4.0** • Internet of Things (IoT) • Artificial Intelligence (AI) and Machine Learning (ML) • Big Data and Analytics • Cyber Physical Systems (CPS) • Robotics and Automation • Additive Manufacturing.	• Simulate a smart factory layout using software (e.g., Factory I/O or Siemens TIA Portal). • Design a basic layout for a smart factory. *(*Refer *Annexure- Exercise No.2)*
3	3	1,2,3,4	**Smart Factories** • Concept of smart factories. • Comparison between traditional factories and Industry 4.0 factories. • Key components: IoT enabled machines, digital twins, and real time monitoring.	• Build a simple IoT project using an ESP-8266/ESP32 to monitor and control a device (LED or motor). *(Refer Annexure- Exercise No.3)*
4	2,4	2,4,6	**Role of IoT in Industry 4.0.** • **IoT Architecture:** Sensors, connectivity, cloud, and analytics. • Applications in predictive maintenance and asset tracking	• Build a simple IoT project using an ESP-8266/ESP32 to monitor and control a device (Temperature and Moisture) (*Refer* Annexure-*Exercise No.4*)
5	1	1,2,3,4	**Role of robotics in Industry 4.0.** • Types of industrial robots: Articulated, SCARA, Delta, and others. • Robot Configurations • Robotic Drives	• Program a small robotic arm to perform a simple task (pick and place). *(Refer Annexure- Exercise No.5)*
6	1	1,2,3,4	• End effectors & Tooling • Applications in assembly • Welding • Material handling.	• Program a small robotic arm to perform a simple task (Welding). *(Refer Annexure- Exercise No.6)*
7	1	1,2,3,4	**Additive Manufacturing** • Introduction to additive manufacturing. • Types of 3D printing technologies: FDM, SLA, SLS. • Applications in prototyping, tooling, and production.	• 3D print a simple mechanical component using an FDM printer. • Design and submit a 3D model of a mechanical part. *(Refer Annexure-Exercise No.7)*

8	1	1,2,3,4	**Big Data and Analytics** • Role of big data in Industry 4.0. • Data collection, storage, and analysis. • Applications in quality control and process optimization.	• Analyze a dataset using Python (Pandas, Matplotlib) to identify trends. *(Refer Annexure- Exercise No.8)*
9	2	1,2,3,4	**Artificial Intelligence and Machine Learning:** • Basics of AI and ML. • Applications in predictive maintenance, quality inspection, and supply chain optimization. • Case studies of AI in manufacturing.	• Train a simple ML model using Python (Scikit learn) to predict equipment failure. • Prepare and present simple AI application in mechanical engineering. *(Refer Annexure- Exercise No.9)*
10	2	2,3,4	**Cyber-security in Industry 4.0** • Importance of cyber-security in smart factories. • Common threats and vulnerabilities. • Best practices for securing industrial systems.	• Write a case-study report on cyber-security challenges in Industry 4.0. *(Refer Annexure- Exercise No.10)*
11	4	2,3,4	**Digital Twins** • Concept of digital twins. • Applications in simulation, monitoring, and optimization. • Tools and software for creating digital twins.	• Create a digital twin of a simple mechanical system using simulation software (e.g., MATLAB or ANSYS). • Prepare and submit a digital twin model of a mechanical component.
12	4	2,3,4,7	**Human Machine Collaboration** • Role of humans in Industry 4.0. • Collaborative robots (cobots) and their applications. • Safety standards and ergonomics.	• Program a cobot to work alongside a human in a simulated task. *(Refer Annexure- Exercise No.11)*
13	4	1,2,3,5	**Sustainable Manufacturing** • Role of Industry 4.0 in promoting sustainability. • Energy efficient manufacturing processes. • Circular economy and waste reduction.	• Write a report on sustainable practices in Industry 4.0. *(Refer Annexure- Exercise No.12)*

Annexure -List of Exercises

1. Analyze real-world implementations (e.g., Audi, Mercedes) to understand how Industry 4.0 boosts vehicle production, and prepare short reports on transforming traditional manufacturing.

2. Simulate a smart factory layout using software such as Factory I/O or Siemens TIA Portal, and design a basic layout for a smart factory.
3. Build a simple IoT project with an ESP-8266/ESP32 to monitor and control a device (e.g., an LED or motor), and write a report on the impact of IoT on mechanical systems.
4. Develop an IoT project using an ESP-8266/ESP32 to monitor temperature and moisture, demonstrating sensor integration in a manufacturing context.
5. Program a small robotic arm perform simple tasks (pick and place, welding), and present a case study on robotics in manufacturing.
6. 3D print a simple mechanical component using an FDM printer, and design and submit a corresponding 3D model.
7. Analyze a dataset with Python (Pandas, Matplotlib) to identify manufacturing trends, and report on how data analytics enhances production processes.
8. Train a simple ML model using Python (Scikit-learn) to predict equipment failure, and present an AI application relevant to mechanical engineering.
9. Conduct a basic cybersecurity audit on a simulated IoT system, and report on the challenges and solutions for cybersecurity in Industry 4.0.
10. Program a cobot to work safely alongside a human in a simulated task, ensuring adherence to safety standards and ergonomics.
11. Analyze energy consumption data to propose optimization strategies, and write a report on sustainable practices within Industry 4.0 environments.
12. Simulate a blockchain-based system to track production, shipping, and inventory in a manufacturing supply chain, emphasizing data integrity and transparency.

4. References:

Sl. No	Author Name	Title	Publisher Detail (Edition & Year)
1	Alasdair Gilchrist	Industry 4.0: The Industrial Internet of Things	Apress, 1st Edition, 2017
2	Dr. P. Ramana Reddy	Industry 4.0: Concepts and Applications	Wiley, 1st Edition, N/A
3	Dr. S. N. Sivanandam	Artificial Intelligence and Machine Learning in Industry 4.0	Springer, 1st Edition, N/A
4	Dr. R. K. Jain	Smart Manufacturing: The Lean Six Sigma Way	McGraw Hill Education, 1st Edition, N/A
5	ArshdeepBahga and Vijay Madisetti	Internet of Things: A Hands-On Approach	VPT Publishing, 1st Edition, N/A

6	Ian Gibson, David Rosen, and Brent Stucker	Additive Manufacturing Technologies	Springer, 2nd Edition, N/A
7	Dr. K. R. Anupama	Big Data and Analytics in Industry 4.0	Pearson Publications, 1st Edition, N/A
8	Dr. S. K. Saha	Robotics and Automation in Industry 4.0	Cambridge University Press, 1st Edition, N/A
9	Dr. P. V. Rao	Digital Twins: Concepts and Applications	CRC Press, 1st Edition, N/A
10	Houbing Song, Danda B. Rawat, and Sabina Jeschke	Cyber-Physical Systems: Foundations, Principles, and Applications	Academic Press, 1st Edition, N/A

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all Practical Exercises and Activities through rubrics	1-13		50	
				Total	

6. SEE – Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test Model Question Paper

Program	Mechanical Engineering			**Semester -**V	
Course Name	Industry 4.0			**Test**	I/III
Course Code	25ME51IA	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Explain the evolution of Industry 4.0 and compare it with the previous industrial revolutions (Industry 1.0 to Industry 3.0). Provide examples of technologies that define each revolution.	Apply	CO1	5
	b. Discuss the key drivers that have led to the emergence of Industry 4.0.	Apply	CO1	5
	c. Evaluate the applications of Industry 4.0 in Automobile Company.	Apply	CO1	5
	d. Explain the role of the Internet of Things (IoT) in Industry 4.0. How does IoT enable real-time monitoring and control in a smart factory?	Apply	CO1	5
	e. Compare the roles of robotics and automation in traditional manufacturing versus Industry 4.0.	Apply	CO1	5
2	a. Describe the historical context of Industry 4.0. How has the integration of digital technologies transformed traditional manufacturing systems?	Apply	CO1	5
	b. Analyze the benefits of Industry 4.0 in the context of mechanical engineering.	Apply	CO1	5
	c. Evaluate the applications of Industry 4.0 in pharmaceutical company.	Apply	CO1	5
	d. Discuss the applications of Artificial Intelligence (AI) and Machine Learning (ML) in predictive maintenance.	Apply	CO1	5
	e. Explain the significance of additive manufacturing in Industry 4.0.	Apply	CO1	5
	Section – 2			
3	a. What is a smart factory? Discuss the key components of a smart factory and how they work together to optimize production processes.	Apply	CO3	5
	b. Discuss the challenges of implementing IoT in Industry 4.0. How can these challenges be addressed to ensure seamless integration of IoT technologies?	Apply	CO3	5
	c. Describe the concept of Cyber-Physical Systems (CPS) and their role in Industry 4.0. Provide an example of a CPS application in a smart factory.	Apply	CO3	5
	d. Analyze the importance of Big Data and Analytics in Industry 4.0. How can data-driven decision-making improve quality control in manufacturing?	Apply	CO3	5
	e. Compare the different types of industrial robots (Articulated, SCARA, Delta, and their applications in manufacturing. Which type of robot would be most suitable for a high-precision assembly task, and why?	Apply	CO3	5
4	a. Compare traditional factories with Industry 4.0 factories. Highlight the advantages of smart factories in terms of efficiency, flexibility, and cost-effectiveness.	Apply	CO3	5
	b. Explain how IoT can be used for asset tracking in a manufacturing plant. Provide an example of an IoT-based solution for tracking inventory in real-time.	Apply	CO3	5
	c. Compare traditional factories with Industry 4.0 factories. Highlight the advantages of smart factories in terms of efficiency, flexibility, and cost-effectiveness**.**	Apply	CO3	5

	d. Explain the concept of digital twins and their role in smart factories. Provide an example of how digital twins can be used for real-time monitoring and optimization.	Apply	CO3	5
	e. Compare traditional factories with Industry 4.0 factories. Highlight the advantages of smart factories in terms of efficiency, flexibility, and cost-effectiveness.	Apply	CO3	5
***Note for the Course coordinator**: Each question may have two or three or four or five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*				

8. CIE Practice Test model question paper

Program	Mechanical Engineering				**Semester**	V
Course Name	Industry 4.0				**Test**	II
Course Code	25ME51IA	Duration	**180 min**		**Marks**	50
Name of the Course Coordinator:						
Note: Answer any one full question from the following						
Questions					**CO**	**Marks**
1. Build a simple IoT project with an ESP-8266/ESP32 to monitor and control a device (e.g., an LED or motor), and write a report on the impact of IoT on mechanical systems. or Develop an IoT project using an ESP-8266/ESP32 to monitor temperature and moisture, demonstrating sensor integration in a manufacturing context.					CO1	**25 Marks**
2. Program a small robotic arm to perform pick and place operation or Program a robotic arm to perform welding					CO1	**25 Marks**
Scheme of Assessment - Q No.1 & 2 - • Programming - 10 • Execution - 15						**50 Marks**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	**Case Study 1: Audi's Smart Factory Transformation** Audi has implemented Industry 4.0 technologies such as IoT, AI, and robotics in its vehicle production lines. The company utilizes automated guided vehicles (AGVs), cyber-physical systems, and real-time data analytics to optimize manufacturing processes. This transformation has led to increased production efficiency, predictive maintenance, and enhanced quality control, significantly reducing downtime and defects in production.
02	**Case Study 2: Siemens Digital Twin in Manufacturing** Siemens has integrated digital twin technology to simulate and optimize its manufacturing processes. By creating virtual models of physical production systems, Siemens enables real-time monitoring and predictive analytics. This approach has improved production accuracy, reduced errors, and enhanced resource utilization, making operations more flexible and cost-efficient
03	**Case Study 3: Tesla's Automation and AI-Driven Manufacturing** Tesla's factories use highly automated production lines with AI-driven robotic systems to assemble electric vehicles. Machine learning algorithms analyze sensor data to predict component failures and optimize workflow. This implementation has resulted in increased production rates, improved quality assurance, and reduced human intervention in repetitive tasks, setting a benchmark for smart manufacturing.
04	**Case Study 4: GE's Predictive Maintenance Using Big Data** General Electric (GE) has adopted big data analytics and IoT in industrial equipment monitoring. By collecting and analyzing sensor data from turbines, engines, and manufacturing equipment, GE predicts maintenance needs before failures occur. This predictive maintenance strategy has reduced downtime, extended equipment lifespan, and optimized operational efficiency**.**
05	**Case Study 5: BMW's Collaborative Robotics (Cobots) in Assembly** BMW has integrated collaborative robots (cobots) into its assembly lines to enhance human-machine collaboration. These cobots assist workers in assembling vehicle components, reducing physical strain and improving precision. The adoption of cobots has increased production efficiency, improved worker safety, and enhanced overall manufacturing flexibility.
06	**Case Study 6: Boeing's Use of Additive Manufacturing** Boeing has implemented additive manufacturing (3D printing) to produce lightweight and durable aerospace components. This technology allows the company to rapidly prototype and manufacture complex parts with reduced material waste and production costs. The use of 3D printing has also contributed to faster innovation cycles and improved customization in aircraft manufacturing**.**

10. Rubrics for Assessment of Practical Exercises and Activities (Qualitative Assessment)

Sl. No	Dimension	Unsatisfactory	Satisfactory	Good	Very Good	Excellent	Student's Score
		1-10	11-20	21-30	31-40	41-50	
1	Understanding of Industry 4.0 Concepts	No understanding or significant misconceptions about	Limited understanding with major misconceptions.	Basic understanding but lacks depth and clarity.	Shows a good understanding with minor gaps in explanation.	Demonstrates a deep and thorough understanding of Industry 4.0	20

		Industry 4.0 concepts.				technologies and their applications in the case study.	
2	Analysis of Case Study	Analysis is irrelevant, incomplete, or absent.	Analysis is incomplete or lacks relevance to the case study.	Analysis is superficial with limited discussion on key aspects.	Covers most key aspects but lacks depth in some areas.	Provides a well-structured and detailed analysis, covering key aspects such as technology used, benefits, and challenges	30
3	Application of Theoretical Knowledge	No connection between theory and case study.	Weak or no connection between theory and case study.	Some attempt to relate theory to practice but with minimal depth.	Makes relevant connections but lacks strong supporting arguments.	Effectively connects theoretical concepts with real-world applications from the case study.	30
4	Critical Thinking & Problem-Solving	No evidence of critical thinking or problem-solving.	Little or no evidence of critical thinking or problem-solving.	Recognizes some challenges but lacks clear solutions.	Identifies challenges but solutions are not well-developed.	Demonstrates strong critical thinking by evaluating challenges and proposing insightful solutions.	40
	Average Marks=(20+30+30+40)/4=30						**30**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment/software list with Specification for a batch of 30 students

Sl.No.	Particulars	Specification	Quantity
1	IoT Development Kits	ESP32, ESP8266 with sensors	10
2	Industrial Robots	6-Axis Robotic Arms	2
3	3D Printers	FDM Technology, Min. 200mm^3 Build Volume	2
4	Cyber security Tools	Network Security Simulator	1
5	Smart Factory Simulation Software	Factory I/O	5 Licenses
6	Big Data Analytics Tools	Hadoop, Python (Pandas, Matplotlib)	
7	AR/VR Kits	Augmented Reality Headsets for Training	2

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Advanced Manufacturing Technologies	**Type of Course**	Integrated
Course Code	25ME51IB	**Contact Hours**	104 Hrs./Sem. 8Hrs/Week
Teaching Scheme	L: T:P 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. **Rationale**: Manufacturing Industries are evolving rapidly with the advent of advanced machining techniques, automation and quality inspection methods. Traditional machining processes are often insufficient to meet the increasing demand for precision, efficiency and the ability to machine hard and complex materials. Therefore, it is essential to bridge the gap between Conventional and Advanced machining.

   This course is designed to equip students with knowledge and hands-on experience in non-conventional machining, additive manufacturing and non-destructive testing. This course emphasizes to enhance the practical and industry relevant skills in advanced manufacturing processes by ensuring quality through NDT.

2. **Course Outcomes: At the end of the Course, the student will be able to:**

CO-01	**Select** the best non-conventional machining process based on material, automation, and quality.
CO-02	**Develop** components by non-conventional machining processes ensuring dimensional accuracy and surface finish.
CO-03	**Apply** 3D printing technologies to create customized components while ensuring dimensional accuracy and surface finish.
CO-04	**Recommend** suitable NDT methods to detect defects validate compliance with industry quality standards.

3. **Course Content**

WEEK	CO	PO	Theory	Practice
1	1	1,2	**Non-Conventional Machining** • Need and significance • Classification • Advantages of non-conventional over conventional machining process • Selection of Non-conventional machining processes based on, Materials, Manufacturing processes, Automations, Inspection and Quality,	Present a video on Non-conventional machining processes

			Information Technology	
2	1, 2	1,2, 4	**Ultra Sonic Machining (USM)** • Construction & Working Principle • Transducer, Tool Cone, Abrasive Slurry • Feed Mechanism • Process parameters • Characteristics of USM • Applications	**Prepare a job using USM** • Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies
3	1, 2	1,2, 4	**Water Jet Machining (WJM)** • Construction & Working Principle • Process Parameters • Characteristics of WJM • Effect of process parameters on MRR & Surface Finish • Applications • Simple Problems	**Prepare a job using WJM** • Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies
4	1, 2	1,2, 4	**Electro Chemical Machining (ECM)** • Construction & Working Principle • Electrolytes - Types & Selection Criteria • Tool material - Types, Properties and Selection Criteria • Factor governing surface finish • Process parameters • Process characteristics • Applications • Solve simple problems	**Prepare a job using ECM** • Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies **Virtual Lab Link:** *https://mm-coep.vlabs.ac.in/exp/electrochemical-machining-process/*
5	1, 2	1,2, 4	**Chemical Machining (CHM)** • Construction & Working Principle • Steps involved in CHM • Types – Milling, Blanking, Engraving • Etchants – Commonly used & Selection criteria • Applications	**Prepare a job using CHM** • Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies
6	1, 2	1,2, 4	**Electrical Discharge Machining (EDM) & Wire EDM** • Construction & Working Principle of EDM • Dielectric fluid, Tool Materials • Process parameters • Applications • Construction & Working Principle of WEDM • Solve simple problems	**Prepare a job using EDM/Wire-EDM** • Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies **Virtual Lab Link:** *http://vlabs.iitkgp.ac.in/vamm/exp1/webpage/index.html* *https://mm-coep.vlabs.ac.in/exp/wire-edm/*
7	1,	1,2,	**Laser Beam Machining (LBM)**	**Prepare a job using LBM**

	2	4	• Construction & Working Principle • Materials for LBM • Process Parameters • Characteristics of LBM • Applications • Simple Problems	• Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies **Virtual Lab Link (Laser Beam Welding):** *https://mm-coep.vlabs.ac.in/exp/welding-ndyag-laser/simulation.html*
8	3	1,2, 4	**Additive Manufacturing** • Introduction • Generic AM Process • Applications of AM in Bio-Medical, Aviation & Automobile Industries • AM Techniques ○ **Fused Deposition Modeling** – Process mechanism, process parameters, advantages, disadvantages & applications. ○ **Laser Stereo lithography** – Process mechanism, process parameters, advantages, disadvantages & applications.	Prepare the given component on Filament based 3D Printing Machine **Virtual Lab Links:** *https://3dp-dei.vlabs.ac.in/exp/simulation-modelling-process/simulation.html* *https://3dp-dei.vlabs.ac.in/exp/simulation-stereolithography-process/simulation.html*
9	3	1,2, 4	○ **Polyjet** - Process mechanism, process parameters, advantages, disadvantages & applications. ○ **Digital Light Processing** - Process mechanism, process parameters, advantages, disadvantages & applications. ○ **Selective Laser Sintering** - Process mechanism, process parameters, advantages, disadvantages & applications. ○ **Selective Laser Melting** - Process mechanism, process parameters, advantages, disadvantages & applications.	Prepare the given component on Filament based 3D Printing Machine **Virtual Lab Links:** *https://3dp-dei.vlabs.ac.in/exp/simulation-laser-sintering-metal/simulation.html* *https://3dp-dei.vlabs.ac.in/exp/simulation-laser-sintering-nonmetal/simulation.html*
10	3	1,2, 4	○ **Electron Beam Melting** - Process mechanism, process parameters, advantages, disadvantages & applications. ○ **Binder Jetting** - Process mechanism, process parameters, advantages, disadvantages & applications. ○ **Laminated Object Manufacturing** - Process mechanism, process parameters, advantages,	Prepare the given component on Resin Based 3D Printing Machine **Virtual Lab Link:** *https://3dp-dei.vlabs.ac.in/exp/simulation-powder-binding/simulation.html* *https://3dp-dei.vlabs.ac.in/exp/simulation-laminated-object/simulation.html*

			disadvantages & applications.	
11	3	1,2, 4	• **Binding Mechanisms** – Chemical Induced Binding, Secondary Phase assisted Binding, Liquid Fusion & Solid-State Sintering • Post processing of 3D printed parts	Prepare the given component on Resin Based 3D Printing Machine **Virtual Lab Link:** *https://3dp-dei.vlabs.ac.in/exp/simulation-post-processing/simulation.html*
12	4	1,2, 4	**Non-Destructive Testing** • NDT – Importance, Applications, Benefits • NDT Methods & Techniques - ○ Visual Inspection ○ Ultrasonic Testing ○ Magnetic Particle Testing ○ Penetrant Testing	Conduct NDT with Visual Inspection Method • Identify defects on the given test (Metal/Composite/ Plastic/etc.. material) specimen. Document and report the findings.
13	4	1,2, 4	○ Electro Magnetic Testing ○ Radiography Testing • NDT Codes/Standards/Certifications • Safety Protocols • NDT in Industry	Conduct NDT with Dye Penetrant Testing Method • Identify defects on the given test (Metal/Composite/ Plastic/etc... material) specimen. Document and report the findings.

4. References

Sl. No.	Author	Title of Books	Publication/Year
1.	P.N. Rao	Manufacturing Technology – Volume II	Mc Graw Hill, 2018
2.	P.C. Sharma	A Textbook of Production Technology (Manufacturing Processes)	S.Chand, 2022
3.	Vijay.K.Jain	Advanced Machining Processes	Allied Publishers Pvt. Limited, 2002
4.	Helmi Youssef Hassan El-Hofy	Non-Traditional and Advanced Machining Technologies	CRC Press, 2021
5.	P.C. Pandey H.S. Shan	Modern Machining Processes	McGraw-Hill, 1980
6.	C.P. Paul A.N. Jinoop	Additive Manufacturing: Principles, technologies and Application	Mc Graw Hill, 2021
7.	Andreas Gebhardt	Understanding Additive Manufacturing: Rapid Prototyping – Rapid Tooling – Rapid Manufacturing	Hanser Garden Publication, 2022

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max Marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	

4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE – Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -V**	
Course Name	Advanced Manufacturing Technologies			**Test**	**I/III**
Course Code	**25ME51IB**	**Duration**	**90 min**	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q.No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a) Identify and categorize different non-conventional machining processes based on their working principles and applications. b) Analyze and compare conventional and non-conventional machining, highlighting key drawbacks of conventional methods. c) Determine and justify the influence of key parameters on the performance of Laser Beam Machining (LBM). d) Apply knowledge of Water Jet Machining (WJM) to identify its practical applications in various industries. e) Select and optimize process parameters for Laser Beam Machining (LBM) to enhance efficiency and precision.	Apply	CO1	5X5 = 25
2	a) Illustrate the working of Laser Beam Machining (LBM) with a sketch and applications. b) Evaluate the drawbacks of non-conventional machining and suggest improvements. c) Apply the characteristics of Water Jet Machining (WJM) to different materials. d) Identify applications of Ultrasonic Machining (USM). e) Recommend suitable uses for Laser Beam Machining (LBM).	Apply	CO1	
	Section - 2			
3	a) Justify the use of Ultrasonic Machining (USM) for a given material by analyzing its construction, working principles, and advantages with a suitable sketch." b) Find out the approximate time required to machine a hole of diameter equal to 6.0mm in a tungsten carbide plate (fracture hardness = 6900		CO1	10+ 15 = 25

	N/mm^2) of thickness equal to one and half times of hole diameter. The mean abrasive grain size is 0.015mm diameter. The feed force is equal to 3.5 N. The amplitude of tool oscillation is 25μm and the frequency is equal to 25kHz. The tool material used is copper having fracture hardness equal to 1.5×10^3 N/mm^2. The slurry contains one-part abrasive to one part of water. Take the values of different constants as $K_1 = 0.3$, $K_2 = 1.8$ mm^2, $K_3 = 0.6$, and abrasive density = 3.8 g/cm^3. Also calculate the ratio of the volume removed by throwing mechanism to the volume removed by hammering mechanism.	Apply		
4	a) Apply Water Jet Machining (WJM) setup for cutting different materials, considering its construction, working principles, and efficiency." b) A job was found to be prepared either by USM, EDM or EBM. What are the aspects to be considered for the correct selection of above non-conventional methods on the basis of • Physical parameters of the process • Shape to be machined • Process capability • Economics	Apply	CO1	10+ 15 = 25 Marks
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	Advanced Manufacturing Technologies			**Test**	II
Course Code	20ME51IB	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Questions				**CO**	**Marks**
1. Question on preparing the job using LBM/USM/WJM/ECM/CHM/EDM • Study the component drawing • Select the process parameters • Perform the machining process • Check for dimensional accuracies				CO1	50
Scheme of assessment a. Selecting Process Parameters = 05 Marks b. Modelling &G-Code generation using relevant software = 15 Marks c. Performing machining process = 20 Marks d. Performing Dimensional checks and Documenting = 10 Marks				CO1	
				Total Marks	**50**
Note for the Course coordinator: One Optional question carrying the same weightage of marks, cognitive level and course outcomes can also be given					

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

Program	Mechanical Engineering			**Semester**	V
Course Name	Advanced Manufacturing Technologies			**Test**	IV
Course Code	20ME51IB	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Questions				**CO**	**Marks**

1. Prepare a job using – 3D Printing (Filament Based or Resin Based) 2. Conduct NDT with Dye Penetrant Testing Method to Identify the defects on the given test (Metal/Composite/ Plastic/etc... material) specimen.	CO3 CO4	25 25
Scheme of assessment **1.** a. Solid Modelling & G-Code generation = 10 Marks b. Machine Setup & Printing = 10 Marks c. Performing Dimensional checks and Documenting = 05 Marks **2.** a. Work piece preparation = 05 Marks b. Conducting other steps in test = 10 Marks c. Inspection & Interpretation of Results = 10 Marks	CO3 CO4	
	Total Marks	**50**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
1	Make a Case Study on application of USM. Give presentation and submit the report.
2	Collect the model prepared by any non-conventional machine. Make study on its surface finish and suggest the process parameters might have been implemented to improve its surface finish.
3.	Prepare the hexagonal nut and bolt assembly using Filament based 3D printer. Use NDT and Submit report on the defects.
4	Visit Industry which has adopted AGVs / AS&RS. Study the features. Present and submit the report
5	Collect Manufacturers Catalogue of ECM and LBM. Present and submit the report on selection criteria adopted for various applications of these machines.
6.	Visit nearby Industries/Workshops having non-conventional machines. Study the features and applications. Present and submit its report.
7.	Visit the nearest 3D printing or additive manufacturing shop and list out the different stages followed by them for building a component. Present and Submit the report.
8.	Conduct a literature survey and list out the different manufacturing techniques for creating multi material components other than additive manufacturing. Present and submit the report.

12. Rubrics for Assessment of Practical Exercises & Activity (Qualitative Assessment)

Sl. No.	Dimension	Needs Improvement	Basic	Competent	Proficient	Excellent	Students Score
		0-10	11-20	21-30	31-40	41-50	
1	Data Collection	Not collected or analyzed.	Incomplete or poorly organized,	Adequate but lacks organization or	Mostly complete, with a clear	Thoroughly collected & organized in a	40

			with little to no analysis	clarity in some areas.	structure, though some data may be less organized	effective manner, with a well-structured analysis.	
2	Operations / Task Carried	Not carried out properly	Partially carried, leading to some significant errors	Partially carried, but there is noticeable disorganizatio n	Mostly carried correctly, with minor mistakes	Carefully followed, and is executed with high skill and accuracy.	40
3	Impact and Effectiveness of work/task	Fails to make an impact or is ineffective in achieving goals	Minimal impact and fall short of achieving its intended purpose	Moderate impact but could be more effective	Positive impact effectively achieving its purpose	Outstanding impact exceeding expectations	40
4	Presentation and Report submission	Missing critical information, incomplete, or unclear.	Incomplete, poorly organized, or lacks important components .	Includes some key elements but lacks clarity or detail in some areas.	Mostly complete, with minor omissions or organizationa l issues.	Comprehensive , well-organized, and includes all necessary details.	40
	Average Marks						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities.

11.Equipment/Consumables/software list with Specification for a batch of 30 students

Sl.No.	Particulars	Specification	Quantity
01	3D Printer (Filament Based)	Approximate Build Volume: 220 x 220 x 250 mm Material Compatibility: PLA/ABS/ PETG/TPU Interfacing Software Other Features Suitably Selected	01
02	3D Printer (Resin Based)	Approximate Build Volume: 190 x 120 x 245 mm Light Source: UV Interfacing Software Other Features Suitably Selected	01
03	LBM Machine	Approximate Laser Type: CO_2, Fiber, Nd:YAG Application: Sheet metal cutting/ Engraving/ Precision Cutting Work Area: 1500x3000x100 mm Other Features Suitably Selected	01
04	USM Machine	Approximate Type: Conventional/Rotary Material Compatibility: Hard and Brittle materials Axis control: Manual/CNC Abrasive: SiC/B4C/Al_2O_3 Interfacing Software Other Features Suitably Selected	01
05	WJM Machine	Approximate Cutting Speed: 100 mm/min Operating Pressure: 300 MPa Work Area: 2000 x 3000 x 150 mm Interfacing Software Other Features Suitably Selected	01

06	ECM Machine	Approximate Type: Conventional ECM Work Area: 500 x 500 x 300 Electrolyte: NaCl, $NaNO_3$, KCl Tool: Copper/Brass/Stainless Steel Interfacing Software Other Features Suitably Selected	01
07	CHM Machine	Approximate Type: Chemical Mill Work Area: 250 x 250 mm Interfacing Software Other Features Suitably Selected	01
08	EDM Machine	Approximate Type: Die-Sinking / Wire Dielectric Fluid: Kerosene/ Deionized Water / EDM Oil Interfacing Software Other Features Suitably Selected	01
09	Dye penetrant testing kit	Approximate Purpose: Crack / porosity / leak / other surface defect detection Penetrant Type: Visible Other Features Suitably Selected	01
10	NDT Test	-	01 Each

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Power Plant Engineering	**Type of Course**	Integrated
Course Code	25ME51IC	**Contact Hours**	104 Hrs./Sem. 8Hrs/Week
Teaching Scheme	L: T:P: 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale:

The syllabus is designed to help students understand different types of power plants and how electricity is generated from various energy sources. It covers thermal, hydro, nuclear, wind, and solar power plants, explaining their working principles, major components, and efficiency. The course also introduces boilers, steam turbines, condensers, cooling towers, and hydro turbines, providing a strong foundation in conventional and renewable energy technologies. By learning about the Rankine cycle, nuclear fission, and hybrid power systems, students gain insights into real-world energy production and sustainability**.**

This syllabus emphasizes practical learning through models, simple calculations, and industrial visits to power plants. It encourages students to compare renewable and non-renewable energy sources, analyze their impact, and explore future energy technologies. By integrating theory with hands-on experience, students develop problem-solving skills and an understanding of modern power generation methods, preparing them for careers in the energy sector.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	**Interpret** the working principles of different power plants and compare renewable and non-renewable energy sources.
CO-02	**Examine** key components, working principles and performance parameters of various power generation systems.
CO-03	**Enhance** power plant performance by implementing efficient layouts and sustainable energy storage solutions.
CO-04	**Assess** Hybrid power technologies, renewable energy policies and emerging innovations in power generation.

3. Course Content:

WEEK	CO	PO	Theory	Practice
1	1	1,3,6	**Introduction to Power Plants** • Basics of Power Generation • Types of Power Plants (Thermal, Hydro, Nuclear, Renewable) • Comparison of Renewable & Non-Renewable Energy Sources	• Study of different power plant layouts – thermal, solar hydro and wind power plant
2	1,2	1,2,4	**Steam Power Plants** • Generation of steam, steam properties • Working Principle of Steam Power Plants • Major Components of a Steam Power Plant • Simple problems on Simple Rankine Cycle	• Video demonstration and Identification of components of steam power plant • Case study on Impact of Coal-Based Steam Power Plants on Air Quality
3	1,2	2,4	**Steam Power Plants** • Types of boilers: Fire-tube, Water-tube, Supercritical boilers • Boiler mountings and accessories Steam turbines: Impulse and Reaction types • Steam condensers: Jet and Surface condensers • Cooling towers: Wet, Dry, Hyperbolic cooling towers	• Case study on Fly Ash Management and Utilization in Thermal Power Plants
4	1,2	1,2	**Nuclear Power Plants** • Principle: Nuclear Fission Process • Types of Nuclear Reactors • Nuclear Fuel and Fuel Cycle • Layout of a Nuclear Power Plant	• Case Study on Nuclear Power Plant and Virtual Tour of a Nuclear Power Plant
5	1,2	2,4,6	• Main Components Nuclear Power Plants**:** o Reactor Core & Fuel Rods o Control Rods & Moderators o Steam Generator & Turbines o Cooling Systems & Containment Structure • Nuclear Power Plant Safety & Hazards • Layout of a Diesel Power Plant • Layout of a Gas Power Plant	• Simple heat balance calculations for nuclear power plants • Recent Developments in Nuclear Waste Management
6	1,3	1,3,5	**Hydro Power Plants – Fundamentals & Classification** • Principles of hydroelectric power generation • Types: Run-of-river, Storage, Pumped-storage • Site selection for hydro power plants	• Case study on a major hydro power project
7	1,3	2,3,6	**Hydro Power – Turbines & Performance Analysis** • Types of hydro turbines: Pelton, Francis, Kaplan • Pumped storage hydro plants and their applications • Environmental and social impact of hydro projects	• Performance analysis of a Pelton wheel model

8	1,3	1,4,6	**Wind Energy – Fundamentals** • Wind energy basics: Wind speed, Power coefficient • Simple problems on Power Coefficients • Types of wind turbines: Horizontal-axis, Vertical-axis • Wind turbine aerodynamics and power equation	• Wind speed and power coefficient calculations
9	1,3	2,5,6	**Wind Energy – Turbine Technology & Grid Integration** • Wind turbine components: Blades, Gearbox, Generator, Controller • Grid integration of wind energy and storage options.	• Small wind turbine model performance analysis
10	4	1,3,5	**Solar Power – Fundamentals & Photovoltaic Systems** • Basics of solar energy and radiation • Working of photovoltaic (PV) cells, Solar panel types • Grid-connected vs. off-grid solar power systems	• Solar PV system performance evaluation
11	4	2,4,6	**Solar Power – Solar Thermal & Storage Systems** • Solar thermal power plants (CSP, Parabolic trough, Solar tower) • Thermal energy storage: Molten salt, Batteries • Applications of solar energy in industries and homes	• Case study on solar thermal power plants
12	4	3,5,6	**Hybrid Power Plants & Future Power Technologies** • Definition and working of hybrid power systems • Hybrid combinations: Solar-Wind, Solar-Thermal, Hydro-Wind • Renewable energy policies and investment opportunities • Floating Solar & Offshore Wind Energy	• Case study on hybrid power projects • Discussion on new innovations in power generation
13	1,2, 3,4	1,5,6	**Industrial Visit** • Visit to a thermal, hydro, wind, or solar power plant • Observe operational aspects and interact with engineers • Discuss industrial challenges and innovations • Industrial visit report submission	

4. References

Sl. No.	Author(s)	Title of Books	Publication/Year
1	P.K. Nag	Power Plant Engineering	McGraw Hill, 5th Edition, 2021

2	Domkundwar& Arora	Power Plant Engineering	Dhanpat Rai Publications, 2018
3	R.K. Rajput	Thermal Engineering	Laxmi Publications, 10th Edition, 2020
4	R.S. Khurmi& J.K. Gupta	A Textbook of Thermal Engineering	S. Chand, 2017
5	AmlanChakrabarti	Energy Engineering and Management	PHI Learning, 2016
6	D.P. Kothari, K.C. Singal, Rakesh Ranjan	Renewable Energy Sources and Emerging Technologies	PHI Learning, 2nd Edition, 2019
7	G.D. Rai	Solar Energy: Fundamentals and Applications	Khanna Publishers, 2019
8	D. Mukherjee & S. Chakrabarti	Fundamentals of Renewable Energy Systems	New Age International, 2011
9	M.M. El-Wakil	Nuclear Power Plants	McGraw Hill, 2004

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	Power Plant Engineering			**Test**	I
Course Code	25ME51IC	**Duration**	90 min	**Marks**	50

Name of the Course Coordinator:				
Note: Answer any one full question from each section. Each full question carries equal marks.				
Q. No	**Questions**	**Cognitive Level**	**Course Outcome**	**Marks**
	Section - 1			
1	a. **Analyze** why renewable power plants are more suitable for remote rural areas compared to non-renewable power plants.	Apply	CO1	10
	b. **Distinguish** between jet and surface condensers in terms of heat rejection and working principle	Apply	CO2	10
	c. **Describe** how mechanical energy is converted into electrical energy in a power plant..	Apply	CO1	5
2	a. **Distinguish** between the working of impulse and reaction turbines in steam power plants.	Apply	CO1	10
	b. **Discuss** the importance of each major component in a steam power plant for overall system performance.	Apply	CO2	10
	c. **Analyze** the role of steam properties in improving the efficiency of a Rankine cycle.	Apply	CO1	5
	Section – 2			
3	**a. Distinguish** between the environmental impact of hydro power plants and other renewable sources.	Apply	CO1	10
	b. **Interpret** how cooling towers contribute to maintaining a stable power plant operation.	Apply	CO2	10
	c. **Discuss** the advantages and limitations of renewable energy over non-renewable energy in power generation**.**	Apply	CO1	5
4	a. In a nuclear Power plant, the Reactor, Turbine and Cooling system are key components. **How** do these components work together to generate Electricity.	Apply	CO1	10
	b. **Discuss** the importance of each major component in a Nuclear power plant for overall system performance.	Apply	CO2	10
	c. **Discuss** the type of fuel commonly used in Nuclear Power plants.	Apply	CO1	5
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	Power Plant Engineering			**Test**	IV
Course Code	25ME51IC	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer all the questions. Each question carries 25 marks					
Questions				**CO**	**Marks**
Section-I					

1.	Conduct an experiment to analyze the performance of a small wind turbine model under varying wind speeds.	CO1, CO3	25
2.	Conduct an experiment to evaluate the performance of a solar photovoltaic (PV) system by measuring solar irradiance, voltage, current, and power output under different environmental conditions	CO4	25
Scheme of Assessment 1. Understanding of Concept & Objectives– 06 Marks Experimental/Industrial Setup & Observations – 07 Marks Data Collection & Analysis- 07Marks Results, Interpretation & Discussion- 05Marks 2. Understanding of Concept & Objectives– 06 Marks Experimental/Industrial Setup & Observations – 07 Marks Data Collection & Analysis- 07Marks Results, Interpretation & Discussion- 05Marks **Total Marks - 25 Marks**			**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Efficiency Analysis of Hybrid Power Systems **Activity:** Evaluate the effectiveness of hybrid power systems (Solar-Wind, Hydro-Wind, Solar-Thermal). **Task:** Prepare a PowerPoint presentation comparing their efficiency, feasibility, and real-world applications using case studies. Include efficiency graphs and system layouts (8–10 slides).
02	Waste Heat Recovery in Thermal Power Plants **Activity:** Investigate the role of waste heat recovery in improving power plant efficiency. **Task:** Develop a PowerPoint presentation explaining waste heat sources, recovery technologies, and case studies on industrial applications. Use thermodynamic cycle diagrams and efficiency comparisons (8–10 slides).
03	Comparative Study of Renewable Energy Sources **Activity:** Compare wind energy with other renewable sources like solar, geothermal, and biomass. **Task:** Develop a PowerPoint presentation discussing energy generation efficiency, costs, scalability, and environmental impact of each source. Use visuals, tables, and graphs across 8–10 slides
04	Impact of Climate Change on Hydropower Generation **Activity:** Examine how climate change affects water availability and hydropower efficiency. **Task:** Prepare a PowerPoint presentation highlighting case studies, rainfall patterns, reservoir management strategies, and future adaptation measures. Use climate models and impact graphs (8–10 slides).
05	Hydrogen as a Future Fuel for Power Generation **Activity:** Assess hydrogen's potential as a clean energy source for power plants.

	Task: Present an analysis of hydrogen production methods, storage, transportation, and its use in fuel cells and power plants. Include hydrogen economy trends and policy insights (8–10 slides).

10. Rubrics for Assessment of Practical Exercises and Activities (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Content Accuracy	Major errors, lacks key points.	Some inaccuracies or missing details.	Mostly accurate, minor gaps.	Accurate and well-covered.	Fully accurate and detailed.	45
2	Research Depth	Little to no research done.	Limited research or incomplete.	Adequate research, covers basics.	Well-researched, includes examples.	Extensive, insightful research.	42
3	Clarity & Organization	Disorganized and unclear.	Somewhat clear, needs better flow.	Mostly clear with minor issues.	Clear and well-structured.	Very clear, logical, and engaging.	35
4	Visuals & Creativity	No visuals or poorly designed.	Basic visuals, lacks creativity.	Adequate visuals, some creativity.	Good visuals, engaging design.	Exceptional visuals and creativity.	40
5	Overall Quality	Poor quality, lacks professionalism.	Basic quality, needs improvement.	Satisfactory quality, minor flaws.	High quality, polished work.	Professional-level quality.	45
	Average Marks=(45+42+35+40+45)/5=42						**42**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars Required	Specifications	Quantity
1	Steam Boiler Model	Fire-tube/Water-tube, Cut-section for demonstration	1
2	Steam Turbine Model	Impulse & Reaction turbine models	1 each
3	Condenser Model	Jet / Surface condenser models	1 each
4	Cooling Tower Model	Wet / Dry cooling tower models	1 each
5	Hydroelectric Power Plant Model	Run-of-river, Storage, Pumped-storage	1 each
6	Hydraulic Turbines	Pelton, Francis, Kaplan turbines	1 each
7	Wind Turbine Model	Horizontal-axis / Vertical-axis wind turbines	1 each
8	Anemometer	Digital, Wind speed range: 0-30 m/s	2
9	Solar Panel	Monocrystalline, 100W capacity	2
10	Solar PV System Kit	With inverter and battery storage	1
11	Solar Thermal Collector Model	Parabolic trough and Solar tower models	1 each
12	Nuclear Reactor Model	Cut-section of Pressurized Water Reactor (PWR)	1

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	**V**
Course Name	Product Design	**Type of Course**	Integrated
Course Code	25ME51ID	**Contact Hours**	104 Hrs./Sem. 8Hrs/Week
Teaching Scheme	L: T:P 4:0:4	**Credits**	6
CIE Marks	**50**	**SEE Marks**	50 (Theory)

1. Rationale -

The syllabus for the **Product design** focuses on providing students with a comprehensive understanding of the design principles for essential components used in mechanical systems, such as shafts, beams, bearings, springs, and gears, under various loading conditions. Initially, the course covers fundamental concepts in **static and dynamic loading**, **fatigue failure**, and the **design of structural components** like shafts and beams. Students will learn to apply these principles to solve real-world design challenges through hands-on problems, fostering their problem-solving and analytical skills. As the course progresses, emphasis is placed on **fatigue design**, including the use of **S-N curves** for predicting fatigue life and designing components for **cyclic loading**, with virtual labs enhancing understanding.

The **bearing design** segment teaches students about **load distribution**, **material selection**, and **bearing life prediction** through FEA software, while the **gear design** portion covers essential aspects like gear geometry, efficiency, and stress analysis. Additionally, the **spring design** section introduces students to the design and analysis of **coil and leaf springs**, focusing on factors like spring rate, stiffness, and deflection.

Virtual labs and FEA simulations are integrated to bridge theory with practical experience, allowing students to simulate and analyze real-world component behavior, making them proficient in using modern engineering tools. This course prepares students to tackle complex design problems in mechanical engineering and equips them with the skills necessary for industry applications.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Design and analyze mechanical components under static and torsional loading using theoretical and FEA validation.
CO-02	Apply stress analysis and failure theories for fatigue and cyclic loading using S-N curves and FEA validation.
CO-03	Develop and analyze bearings for mechanical applications with theoretical and simulation-based verification.
CO-04	Develop and analyze Gears and Springs for mechanical applications with theoretical and simulation-based verification.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,2, 3,4	**Design for Static Loading** • **Design of Simple Structural Components**: Design of shafts, beams, and columns under static loading conditions. Simple problems • **Design for Axial Loading**: Design of bars, rods, and columns subjected to tensile/compressive forces. • Simple Problems	**Design of Mechanical Components**: Hands-on problems involving real-world design challenges, including shafts, beams, brackets, and machine elements Validate the answers with FEA software
2	1	1,2, 3,4	• **Design for Torsion**: Design of shafts subjected to torsional loads (shear stress, angle of twist), Simple problems • **Design for Bending**: Design of beams under bending stress, calculation of bending moment, shear force, and deflection, • Simple problems	**Design of Mechanical Components**: Hands-on problems involving real-world design challenges, including shafts, beams, brackets, and machine elements Validate the answers with FEA software
3	1	1,2, 3,4	• **Theories of Failure** • **Combined Stresses**: Understanding axial, bending, and torsional stresses in components. • **Principal Stresses and Strains**: Finding principal stresses, and maximum shear stress.	**Principal Stresses and Strains**: Drawing Mohr's circle for the given bi-axial state of stresses. Validate the answers with FEA software
4	2	1,2, 3,4	**Design for Variable Loading:** • **Fatigue and Fatigue Failure:** Understanding fatigue failure, fatigue strength, and endurance limits. • **S-N Curves (Wöhler Curves):** Use of S-N curves for fatigue life prediction and design. • Simple problems	**Determine the endurance limit of the given specimen under fatigue or cyclic loading.:** (Use following virtual lab link) *https://eerc01-iiith.vlabs.ac.in/exp/fatigue-test-experiment/simulation.html*
5	2	1,2, 3,4	• **Design for Fatigue:** Methods for designing components under fluctuating loads (e.g., shafts, gears). • **Cyclic Loading**: Effects of cyclic loading on materials, design considerations for repeated loading conditions. • Simple problems	**Determine the endurance limit of the given specimen under fatigue or cyclic loading.:** (following virtual lab link for reference) *https://eerc01-iiith.vlabs.ac.in/exp/fatigue-test-experiment/simulation.html*
6	3	1,2, 3,4	**Design of Bearings:**	Study the **Load friction testing** of the bearings.

			• Introduction to Bearings: Types of Bearings, Bearing Materials • Bearing Loads and stresses	
7	3	1,2, 3,4	**Design of Rolling Element Bearings**: • Analysis of rolling contact bearings: Load distribution, contact stresses. • Calculating bearing life, bearing selection for a given load and speed. • Calculation of bearing life.	• Study the **Bearing Life** Testing (following virtual lab link for reference) http://vlabs.iitkgp.ac.in/rmfs/exp6/webpage/index.html • FEA software to simulate bearing performance under load and calculate life expectancy.
8	3	1,2, 3,4	**Journal Bearings and Fluid Film Lubrication:** • Introduction to journal bearings and hydrodynamic lubrication. • Design and analysis of journal bearings: Load distribution, oil film thickness, and pressure distribution. • Bearing material selection and the effect of temperature on performance.	Calculate the required dimensions of a journal bearing for a shaft application.
9	4	1,2, 3,4	**Gears and Gear Systems:** • **Gear Terminology and Types:** Types of gears (spur, bevel, helical, worm), gear trains, and their applications. • **Gear Design Principles:** Gear geometry, pitch, pressure angle, and tooth form.	• Draw and calculate gear parameters for simple spur gears. • Verify the gear ratio and speed reduction/increase between gear pairs in lathe machine.
10	4	1,2, 3,4	**Stress and Load Analysis in Gears:** • Gear force distribution and load analysis. • Bending stress, contact stress, and wear analysis in gears. • Perform bending stress and contact stress calculations for a spur gear design.	• Use FEA software to simulate load distribution and check for stress concentrations.
11	4	1,2, 3,4	**Design of Spur Gears:** • Design process for spur gears: Selection of module, pitch, and pressure angle. • Design for strength: Bending stress and tooth root stress calculation. • Efficiency of gear pair and lubrication. • Design and calculate dimensions for a spur gear.	• Simulate spur gear operation using FEA simulation software for load and stress analysis.
12	4	1,2, 3,4	**Design of Springs:** • **Types of Springs**: Coil springs (compression, tension, torsion), leaf springs, and their applications. • **Spring Materials and Manufacturing**: Selection of materials based on spring characteristics.	Measure the geometric properties of a spring to verify it matches the design specifications (e.g., coil diameter, wire diameter, and pitch).
13	4	1,2,	**Design of Compression Springs**:	**Practice -** • Compare the theoretical Deflection

		3,4	• **Helical compression Springs**: Design calculations for spring rate, stiffness, deflection, and stress. Stress analysis, fatigue considerations. • **Numerical examples -** Determine the deflection, stiffness & strain energy of a coiled spring.	and Stiffness with virtual lab results. (following virtual lab link for reference) https://eerc01-iiith.vlabs.ac.in/exp/compression-test-spring-experiment/objective.html • Analyze the fatigue life of the compression spring using FEA software tools.

4. References:

Sl. No.	Author	Title of Books	Publication/Year
1.	Robert L. Norton	Machine Design: An Integrated Approach	Pearson Education India / 2013
2.	V.B. Bhandari	Design of Machine Elements	McGraw Hill Education India Private Limited / 2017
3.	J.E. Shigley	Mechanical Engineering Design	McGraw-Hill Science Engineering/2014
4.	B. Bhushan	Introduction to Tribology of Bearings	Wiley-Blackwell / 2013
5.	K. Mahadevan&Balaveera Reddy	Mechanical Engineering Design date Hand Book	CBS / 2019
6.	R.S. Khurmi& J.K. Gupta	Machine Design	S Chand / 2020
7.	P. C. Sharma	Design of Machine Elements	Prentice Hall India Learning Private Limited / 2002
8.	J B K Das, P Srinivasa Murthy	Design of Mechanical Elements	Sapna Book House / 2018

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5.	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
Total					**51 Marks**

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering		**Semester- V**
Course Name	Product Design		**Test** I
Course Code	25ME51ID	**Duration-** 90 min	**Marks-**50
Name of the Course Coordinator:			

Note: Answer any one full question from each section. Each question carries equal marks.

Q. No	Questions	CL	CO	Marks
	Section – 1			
1	a. Explain the design considerations for structural components such as shafts, beams, and columns when subjected to static loading conditions. b. A shaft with a diameter of 40 mm is subjected to an axial load of 60 kN. Calculate the axial stress in the shaft and determine whether the shaft will withstand this load if the material's tensile strength is 250 MPa. c. A simply supported beam with a length of 3 meters is subjected to a uniform load of 15 kN/m. Calculate the maximum bending stress, shear force at the supports, and deflection at the center of the beam, assuming the beam has a circular cross-section with a diameter of 150 mm. d. A component is subjected to a fluctuating load with a maximum of 80 kN and a minimum of 20 kN. Using an **S-N curve for mild steel** and the given load range, estimate the fatigue life (in cycles) of the component, assuming the material's endurance limit is 120 MPa.	Apply	CO1 CO1 CO1 CO2	6 6 6 7
2	a. A steel shaft of length 2 meters and diameter 30 mm is subjected to a torsional load producing a shear stress of 60 MPa. Calculate the angle of twist for the shaft. b. A vertical column with a length of 5 meters and a cross-sectional area of 300 mm^2 is subjected to a compressive load of 180 kN. Calculate the axial stress in the column. Also, determine if the column design is safe if the yield strength of the material is 250 MPa. c. A simply supported beam with a length of 3 meters is subjected to a uniform load of 15 kN/m. Calculate the maximum bending stress, shear force at the supports, and deflection at the center of the beam, assuming the beam has a circular cross-section with a diameter of 150 mm. d. A steel bar is subjected to a cyclic loading of 40 kN to 100 kN. Using the **S-N Curve** for steel with an endurance limit of 150 MPa, calculate the number of cycles the bar can withstand before failure.	Apply	CO1 CO1 CO1 CO2	6 6 6 7
	Section – 2			
3	a. What are combined stresses, and how do you calculate principal stresses and maximum shear stress in a component? b. A shaft is subjected to an axial load of 50 kN, a bending moment of 300 Nm, and a torsional moment of 600 Nm. The shaft has a diameter of 40 mm. Using the **Distortion Energy Theory** (Von Mises stress), calculate the equivalent stress at a point on the shaft. c. A shaft with a diameter of 60 mm is subjected to a torsional moment of 1200 Nm. Calculate the maximum shear stress in the shaft and the angle of twist, assuming that the modulus of rigidity of the material is 80 GPa. d. A shaft is subjected to a bending moment that varies from 50 Nm to 200 Nm in a cyclic manner. If the yield strength of the material is 300 MPa and the ultimate	Apply	CO1 CO1 CO1 CO2	6 6 6 7

	tensile strength is 600 MPa, calculate the **fatigue strength** using the **Gerber Parabola Approach** for the material.			
4	a. A beam with a rectangular cross-section (100 mm x 200 mm) is subjected to both a bending moment of 1000 Nm and a shear force of 500 N. The beam is made from steel with a yield strength of 250 MPa. Calculate the maximum normal stress, shear stress, and determine the principal stresses in the beam. b. A steel rod with a diameter of 20 mm is subjected to both an axial tensile load of 40 kN and a bending moment of 120 Nm. Using the **Maximum Normal Stress Theory**, determine whether the rod will fail if the yield strength of the material is 250 MPa. c. A shaft of diameter 30 mm is subjected to an axial load of 40 kN and a bending moment of 250 Nm. Using the principle of superposition, calculate the combined stress at a point on the shaft, considering both axial and bending stresses. d. A steel component is subjected to an alternating stress of 120 MPa. Given that the material has an endurance limit of 200 MPa and follows the **Basquin's Law** (S-N curve), estimate the number of cycles to failure if the load varies between 40 kN and 150 kN.	Apply	CO1 CO1 CO1 CO2	6 6 6 7
Note for the Course coordinator: Each question may have two, three, four and five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	**V**
Course Name	Product Design			**Test**	II
Course Code	25ME51ID	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator: **Note:** Answer any one full question from the following					

Questions	**CO**	**Marks**
1. a. Design a shaft to transmit 50 kW of power at 1200 RPM. The shaft should be made of steel with a yield strength of 250 MPa. Consider both torsional and bending loads acting on the shaft. i. Calculate the shaft diameter based on the maximum shear stress theory. ii. Simulate the stress distribution using FEA software and verify if the designed shaft meets the strength requirements.	CO1	25
1. b. Using Experiment/Virtual lab simulation, conduct a fatigue test on a specimen subjected to cyclic loading. The specimen material is mild steel with an endurance limit of 150 MPa. The applied stress range is from 100 MPa to 250 MPa. i. Determine the number of cycles to failure of the specimen. ii. Record the fatigue life and analyze the results by plotting the S-N curve. iii. Compare the results with theoretical answers and identify any differences or in the behavior of the material.	CO2	25
2. a. A beam is subjected to a bending moment and an axial load resulting in the following stress components at a point: Normal stress, σx = 80 MPa (tensile) Shear stress, τxy = 40 MPa Normal stress, σy = 30 MPa (compressive) Using Mohr's Circle, determine: i. The principal stresses (σ1, σ2). ii. The maximum shear stress (τmax). iii. The angle at which the principal stresses occur.	CO1 CO2	25 25

2. b. Using Experiment/ Virtual lab simulation, for a shaft undergoes a load fluctuation between 100 N and 300 N. The material's fatigue limit is 350 N, Determine the following. i. Estimate the fatigue life of the shaft for 1 million cycles. ii. Record the fatigue life and analyze the results by plotting the S-N curve. iii. Compare the results with theoretical answers and identify any differences or in the behavior of the material.		
Scheme of Evaluation		
1. a. Calculate the shaft diameter = 10 Marks, Simulation of stress distribution using FEA software = 15 Marks 1. b. Determination of number of cycles to failure = 10 Marks ii. Plotting the S-N curve. = 10 Marks iii. Comparison of results = 5 Marks	CO1 CO2	25 25
2. a. i. Drawing Mohr's Circle = 10 Marks ii. Calculation of principal stresses (σ1, σ2) = 5 Marks iii. Calculation of maximum shear stress (τmax) = 5 Marks iv. The angle at which the principal stresses occur = 5 Marks 2. b. Determination of number of cycles to failure = 10 Marks ii. Plotting the S-N curve. = 10 Marks iii. Comparison of results = 5 Marks	CO1 CO2	25 25

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl.No.	Suggestive Activities for Tutorials
01	An automotive manufacturer is **designing a transmission shaft** that will transfer torque from the engine to the wheels. The shaft is subjected to static and dynamic loading, including both bending and torsional forces. The vehicle will operate under both high and low-speed conditions, with the shaft needing to withstand fluctuating loads due to road conditions. Perform the following tasks for the given data **Tasks:** 1. Static Loading Design 2. Fatigue Analysis 3. **FEA Simulation** 4. Reporting
02	A company is designing a **suspension system for a heavy-duty truck.** The suspension needs to support the weight of the vehicle (30,000 N) and absorb dynamic loads caused by road irregularities. The design requires the use of coil compression springs. Perform the following tasks for the given data **Tasks:** 1. Spring Design Calculations 2. Fatigue Analysis 3. **FEA Simulation** 4. Reporting

03	A manufacturing plant needs a new **power transmission gearbox for a conveyor system**. The gearbox will consist of a pair of spur gears to reduce the input shaft speed from 2400 RPM to 400 RPM. The input torque is 50 Nm, and the output shaft must handle the reduced speed and increased torque. Perform the following tasks for the given data **Tasks:** 1. Gear Design Calculations 2. Stress Analysis 3. **FEA Simulation** 4. Reporting

10. Rubrics for Assessment of Practical Exercises / Tutorials (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Concept Understanding	Lacks understanding of core concepts.	Lacks several important materials or tools	Adequately prepared but missing key items	Mostly prepared with minor omissions	Fully prepared with all necessary materials and tools	40
2	Application to Design	Fails to apply design principles effectively.	Inconsistent application of principles.	Applies basics, but struggles with complexity.	Mostly applies principles, some minor errors.	Optimally applies principles to solve complex problems.	40
3	FEA Simulation & Validation	Does not use or misapplies FEA.	Fails to interpret or validate using FEA.	FEA used, but struggles with result interpretation.	Mostly accurate FEA with minor issues.	Expert use of FEA, accurate results interpretation.	30
4	Hands-On Skills	Fails to perform hands-on tasks correctly.	Inaccurate measurements, struggles with tasks.	Adequate skills, some measurement or fabrication issues.	Good accuracy with minor discrepancies.	Precise measurements and fabrication, excellent testing.	40
5	Practical Record / Report making	Major sections are not addressed.	Major sections are missing or poorly addressed.	Some sections are included, but lack detail.	Most sections are complete with minor omissions.	All required sections are included and thoroughly detailed.	50
	Average Marks=(40+40+30+40+50)/5=40						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment/software list with Specification for a batch of 30 students

Sl.No.	Particulars	Specification	Quantity
01	Computers	Latest Configuration	30
02	FEA Software	ANSYS / SolidWorks Simulation/ Abaqus or any other	30
03	Design tools for Modelling	AutoCAD/ SolidWorks/CATIA/ any other	30

04	Fatigue testing Machine/ Virtual lab	Rotating bending apparatus/ Computer with internet access for virtual lab access	01 / 30
05	Test rig for bearing friction and load testing	Test rig / Computer with internet access for virtual lab access	01 / 30
06	Measuring tools for gear dimensions	Gear tooth Vernier. Micrometer	05
07	Spring testing machine	Machine / Computer with internet access for virtual lab access	01 / 30

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Automobile engineering	**Type of Course**	Integrated
Course Code	25ME51IE	**Contact Hours**	104 Hrs./Sem. 8Hrs/Week
Teaching Scheme	L: T:P: 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale:

Automobile Engineering is a dynamic and evolving field that blends mechanical, electrical, and electronic systems to create efficient and sustainable transportation solutions. This course is designed to provide a comprehensive understanding of automotive engineering principles, covering everything from engine fundamentals and thermodynamics to power transmission, suspension, braking, electrical systems, and vehicle diagnostics. A key aspect of this program is its practical, hands-on approach to learning. Students will not only gain theoretical knowledge but also engage in real-world applications, including engine teardown, gearbox disassembly, fuel system servicing, emission testing, and electrical diagnostics. By incorporating simulation tools and hardware-based experiments, learners will develop critical problem-solving skills necessary for automotive maintenance and innovation.

The curriculum also covers modern advancements such as electric powertrains, regenerative braking, alternative fuels, and electronic control units (ECU), ensuring that students are prepared for the future of mobility. Additionally, emphasis is placed on vehicle safety, emission control systems, and sustainability, aligning with current environmental and regulatory standards (e.g., EURO emission norms). By integrating fundamental theories, practical applications, and emerging technologies, this course bridges the gap between academic learning and industry requirements, making students highly competent in automobile servicing, diagnostics, and innovation

2. Course Outcomes: At the end of the syllabus the student will be able to

CO-01	Describe the fundamentals of automobile engineering, including history, classification, and workshop safety.
CO-02	Analyze engine and powertrain systems for efficient performance and fuel management.

CO-03	Diagnose, troubleshoot, and maintain key vehicle systems, including engines, brakes, and suspension.
CO-04	Evaluate automotive electrical and electronic systems using sensors, ECU operations, and diagnostic tools.
CO-05	Apply knowledge of advanced vehicle technologies, including alternative fuels, emissions control, and EV systems

3. Course Content

WEEK	CO	PO	Theory	Practice
1	01		**Introduction to Automobile Engineering** • Overview of Automobile Engineering • History and evolution of automobiles • Classification of automobiles • Automobile Manufacturer's List in India, Location and Models	• Identify and document basic tools and workshop equipment used in automobile workshop. • Safety protocols in the automobile workshop
2	01		**Engine Fundamentals** • Types of Power source**:** Petrol, Diesel, Hybrid and Electric • Spark ignition and Compression ignition engines: Working and comparison • 2-Stroke vs. 4-Stroke Cycle: Working Principle and comparison • Major Components: Material and Construction features - Cylinder, Pistons, Crankshaft, Camshaft, Valves	• Engine teardown: Disassemble, Assemble and Document features with justification • Use a model engine or simulation software to observe the intake, compression, power, and exhaust strokes.
3	01		**Thermodynamics principles** • Laws of Thermodynamics in Engines • Thermodynamic Cycles in Engines- Processes and Application of Otto cycle, Diesel Cycle, Dual Cycle • Key Thermodynamic Concepts in Engines- Compression Ratio (CR), Work & Efficiency, Specific Heat Capacity, Simple Problems • Energy losses • Improving Energy Efficiency	• Find the compression ratio and Pressure • Evaluate the performance characteristics of a four-stroke petrol engine
4	02		**Engine Systems** **1. Fuel and Air Induction** • Fuel Delivery Methods: Types, Working Principle of Carburetion, Fuel Injection in Diesel Engines- types, Working Principal of In-Line Pump • Air Intake Systems: Forced Induction- Need, Merits and Demerits • Turbo charging and Supercharging • Air-Fuel Mixture Requirements	• Servicing of Carburetor • Injector Testing .

5	02		• Combustion Process in SI Engine, Abnormal combustion- Types, List effects and Remedies **2. Ignition systems:** Working Principle of Electronic Ignition systems, Distributor less Ignition System **3. Exhaust Systems:** Layout and Functions of Manifolds, Catalytic Converters and Mufflers **4. Lubrication and cooling systems-** Need and Types	• Spark Plug Cleaning and Testing • Servicing and Decarbonizing of Exhaust Systems
6	02		**Transmission Systems** • Clutch – Functions, Requirements, Types • Transmission systems: Function, Types, Working of Synchromesh Gear Box • Automatic Transmission- Need, Types • Differential – Need, Working	• Disassemble Gearbox and find Gear Ratio • Clutch Play adjustment and inspection
7	03		**Suspension and Steering Systems** • Suspension systems: Need, Types • Shock Absorber- Functions, Working of Telescopic shock absorber • Working - MacPherson, Multi-link, Leaf spring • Steering mechanisms: Functions, Types and Working - Rack and pinion type Power steering • Wheel Alignment – Terms- Castor, Camber, King Pin Inclination	• Shock absorber test: Measuring damping efficiency using a shock dynamometer • Servicing of MacPherson suspension system • Check and Adjust Wheel Alignment
8	03		**Braking Systems** • Functions, Types • Working of Drum and Disc brake system • Working of Master cylinder and Wheel Cylinder • Compare Drum and Disc brake system	• Brake system inspection and maintenance. Brake fluid bleeding and Pad/ Shoe replacement • Determine Braking efficiency
9	03		**Chassis and Body Construction** • Role of Chassis frame, Types of chassis frames, Materials • Ladder frame- Construction • Monocoque Chassis- Merits, Demerits • Automobile body – Function, Types, Styles, Materials • Automobile body- Components • Safety features: Crumple zones, Roll cages • Air Bags- Need, Types, Working	• Checking Alignment of frame • Prepare a Scale down models of different body styles

10	05		**Fuel and Emissions Control Systems** • Alternative fuels - Need, Types, Properties and storage- LPG, CNG, Ethanol, Biofuels, Hydrogen • Emission control systems: Need, Components- Catalytic converters, EGR systems, and Oxygen sensors • Environmental regulations (EURO standards, etc.)	• Determine Calorific Value, Flash and Fire Point • Emissions testing using Exhaust Gas Analyzer (4 Element), Smoke meters
11	04		**Electrical and Electronics in Automobiles** • Automotive electrical systems: Functions of each system • Engine Status Sensors: Importance, Types, Functions of Oxygen sensors, Temperature sensors, Position sensors, Speed Sensor, MAP Sensor, MAF Sensor, • Working – Solenoid Actuators, Motorized Actuators • Introduction to ECU (Engine Control Unit) and its role	• Test the condition of Sensors using OBD II Scanner
12	04		**Automotive Air Conditioning** • Air Conditioning- Functions, Components and its function • Working principles of automotive air conditioning • Maintenance and Efficiency Considerations	• Air conditioning system troubleshooting • Refrigerant refilling and pressure checks
13	05		**Vehicle Maintenance and Management, Troubleshooting** • Preventive maintenance: Oil changes, Tire rotations, Brake inspections • Maintenance schedules and service manuals • Trends in Automotive repair • Trouble codes and how to interpret them • Basic troubleshooting techniques for engine and electrical systems	• Complete vehicle inspection and maintenance checklist • Oil change, tire balancing, and routine checks • Troubleshooting engine performance and electrical issues

4 References

SL. No	Author	Title of the Book	Publication/Year
1	Kirpal Singh	*Automobile Engineering Vol. 1 & 2*	Standard Publishers, 2019
2	Crouse & Anglin	*Automotive Mechanics*	McGraw Hill, 2017
3	William H. Crouse & Donald L. Anglin	*Automotive Engines: Theory and Servicing*	Pearson, 2015

4	R.B. Gupta	*Automobile Engineering*	Satya Prakashan, 2020
5	Tom Denton	*Automobile Electrical and Electronic Systems*	Routledge, 2018
6	Heisler Heinz	*Advanced Engine Technology*	Butterworth-Heinemann, 2015
7	Jack Erjavec	*Automotive Technology: A Systems Approach*	Cengage Learning, 2019
8	Joseph Heitner	*Automotive Mechanics Principles and Practices*	CBS Publishers, 2016
9	Richard Stone	*Introduction to Internal Combustion Engines*	Macmillan, 2017
10	Newton, Steeds & Garrett	*Motor Vehicle*	Butterworth-Heinemann, 2016

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of Practical Exercises and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE – Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	Automobile engineering			**Test**	I
Course Code	25ME51IE	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					
Q. No	**Questions**		**Cognitive Level**	**Course Outcome**	**Marks**

Section - 1				
1	a. How have automobiles changed over time, from early models to modern electric vehicles?	Apply	CO1	5
	b. Why are vehicles classified into different categories? How does this classification help in the industry?	Apply	CO1	5
	c. What were the key differences between early steam-powered vehicles and modern electric cars?	Apply	CO1	5
	d. How does classifying automobiles based on fuel type (petrol, diesel, electric) help consumers and manufacturers?	Apply	CO1	5
	e. How do Indian automobile brands compete with global manufacturers in terms of technology and pricing?	Apply	CO1	5
2	a. Why do diesel engines generally provide better fuel economy than petrol engines?	Apply	CO1	5
	b. How does the difference in ignition methods affect the efficiency and performance of spark ignition and compression ignition engines?	Apply	CO1	5
	c. Why are 2-stroke engines more commonly used in small vehicles like motorcycles, while 4-stroke engines are preferred in cars?	Apply	CO1	5
	d. Why are engine components like cylinders and pistons made from specific materials such as aluminum or cast iron?	Apply	CO1	5
	e. How does lubrication differ in 2-stroke and 4-stroke engines, and how does it affect engine lifespan?	Apply	CO1	5
Section – 2				
3	a. How does the first law of thermodynamics apply to energy conversion in an internal combustion engine?	Apply	CO1	5
	b. How do the Otto cycle and Diesel cycle differ in terms of efficiency and combustion process?	Apply	CO1	5
	c. Why do diesel engines use fuel injection instead of a carburetor?	Apply	CO2	5
	d. Why is forced induction necessary in high-performance and heavy-duty engines?	Apply	CO2	5
	e. How does a turbocharger utilize exhaust gases to enhance engine performance?	Apply	CO2	5
4	a. What are the major sources of energy loss in an internal combustion engine, and how can they be minimized?	Apply	CO1	5
	b. Why does the Dual cycle combine elements of both Otto and Diesel cycles, and where is it used?	Apply	CO1	5
	c. How does an in-line fuel injection pump regulate fuel delivery in a diesel engine?	Apply	CO2	5
	d. What are the advantages and disadvantages of forced induction systems in modern engines?	Apply	CO2	5
	e. How does the air-fuel ratio affect engine performance and emissions?	Apply	CO2	5
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering	**Semester**	**V**

Course Name	Automobile engineering			**Test**	II
Course Code	25M351IE	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					
	Questions			**CO**	**Marks**
	Section-I				
1.	Use a model engine or simulation software to visualize and analyze intake, compression, power, and exhaust strokes. **OR** Find the compression ratio and Pressure of a given engine.			CO1	25
	Section-II				
2.	Conduct an experiment to **clean, inspect, and test a spark plug,** ensuring it functions optimally for engine ignition. **OR** Disassemble a gearbox, identify its components, and calculate the gear ratio **for different gears.**			CO2	25
	Scheme of Assessment Procedure 05 Observations 05 Conduction 05 Calculations 05 Interpretation and Conclusion 05 Total 25 Marks				
Total Marks					**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	**Suggestive Activities for Tutorials**

01	Research and present the history and evolution of automobiles. Classify different types of vehicles based on fuel type, purpose, and design. Conduct a workshop safety session, identifying tools and safe practices.
02	Study properties and benefits of LPG, CNG, Ethanol, Biofuels, and Hydrogen. Analyze EURO emission standards and impact of catalytic converters.
03	Study the working principles of automotive air conditioning. Perform basic maintenance tasks like refrigerant level checking.
04	Visit automobile workshops, manufacturing plants, or interact with industry experts.
05	Study real-world automotive case studies on safety systems, fuel efficiency, and alternative fuels.
06	Develop basic automotive models, such as chassis structures or fuel injection systems.
07	Evaluate the architecture of hybrid and electric vehicles, analyzing battery pack efficiency, motor performance, and regenerative braking effectiveness.+
08	Connect an OBD-II scanner to a vehicle, retrieve fault codes, and analyze potential causes and solutions.

10. Rubrics for Assessment of Graded Exercises and Activity (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Technical Knowledge & Understanding	Minimal understanding, major errors in concepts	Basic understanding, but with significant misconceptions	Sufficient knowledge with minor errors	Good comprehension with relevant explanations	In-depth technical understanding with strong conceptual clarity	40
2	Practical Skills & Execution	Unable to conduct experiments	Basic setup attempted but with errors	Can perform practical tasks with guidance	Executes tasks correctly with minor mistakes	Fully proficient in conducting experiments	45
3	Data Collection & Analysis	No data collected or incorrect readings	Incomplete or inconsistent data	Correct data collection, basic analysis	Accurate data with logical analysis and insights	Detailed data collection with in-depth interpretation	40
4	Problem-Solving & Troubleshooting	Unable to identify or address issues	Recognizes problems but cannot solve them effectively	Can troubleshoot with assistance	Effectively identifies and resolves issues	Demonstrates excellent troubleshooting skills	45
5	Report Writing & Presentation	No documentation or poorly structured report	Incomplete or unclear report, lacks structure	Report is complete but lacks depth in explanation	Well-structured report with clear presentation	High-level documentation with in-depth analysis	45
	Average Marks= (40+45+40+45+45)/5=43						43

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment/software list with Specification for a batch of 30 students

SL NO	Particulars Required	Specifications	Quantity
1	Engine Teardown Kit	Model Engine (Petrol/Diesel) with complete components	1 Set
2	Compression Ratio Measurement Kit	Compression Gauge (0-300 psi), Piston Displacement Measuring Tools	1 Set
4	Four-Stroke Petrol Engine Test Rig	Mounted engine with dynamometer for efficiency analysis	1 Set
5	Carburetor Servicing Kit	Ultrasonic Cleaner, Screwdrivers, Cleaning Fluids, Brushes	1 Set
6	Injector Testing Kit	Injector tester with pressure gauge and fuel flow monitoring	1 Set
7	Spark Plug Tester and Cleaner	Spark plug testing chamber and sandblasting cleaner	1 Set
8	Exhaust System Decarbonizing Kit	Cleaning chemicals, Brushes, Endoscope Camera	1 Set
9	Gearbox Disassembly Kit	Gearbox model with tools to measure gear ratios	1 Set
10	Clutch Play Adjustment Kit	Clutch adjustment toolset, Dial Indicator	1 Set
11	Shock Absorber Test Rig	Shock dynamometer to measure damping efficiency	1 Set
12	MacPherson Suspension Servicing Kit	Spring compressor, Spanners, Alignment Tools	1 Set
13	Wheel Alignment Kit	Digital Camber-Caster Gauge, Toe Measuring Tools	1 Set
14	Brake System Inspection Kit	Brake fluid tester, Brake pad thickness gauge, Bleeding Kit	1 Set
15	Braking Efficiency Test Rig	Portable brake testing machine	1 Set
16	Chassis Alignment Checking Kit	Laser Alignment Tool, Frame Straightening Tools	1 Set
17	Scale Model Kit	Miniature body styles, Modeling Materials	1 Set
18	Fuel Property Testing Kit	Bomb Calorimeter, Flash & Fire Point Apparatus	1 Set
19	Exhaust Gas Analyzer	4-Gas Analyzer, Smoke Meter	1 Set
20	OBD-II Scanner	Handheld diagnostic tool with Bluetooth/Wi-Fi	1 Set
21	Air Conditioning Troubleshooting Kit	Refrigerant Pressure Gauges, Leak Detector, Manifold Gauge Set	1 Set
22	Refrigerant Refilling Kit	R134a/R1234yf refrigerant cylinder, Charging Hose	1 Set
23	Vehicle Maintenance Toolkit	Wrenches, Torque Wrench, Multimeter, Battery Tester	1 Set
24	Tire Balancing and Rotation Kit	Digital Wheel Balancer	1 Set
25	Engine & Electrical Troubleshooting Kit	Diagnostic Software, Multimeter, Circuit Tester	1 Set

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	PLC, HMI and SCADA	**Type of Course**	Integrated
Course Code	25ME52IA	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale: This course aims to bridge the gap between traditional mechanical systems and modern automation technologies. As industries transition to Industry 4.0, this course equips students with the essential skills to work with automation systems such as PLCs, HMIs, and SCADA, which are central to smart manufacturing. The course enhances the students' understanding of industrial automation, enabling them to optimize machine performance, reduce downtime, and improve overall productivity.

It covers real-world applications like motor control, conveyor automation, and industrial networking, ensuring that students gain practical skills that are directly applicable to industrial settings. By learning to interface mechanical systems with automation tools, students will also develop troubleshooting and diagnostic skills, preparing them for roles in maintenance and automation.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	**Apply** PLC programming techniques to design, implement, and troubleshoot industrial automation systems for various real-time applications.
CO-02	**Design** and **configure** HMI interfaces for real-time process visualization, user interaction, and control in automation environments.
CO-03	**Develop** and **implement** SCADA applications for remote monitoring, data acquisition, and industrial process management.
CO-04	**Integrate** PLCs with industrial drives such as VFDs, Servo, and Stepper motors to achieve precise control in automated systems.

3. Course Content

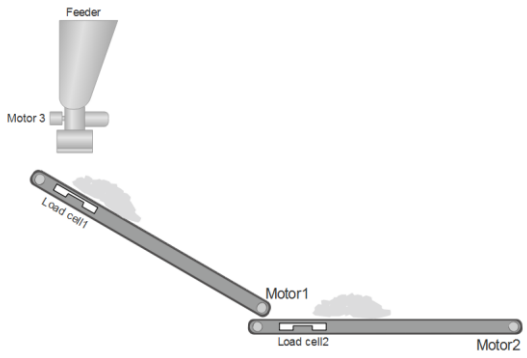
WEEK	CO	PO	Theory	Practice
1	1	3	**Introduction** • Overview of Industrial automation and control systems. • Role of PLC, HMI, and SCADA in manufacturing. • Comparison of traditional and modern automation techniques. • Challenges in Advanced Automation • Applications of Automation in Industries.	• Demonstration of basic PLC programs • Demonstration of Automation Simulation Software (Digital Twin) such as Factory IO, Emulate 3D,3D Experience, Tecnomatix etc. • Automated Material Feeder and Conveyor System (Refer annexure - Program No.1)
2	1	2,3	**PLC Hardware and Programming Basics** • PLC architecture: CPU, I/O modules, power supply, and communication interfaces. • Sink and source type of wiring • Interlocking & Trip Concepts • Types of Interlocking (electrical, mechanical, software), Need of Interlocking • Programming: Timers, Counters and Shift Registers.	• Demonstration of basic PLC programs using timers and counters. • Automated Bottle Filling System (Refer annexure - Program No.2) • Quality Check Sampling in a Production Line (Refer annexure - Program No. 3)
3	1	2,3	**Advanced PLC Programming** • Advanced instructions: arithmetic, comparison, logical operations. • Jump, subroutine, and interrupt handling in PLC. • Real-time applications of PLC in industry.	• Empty Bottle Detection and Removal System (Refer annexure - Program No.4) • Develop a ladder program using a shift register to track and reject oversized products on a conveyor belt. (Refer annexure - Program No.5)
4	1	3	**Industrial Communication and Networking in PLC** • Introduction to industrial communication protocols (Modbus, Profibus, Ethernet/IP). • Serial and parallel communication in PLC. • Peer-to-peer (PLC-to-PLC) and PLC-to-SCADA communication.	• Establishing PLC communication with external devices using Modbus. • Data exchange between two PLCs via communication networks. • Develop a ladder program for Automated Packaging System (Refer annexure - Program No.6)

5	2	3	**Human Machine Interface (HMI) Basics** • Introduction to HMI: types, selection, and specifications. • HMI software tools: configuring graphical objects, animations, and trends. • Security and authentication in HMI systems.	• Designing HMI screens for real-time process visualization. • Configuring alarms, trends, and user authentication. • Develop an HMI screen and configure alarms, trends, and user authentication for the given program (Refer annexure - Program No 1-6)
6	2	3	**Integration of PLC with HMI** • Establishing communication between PLC and HMI. • Animation and object control using HMI. • User interface design for process control and monitoring.	• Configuring HMI to display PLC data in real-time. • Implementing a motor control system using HMI. • Develop an HMI screen and configure alarms, trends, and user authentication for Sorting Objects by Shape and counting them *(*Refer annexure - Program *No 7)*
7	2	3	Develop an HMI screen and configure alarms, trends, and user authentication for Automated Sorting System that sorts objects based on their color using pneumatic mechanism. *(*Refer annexure - Program *No 8)*	
8	3	2,3	**Supervisory Control and Data Acquisition (SCADA)** • Introduction to SCADA: Architecture and components. • SCADA protocols and standards (DNP3, OPC, MQTT). • Data acquisition and remote monitoring principles.	• Setting up a basic SCADA system for monitoring industrial parameters. • Creating graphs, bar charts, and alarm systems in SCADA. • Develop a ladder program and HMI/SCADA for Continuous Stirred Tank Reactor Control (Refer annexure - Program 9)
9	3	3	**Integration of SCADA with PLC and HMI** • Real-time data acquisition using SCADA. • SCADA-based control of industrial processes. • Case study on SCADA implementation in smart factories.	• Interfacing SCADA with PLC for remote monitoring and control. • Configuring SCADA to monitor and analyze real-time process data. • Develop a ladder program and HMI/SCADA for ▪ Automated Drilling System (Refer annexure - Program 10) ▪ Automated Dual-Tank Drainage System (Refer annexure - Program 11)
10	4	1,3	**Industrial Drives – Variable Frequency Drives (VFDs)** • Introduction to VFDs: working principles and applications. • Speed and torque control using VFDs. • Interfacing VFD with PLC for motor control.	• Configuring and programming a VFD for speed control. • Create a ladder logic program and design an HMI interface to control a three-phase AC motor via a Variable Frequency Drive (VFD) (Refer annexure - Program 12)

11	4	1,3	**Servo and Stepper Motor Control in Automation** • Difference between Servo and Stepper motors. • Interfacing Servo drives and Stepper drives with PLC. • Position control and motion profiles in automation.	• Implementing stepper motor control for automated positioning systems (Refer Program 13). • Programming PLC to control Servo motors for pick-and-place operations. (Refer annexure - Program 14)
12	1,2, 3,4	1,2,3	**Advanced Industrial Automation Case Studies** • Real-world applications of PLC, HMI, and SCADA in industrial automation. • Case studies on automated manufacturing, smart factories, and IoT integration. • Troubleshooting and maintenance of automation systems.	• Diagnosing and resolving faults in PLC-based automation systems. • Analyzing real-time SCADA data for process optimization. • Visit a nearby industry where a SCADA system is implemented for factory automation and prepare a report highlighting the advantages of SCADA over traditional automation systems.
13	1,2, 3,4	1,2,3	**Industry 4.0 and Smart Automation** • Introduction to Industry 4.0 • Technologies driving Industry 4.0: IoT, AI, machine learning, and big data analytics. • IoT in industrial automation. • Role of AI and machine learning in smart automation. • Predictive maintenance and digital twin technology.	• Implementing IoT - based monitoring using PLC and HMI/SCADA. • Develop an **IoT-based Smart Conveyor Belt Monitoring System** using **PLC.** The system will monitor conveyor speed, motor temperature, and load, display data on **HMI/SCADA**, and transmit real-time information to a cloud platform for remote monitoring.

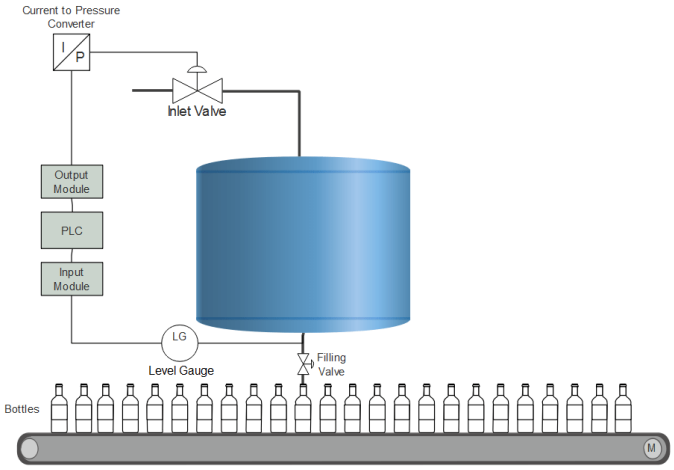
Annexure – Programs for an automated system

1. **Automated Material Feeder and Conveyor System:** This system controls two conveyors for transporting material from a feeder. Load cells detect material presence and automatically start the conveyors.



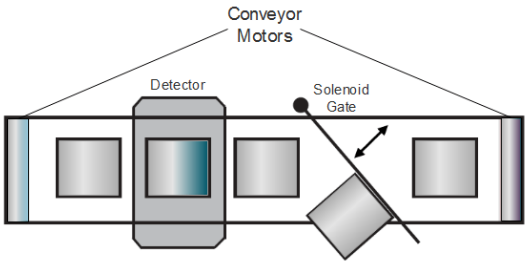
The HMI displays the status of material flow and motor operations, while real-time trends track conveyor performance and material throughput. Alarms notify operators of any material blockage or low material levels, ensuring smooth operation.

2. **Automated Bottle Filling System:** In this experiment, a constant filling speed of 20 bottles per minute is maintained using sensors and control loops. The system controls tank pressure and filling operations.



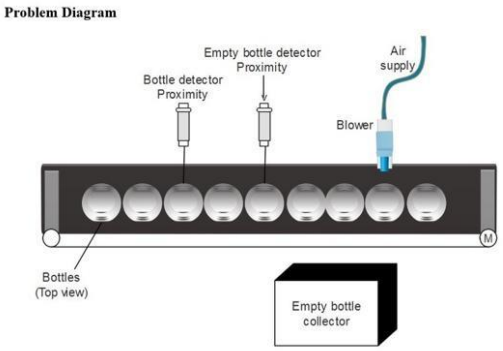
The HMI allows operators to monitor tank pressure, fill levels, and flow rates. It provides alarm notifications for any deviation in pressure and displays real-time trends for filling speed and tank levels, ensuring efficient production.

3. **Quality Check Sampling in a Production Line:** Here, one part out of every 1000 parts is diverted for a quality check. The system uses an up-counter to track the parts and a solenoid to divert the selected part.



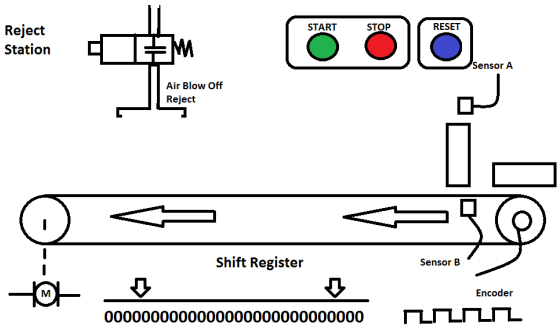
The HMI displays the part count, detection status, and quality check status. It also includes alarms for sensor faults, and user authentication is required to reset the counter.

4. **Empty Bottle Detection and Removal System:** This experiment uses proximity sensors to detect and remove empty bottles from a conveyor system. When an empty bottle is detected, a bit shift register shifts a bit, and a pneumatic system removes the bottle.

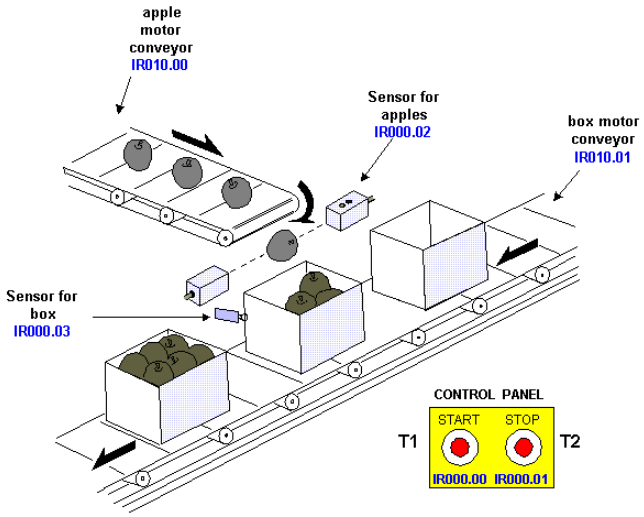


The HMI provides a real-time count of bottles, the number of rejected bottles, and conveyor speed. It also offers alarms for sensor or pneumatic system failures and allows user authentication to adjust rejection criteria.

5. **Shift Register-Based Product Rejection System:** This experiment aims to use a shift register to track and reject oversized products on a conveyor. The system uses sensors to detect products and a reject mechanism to remove defective ones. The HMI interface shows the conveyor's status with accepted and rejected products, displays the reject count, and tracks product movement. Alarms are triggered for encoder or reject mechanism faults, ensuring effective system monitoring.



6. **Automated Packaging System:**

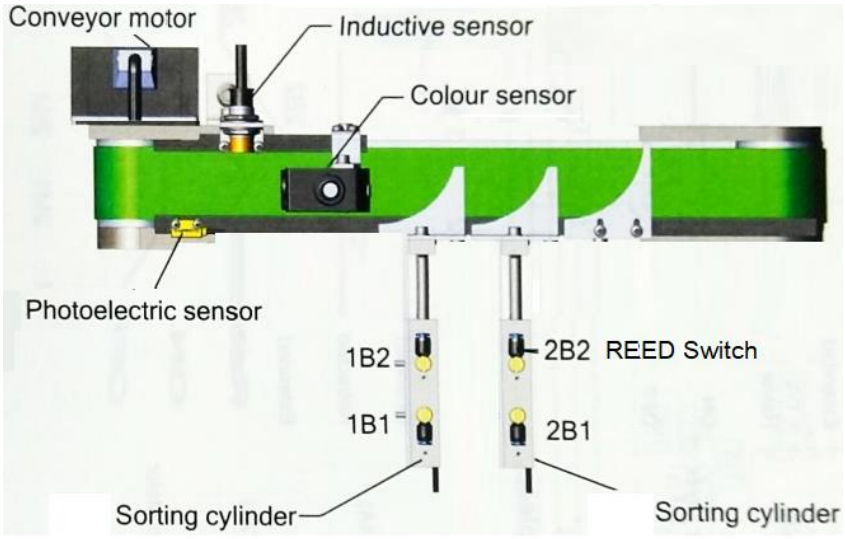


In this experiment, the objective is to automate product packaging by controlling a conveyor system that transports boxes and a secondary conveyor for apples. The system uses a proximity sensor to detect boxes, and a counter counts 10 apples before triggering the next action.

The HMI is used to visualize real-time conveyor status, box counts, and the labeling process. Alarms are displayed for faults in the conveyor or labeling process, and user authentication is provided for different access levels such as operator, supervisor, and admin.

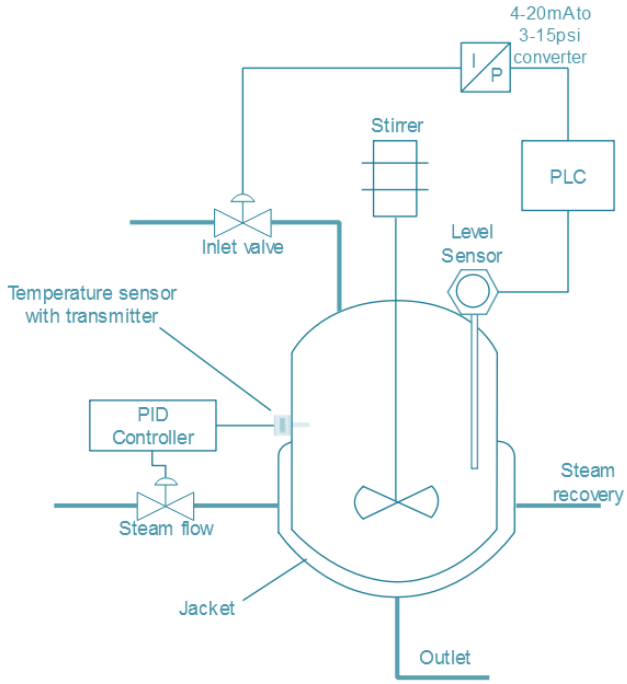
7. **Sorting Objects by Shape and Counting:** The goal is to classify and count objects of different shapes (balls, square, and rectangular blocks) using proximity sensors. The HMI shows the count of each object type and total processed parts, with alarms for sensor misalignment. User authentication allows operators to modify counter settings if necessary.

8. **Automated Sorting System that sorts objects based on their color**: Design a ladder logic diagram for an Automated Sorting System that sorts objects based on their color. The system uses color sensors, a belt conveyor, pneumatic cylinders, and an HMI (Human-Machine Interface) for operation and monitoring. The color sensors will detect the color of the objects as they pass through the system, and the belt conveyor will transport them. Pneumatic cylinders will direct the objects into their respective collectors based on the detected color.



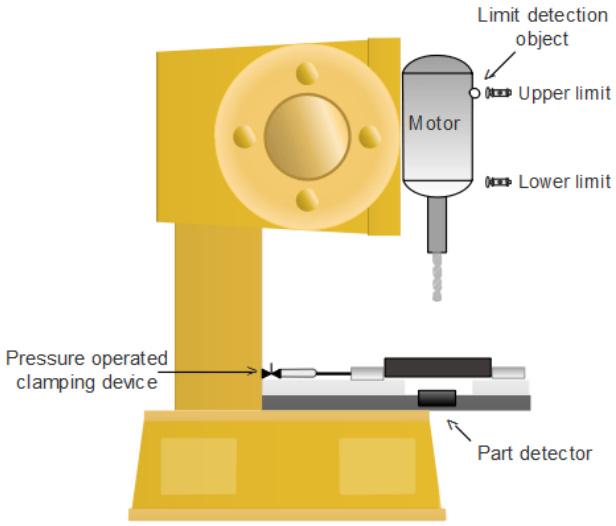
The HMI will provide the user with a graphical interface to monitor the system's status, change operational settings, and manually control the system when needed.

9. **Continuous Stirred Tank Reactor Control:** This system automates temperature, flow, and level control in a chemical reactor using PID controllers.

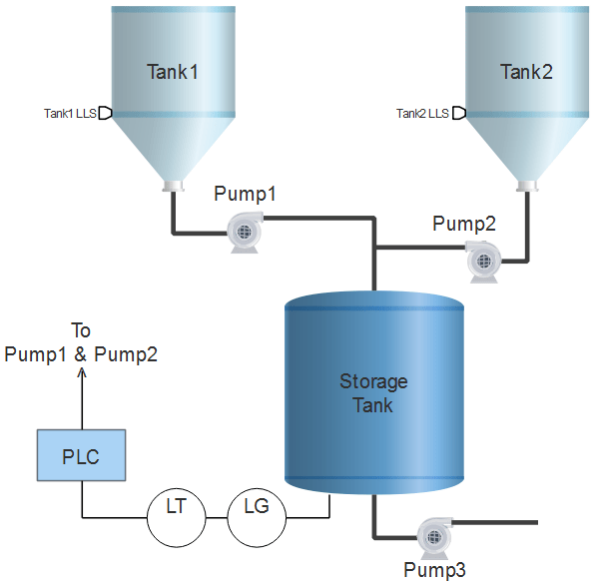


The HMI displays real-time data for temperature, flow rate, and tank levels. Alarm notifications are triggered for parameter deviations, and trends are available for historical data analysis, which helps in optimizing the reactor's operation.

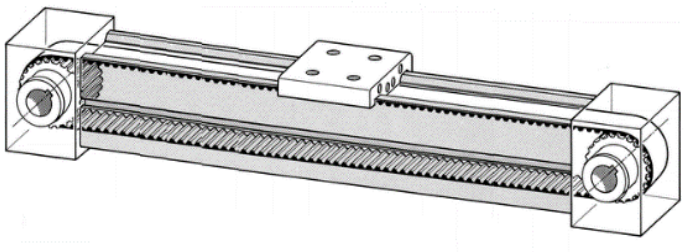
10. **Automated Drilling System:** In this system, the goal is to automate drilling with pneumatic clamping and position detection. The HMI shows the drilling process status, part count, and provides alarms for motor or clamping issues. It also includes trends to track drilling efficiency and to identify potential improvements in the system.



11. **Automated Dual-Tank Drainage System:** This system controls the drainage from two tanks based on their levels, using level gauges. The HMI shows the tank levels, pump status, and flow rates, while alarms notify operators of low-level conditions. Real-time trends for level fluctuations and drainage efficiency are also displayed, providing a clear view of system performance and ensuring effective operation.



12. Create a ladder logic program and design an HMI interface to control a three-phase AC motor via a Variable Frequency Drive (VFD). The HMI should include an input box for entering the motor speed and buttons to switch the motor direction (forward/reverse).
13. Create a ladder logic program and design an HMI interface to control a stepper motor-driven timing belt conveyor system. The system includes a table attached to the belt that moves between left and right extremes, with limit switches at both ends to prevent over travel. The conveyor functions as a load and unload station, moving the table to the right when material is loaded and to the left when it is unloaded. The stepper motor should be controlled via a stepper driver.



14. To design and implement an automated sorting system using a **servo motor-powered conveyor** and a **pneumatic sorting mechanism**, controlled by a **PLC and HMI interface**. The system aims to detect metal objects using an **inductive proximity sensor**, stop the conveyor momentarily, and activate a pneumatic actuator to sort the detected objects into a separate bin. The HMI provides user control and monitoring of the system's operation.

4. References:

Sl. No.	Author	Title of Books	Publication/ Year
1	Mikell P. Groover	Automation, Production Systems and Computer - Integrated Manufacturing	4th Edition, Pearson Education, 2016
2	W. Bolton	Programmable Logic Controllers	6th Edition, Newnes Publisher, 2015
3	Jacob Fraden	Hand book of Modern Sensors, Physics, Designs and Applications	4th ed. Springer-Verlag New York Inc., 2014
4	Austin Hughes And Bill Drury	Electric Motors and Drives	4th Edition, Newnes Publisher, 2013
5	Hugh Jack	Automating Manufacturing Systems with PLC	Publisher: Lulu, 2009
6	Shimon Y. N	Springer Handbook of Automation	Springer 2009
7	A_Boyer	SCADA: Supervisory Control and Data Acquisition	4th Ed, International Society of Automation, 2016
8	Rajesh Mehra & Vikrant Vij	PLCs & SCADA - Theory and Practice	1st Ed, Laxmi Publications Private Limited, 2019
9	Samuel Greengard	The Internet of things	The MIT Press, 2015
10	Gary Dunning	Introduction to PLCs	3rd Edition, Thomson India Edition
11	John W. Webb and Ronald A. Reis.	Programmable Logic Controllers Principles and Applications	5th Edition, Published by PHI Publication

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practical exercises and Activities through Rubrics	1-13	-	50	
				Total	**50**

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test Model Question Paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	PLC, HMI and SCADA			**Test**	I/III
Course Code	25ME52IA	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

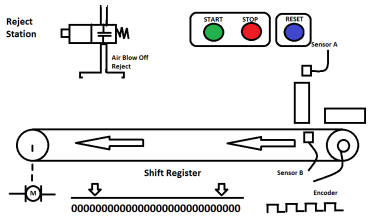
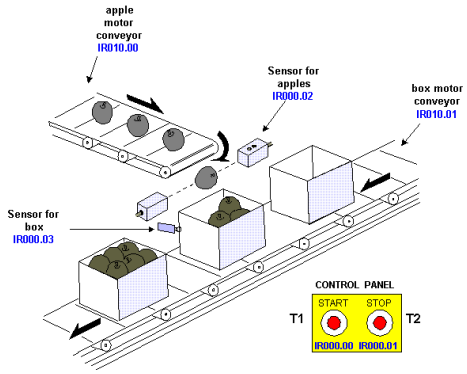
Q. No	**Questions**	**Cognitive Level**	**Course Outcome**	**Marks**
	Section - 1			
1	a. Design a PLC-based conveyor belt system for a smart conveyor in a warehouse that sorts packages by size using a block diagram. Explain how PLC, HMI, and SCADA work together in this automation.	Apply	CO1	10
	b. A manufacturing plant has both sink and source type sensors connected to a PLC. Explain the difference between sink and source wiring with the help of diagrams. Design a wiring diagram for a PLC input module that accommodates both sink and source type sensors. Discuss the advantages and limitations of each type of wiring in an industrial setup	Apply	CO1	10
	c. Develop a ladder logic program for an automated bottle-filling system, explaining the use of timers.	Apply	CO1	5
2	a. Design a PLC-based automatic beverage bottle-filling system using a block diagram. Explain how PLC, HMI, and SCADA work together in this automation.	Apply	CO1	10
	b. In a conveyor system, two motors (Motor A and Motor B) are used to transport materials. Motor A should only start if Motor B is running, and Motor B should stop if Motor A stops due to a fault. Design a ladder logic program to implement this interlocking and trip logic. Explain the importance of interlocking and trip concepts in ensuring safety and preventing equipment damage.	Apply	CO1	10
	c. Develop a ladder logic program for to count the components moving on the conveyor, explaining the use of counters.	Apply	CO1	5
	Section – 2			
3	a. Explain how jump and subroutine improve PLC programming efficiency. Provide an example application in an automated assembly line.	Apply	CO1	10
	b. Explain the working principles of Modbus, Profibus, and Ethernet/IP in industrial communication. Compare their advantages and limitations.	Apply	CO1	10
	c. Create a PLC program that uses comparison operations to detect defective products on a conveyor belt based on size measurements.	Apply	CO1	5
4	a. Develop a PLC program incorporating arithmetic, comparison, and logical operations to control a temperature regulation system in an industrial setup.	Apply	CO1	10
	b. Explain the working principles of RS-232 and RS-485 in industrial communication. Compare their advantages and limitations.	Apply	CO1	10
	c. Develop a ladder logic program using arithmetic operations to control a batch mixing process where ingredients are added based on weight calculations.	Apply	CO1	5

Note for the Course coordinator*: Each question may have two or three or four or five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	**IV**
Course Name	PLC, HMI and SCADA			**Test**	**II**
Course Code	25ME52IA	**Duration**	**180 min**	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one question. Each question carries 50 marks					

	Questions	**CO**	**Marks**
1.	Develop a ladder diagram using shift registers to track and reject oversized products on a conveyor. The system should include sensors for product detection and a reject mechanism for defective items. Implement an HMI interface to display conveyor status, accepted and rejected products, rejection count, and product movement tracking. Ensure alarms trigger for encoder or reject mechanism faults for effective system monitoring 	CO1, CO2	**50**
2.	Develop a ladder diagram for an Automated Packaging System that controls a conveyor transporting boxes and a secondary conveyor for apples. The system should use a proximity sensor to detect boxes and a counter to count 10 apples before triggering the next action. Implement an HMI to visualize real-time conveyor status, box counts, and the labeling process. Ensure alarms are displayed for faults in the conveyor or labeling process, and include user authentication for different access levels such as operator, supervisor, and admin 	C01, CO2	**50**

Scheme of Assessment for Question 1 & 2	**CO**	
a. Develop the ladder diagram for a given application, integrate with appropriate hardware and execute it. ***Note**: Includes Aim of the practical, List of Components Required, Ladder diagram and wiring diagram*	1	30
b. Design a HMI for a given application and execute it. ***Note**: Includes HMI design and implementation*	2	20
Total Marks		**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	**Case Study 1:** Implementation of PLC-Based Automation in Smart Manufacturing Unit- Analyze how PLCs improve efficiency, reduce downtime, and enhance process control in a modern manufacturing facility.
02	**Case Study 2:** HMI Integration for Real-Time Monitoring in a Water Treatment Plant - Study how HMI systems help operators monitor and control water purification processes, ensuring regulatory compliance and efficiency.
03	**Case Study 3:** SCADA System for Remote Monitoring and Control in Power Distribution - Examine how SCADA enables real-time monitoring, fault detection, and load balancing in electrical grid management
04	**Case Study 4:** Automation of a Warehouse Sorting System Using PLC and Conveyor Systems -Investigate how PLC-driven conveyor belts and robotic arms optimize warehouse logistics and reduce human errors.
05	**Case Study 5:** Cyber-security Challenges and Solutions in Industrial Automation Systems - Explore potential cyber-security risks in PLC, HMI, and SCADA systems and propose mitigation strategies to enhance industrial security.
06	**Case Study 6:** The Role of Digital Twins in Industrial Automation- Explore the potential of digital twin technology and propose innovative applications to enhance efficiency and productivity in industrial automation.

10. Rubrics for Assessment of Practical Exercises and Activities (Qualitative Assessment)

Sl. No	Dimension	Unsatisfactory	Satisfactory	Good	Very Good	Excellent	Student's Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Understanding of Concepts	Limited understanding of key automation concepts with minimal explanation.	Basic understanding of concepts but lacks depth in analysis.	Demonstrates a good grasp of concepts with relevant explanations.	Shows strong understanding with well-supported insights.	Exceptional comprehension with in-depth analysis and accurate technical explanations.	20
2	Technical Skills/ Implementation	Struggles with basic implementation of tasks	Able to implement tasks with some assistance or errors	Can complete tasks independently with minor errors	Completes tasks accurately with minimal assistance	Demonstrates advanced technical skills with flawless execution	30
3	Depth of Research and References	Minimal or no research; lacks credible references.	Limited research with few relevant references.	Good research with appropriate sources and citations.	Strong research with multiple credible references	Extensive research with high-quality references, demonstrating	30

					and detailed information.	thorough investigation.	
4	Report/ Presentation Quality	Report/presentation lacks clarity and detail	Provides basic information, but lacks depth or organization	Well-organized report/ presentation with clear details	Clear, concise, and in-depth with appropriate diagrams	Highly professional presentation with comprehensive details and critical insights	40
						Average Marks	**30**

Note: *Dimension and Descriptor shall be defined by the respective course coordinator as per the activities*

11. SEE- Model Practice Question Paper

Program	Diploma in Mechanical Engineering		**Semester**	**IV**
Course Name	PLC, HMI and SCADA	**Course Code:** 25ME52IA	**Duration**	**180 min**

Note*: Answer any one question*

Questions	**CO**	**Marks**
Note*: During the SEE, All questions will be distributed among the group. Each student will be assigned one of the following questions by the examiner, without offering any choice.* Develop a ladder program, interface and develop HMI/SCADA for the below 1. Shift Register-Based Product Rejection System (conveyor experiment) 2. Automated Apple Packaging System: (Double conveyor experiment) 3. Sorting Objects by Shape and Counting (Conveyor System) 4. Automated Sorting System that sorts objects based on their color 5. Continuous Stirred Tank Reactor Control(PID) 6. Automated Drilling System with pneumatic clamping 7. Automated Dual-Tank Drainage System 8. Variable Frequency Drive (VFD). 9. Stepper motor-driven timing belt conveyor system 10. Automated sorting system using a servo motor-powered conveyor and a pneumatic sorting mechanism.	CO1, CO2, CO3, CO4	**50**
Scheme of Assessment		
a. Develop ladder program for given automation applications, download and automating the system ***Note****: Includes Aim of the practical, List of Components Required, Ladder diagram and wiring diagram*	CO1, CO4	30
b. Design a HMI/SCADA for a given application and execute it ***Note****: Includes HMI design and implementation*	CO2, CO3	20
Total		**50 Marks**

1) Signature of the Examiner 1 **2) Signature of the Examiner 2**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Qty.
01	Computers	Latest Configuration	10
02	Factory/Plant Simulation Software	Factory/Plant Simulation Software such as Factory IO, Emulate3D, 3DExperience, Tecnomatix etc.	20
03	HMI and SCADA Software	Factory talk Studio, Movicon, Win CC, AVEVA System etc.	20
04	HMI Panels	10 inch and Ethernet connectivity	05
05	Programmable Logic Controller (PLC)	Minimum 12, 24V DC Inputs, 4 configurable analog input with thermistor voltage reference out, 7 24V DC Source Output, 1 Analog Output, Embedded Ethernet Port and RS-232/485 non-isolated Serial port, Embedded RTC, MicroSD Card support and minimum 2 Plug-In slots.	10
06	24 VDC Power Supply	24 V, 10A DIN Rail Mountable	10
07	12 VDC Power Supply	12 V, 5 A, DIN Rail Mountable	10
08	VFD Drive	AC Drive, with Embedded Ether Net/IP and Safety, 220 VAC, 1 Phase, 0.5 HP, 0.4 kW Normal Duty; 0.5 HP, 0.4 kW Heavy Duty, Frame A, IP20 NEMA / Open Type	1
09	Servo Motor Drive	0.4 kW @ 230V AC (single-phase or three-phase), 0.2 kW @ 120V AC (single-phase)	1
10	Servo Motor	0.2 kW @ 120V AC (single-phase)	1
11	AC Motor	3 Phase, 0.5 HP, 0.4 kW	1
12	Color Sensor	Operating Distance- 10mm to 50mm, Digital Output (NPN or PNP), 12-24V DC (with built-in reverse polarity protection).	1
13	Conveyor Models	3inch flat belt, 2.5 m long, Geared Motor Powered	2
14	Conveyor Models	3inch flat belt, 2.5 m long, AC Motor Motor Powered	1
15	Conveyor Models	3inch flat belt, 2.5 m long, Servo Motor Powered	1
16	Conveyor Models	3inch flat belt, 2.5 m long, Stepper Motor Powered	2

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Computer Aided Manufacturing	**Type of Course**	Integrated
Course Code	25ME52IB	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. **Rationale**: Modern manufacturing plays a critical role in enhancing efficiency, productivity and competitiveness across industries. It is essential, to bridge the gap between Design & Manufacturing, prepare the students for Industry 4.0.and Smart Manufacturing meeting global industry standards and competitiveness.

   For this purpose, providing a foundational understanding of what CAM is?, its importance in modern manufacturing, and how it integrates with other systems like CAD (Computer-Aided Design) and CNC (Computer Numerical Control) has to be imparted in students. This course emphasizes the seamless transition from design (CAD) to manufacturing (CAM), which is critical for efficient production, and how to use CAD models to generate and optimize toolpaths to reduce machining time, minimize material waste, and improve product quality. Students are familiarized and provided hands-on experience in using industry-standard CAM software and execute manufacturing processes in CNC turn/mill.

2. **Course Outcomes: At the end of the Course, the student will be able to:**

CO-01	**Analyze** CNC machine construction and setup processes, and **apply** CAM software to create and simulate part programs.
CO-02	**Analyze** and **estimate** material costs, machining time, and overall production cost for various CNC components.
CO-03	**Generate** CNC part programs for turning and milling processes using CAM software, incorporating tool selection and process planning.
CO-04	**Develop** and **execute** CNC turning and milling programs and validate output through dimensional inspection and process documentation.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1	**Constructional Features of CNC Machines** • Machine Structure, Spindle Motor & Drive, Axes Motor, Guide Ways, LM Guides, Console, Control Switches • Coolant System, Hydraulic System • Automatic Tool Changer	Demonstration on Constructional Features and Operation of CNC Machine
2	1	1	**Tool & Work Holding Devices** • Tool Materials- Insert Types, Holder Types, Boring Tool Holders • Indexable & Other Inserts • Tool Offset Setting • Work piece Datum Setting	• Loading and Unloading of Cutting Tools and Work piece • Offset Setting
3	1	1	**CAM Technology** • Need for generating large programmes • Drawbacks of manual programming • Steps involved in NC program creation	List various CAM Software and their Industrial application. Demonstration on CAM software • Use of Menu bar (File, Edit, View, etc.), Operation Manager, Tool Path Manager, Graphic Window, Status Bar
4	1	1,2,4	• Procedure of CAM • Tool Motion Parameters • CL Data Files • NC Post Processing • Virtual Machining	Demonstration on CAM software • Creating 2D sketch • Creating 3D Model • Importing 3D Model
5	1	1,2,4	• Importance of machine parameters, tool offsets, work piece zero points, and coordinate systems Orientation of user interface (UI) of cam software.	Demonstration on CAM software • Toolpath generation • Select and upload cutting tool library • Running the Simulation for virtual verification of tool path • Generation of Part Program
6	1,2	1,2,4	**CNC Turning – Estimation, Programming and Machining** **CNC Turning** Problems on Estimation of Production Cost of given CNC turning component • Material Cost • Process Plan & Cutting Tool Parameters • Machining Cost – Facing, Plain Turning, Step Turning, Taper Turning, Grooving, Threading, Internal Turning, Drilling, etc.	Estimation of Material cost of given turning component utilizing CAM Software (Volume & Mass to be determined using CAM Software)
7	1,2	1,2,4	Problems on Estimation of Production Cost of given CNC turning component • Material Cost • Process Plan & Cutting Tool Parameters • Machining Cost – Facing, Plain Turning,	Estimation of Machining time for various operations using CAM Software

			Step Turning, Taper Turning, Grooving, Threading, Internal Turning, Drilling, etc.	
8	1,2	1,2,4	Problems on Estimation of Production cost of given CNC turning component • Material Cost • Process Plan & Cutting Tool Parameters • Machining Cost – Facing, Plain Turning, Step Turning, Taper Turning, Grooving, Threading, Internal Turning, Drilling, etc.	Estimation of Production cost of given turning component using CAM software
9	1,3,4	1,2,4	**CNC Lathe Operation** • Procedure o Plan & Optimization of CNC turning programs o Cutting Parameters Calculation o Setting References o Preparation of Operations & Sequences for lathe operations o Test Run o Inspection	• Optimization of the CNC turning program • Export the generated part program to CNC Turning machine and produce the job. • Document dimensional checks.
10	1,2	1,2,4	**CNC Milling – Estimation, Programming and Machining** **CNC Milling** Problems on Estimation of Production Cost of given CNC milling component • Material Cost • Process Plan & Cutting Tool Parameters • Machining Cost	Estimation of Material Cost of given milling component utilizing CAM Software (Volume & Mass to be determined using CAM Software)
11	1,2	1,2,4	Problems on Estimation of Production Cost of given CNC milling component • Material Cost • Process Plan & Cutting Tool Parameters • Machining Cost	Estimation of machining time for various milling operations using CAM software
12	1,2	1,2,4	Problems on Estimation of Production Cost of given CNC milling component • Material Cost • Process Plan & Cutting Tool Parameters • Machining Cost	Estimation of Production cost of given milling component using CAM software
13	1,3,4	1,2,4	**CNC Milling Operation** • Procedure o Plan & Optimization of CNC milling programs o Cutting Parameters Calculation o Setting References o Preparation of Operations & Sequences for milling operations o Test Run o Inspection	• Optimization of the CNC milling program • Export the generated part program to CNC milling machine and produce the job. • Document dimensional checks.

4. References

Sl. No.	Author	Title of Books	Publication/Year
1.	P. N. Rao	CAD/CAM Principles and Applications	Mc Graw Hill, 2017
2.	P. Radhakrishnan S. Subramanyan V. Raju	CAD/CAM/CIM	New Age International Publishers, 2018
3.	Miltiadis A Boboulos	CAD-CAM & Rapid Prototyping Application Evaluation	Bookboon, 2010
4.	T.R. Banga S.C. Sharma	Mechanical Estimation and Costing	Khanna Publishers, 2001
5.	M. Adithan	Process Planning and Cost Estimation	New Age International Publishers, 2015
6.	R. Kesavan C. Elanchezhian B. Vijaya Ramnath	Process Planning and Cost Estimation	New Age International Publishers, 2017

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max Marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all Practices and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -**V	
Course Name	Computer Aided Manufacturing			**Test**	I
Course Code	25ME52IB	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator :					
Note: Answer any one full question from each section. Each full question carries equal marks.					

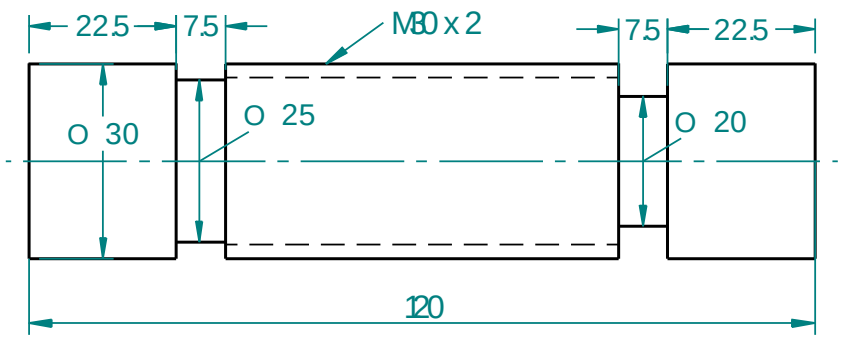
Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a) Modern CNC machines require the generation of large NC programs. Justify. b) Describe the role of CL Data Files in transferring toolpath information to the CNC machine.	Apply	CO1	

	c) Describe the key machine parameters that must be set correctly for optimal CNC machine operation.			8+8+9 =25 Marks
2	a) Describe the overall procedure of CAM in the context of NC programming. b) Discuss how simulation tools allow you to visualize the toolpath, check for collisions, and optimize cutting strategies. c) Discuss the role of coordinate systems in NC programming.	Apply	CO1	
Section - 2				
3	a) Given a CNC machine setup, identify and describe the function of the LM guideways and explain how they contribute to machining accuracy. b) Enumerate the role of a spindle motor in CNC machining and apply this understanding to select an appropriate motor for precision milling operations. c) Given a job with frequent tool changes, recommend and justify the use of an automatic tool changer (ATC) system	Apply	CO1	8+8+9 =25 Marks
4	a) Identify and explain the use of key control switches on a CNC machine panel b) Which insert and holder would you use to machine a part with both roughing and finishing operations? Justify c) Why is an automatic tool changer useful when machining complex parts?	Apply	CO1	
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

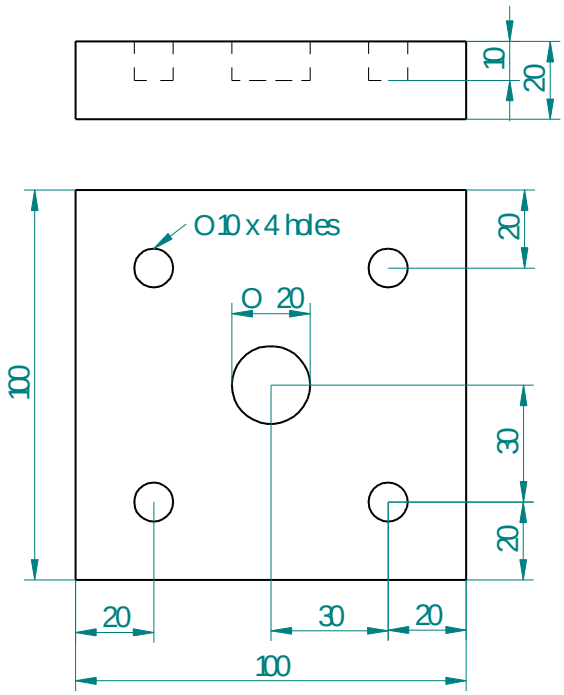
Program	Mechanical Engineering			**Semester**	V
Course Name	Computer Aided Manufacturing			**Test**	II
Course Code	20ME52IB	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					

Questions	**CO**	**Marks**
1. Question on generation of part program and estimation of production cost of given turning component using CAM software. {The component as shown below has to be machined using CNC turning center. Prepare the process planning sheet, also estimate the cost of production for the given details. Raw Material size = Ø32 × 120 *mm*. Material Cost = Rs. 120/kg. Density of raw material = 7.8 gm./cc. For turning, cutting speed = 140 m/min., Feed = 0.5 mm/rev., Depth of cut = 1.0 mm/per pass and for Threading, cutting speed = 8 m/min. Machining Cost = Rs. 625/hr. Consider missing data suitably. Also Generate part program and verify the cost of production using CAM software  All dimensions are in mm }	CO1, CO2,CO3	**50**

Scheme of assessment a. Process planning b. Estimation of cost of production (Material Cost - 05, Machining Time -10) c. Generation of Part Program (Modelling - 10, Toolpath Generation - 15) d. Verification of cost of production using CAM software	= 05 Marks = 15 Marks = 25 Marks = 05 Marks	CO2 CO2 CO1 CO3	
		Total Marks	**50**
Note for the Course coordinator: One Optional question carrying the same weightage of marks, cognitive level and course outcomes can also be given			

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

Program	Mechanical Engineering			**Semester**	V
Course Name	Computer Aided Manufacturing			**Test**	IV
Course Code	20ME52BI	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					

Questions	**CO**	**Marks**
1. Question on generation of part program and estimation of production cost of given milling component using CAM software. {The component as shown below has to be machined using CNC milling center. Prepare the process planning sheet, also estimate the cost of production for the given details. Raw Material size = 100 × 100 × 20 *mm*. Material Cost = Rs. 75/kg. Density of raw material = 7.7 gm./cc. For drilling, cutting speed = 30 m/min., Feed = 0.1 mm/rev., and Machining Cost = Rs. 400/hr. Consider missing data suitably. Also Generate part program and verify the cost of production using CAM software  All dimensions are in mm}	CO2, CO3	**50**

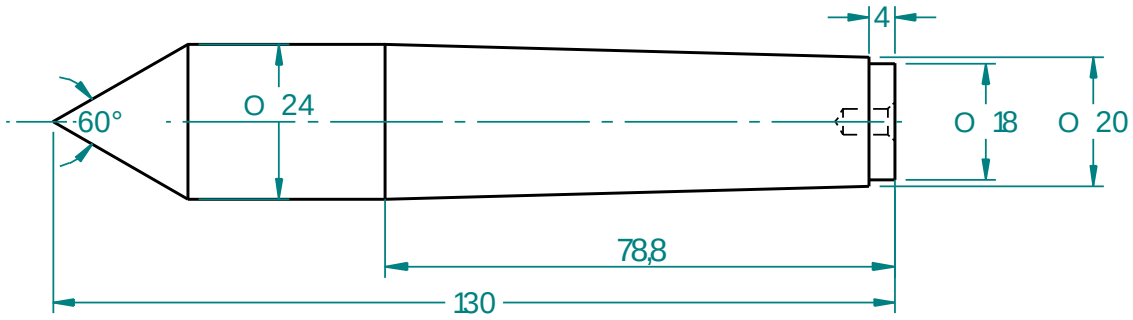
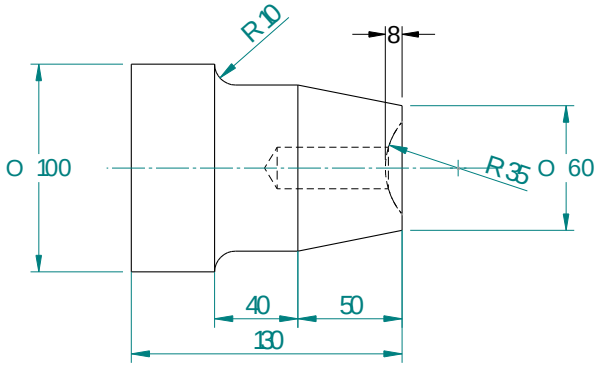
Scheme of assessment a. Process planning b. Estimation of cost of production (Material Cost - 05, Machining Time -10) c. Generation of Part Program (Modelling - 10, Toolpath Generation - 15)	= 05 Marks = 15 Marks = 25 Marks	CO2 CO2 CO3	

d. Verification of cost of production using CAM software = 05 Marks	CO3	
	Total Marks	**50**
Note for the Course coordinator: One Optional question carrying the same weightage of marks, cognitive level and course outcomes can also be given		

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
1	Prepare the given lathe dead center in CNC Turning machine. Flat end has countersink hole of dia. 4mm, depth 8mm and countersink dia. 6mm. Make a survey and collect the required missing data. Also, • Prepare Process Plan • Estimate Cost of Production • Prepare the CNC part program using CAM software • Produce the model in CNC turning center • Document Dimensional Checks  All dimensions are in mm.
2	Make a survey and collect the required missing data required for generating the CNC part program for the given component using CAM software. Also, prepare process plan. Estimate the cost of production utilizing CAM software.  All dimensions are in mm.
3.	Make a survey and collect the required missing data required for generating the CNC part program for M30 Bolt using CAM software. Also, prepare process plan. Estimate the cost of production utilizing CAM software.
4	Analyze how CAM is used in the production of a specific component, such as a turbine blade

	or a car part. Also submit the report
5	Collect Manufacturers Catalogue of CNC machine and select the model required for the particular application. Present and submit the report on selection criteria adopted.
6.	Visit nearby Industries/Workshops having CNC turning/milling machines. Study its features and applications. Present and submit its report.

10.Rubrics for Assessment of Activity (Qualitative Assessment)

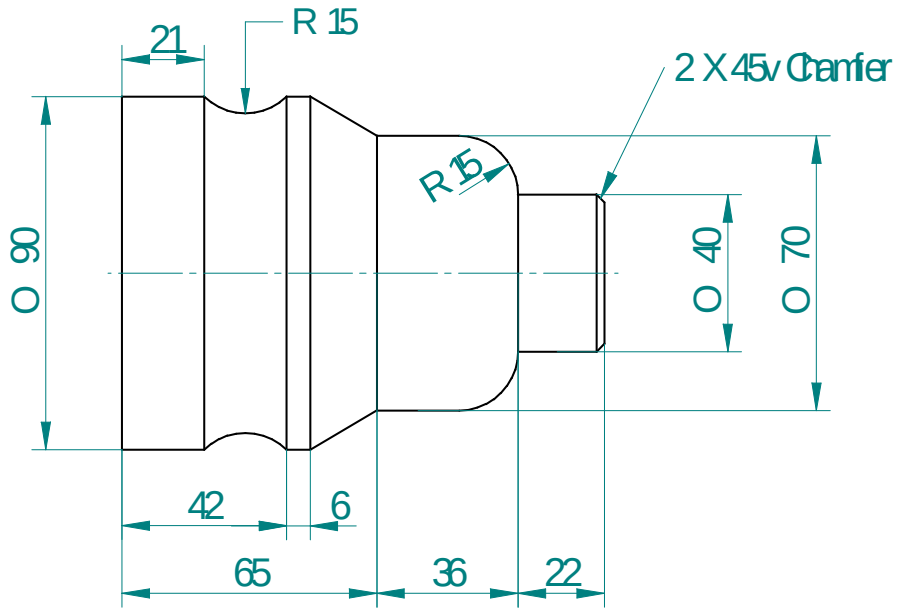
Sl. No.	Dimension	Needs Improvement	Basic	Competent	Proficient	Excellent	Students Score
		0-10	11-20	21-30	31-40	41-50	
1	Survey and Data Collection	Not collected or analyzed.	Incomplete or poorly organized, with little to no analysis	Adequate but lacks organization or clarity in some areas.	Mostly complete, with a clear structure, though some data may be less organized	Thoroughly collected & organized in a effective manner, with a well-structured analysis.	40
2	Operations / Task Carried	Not carried out properly	Partially carried, leading to some significant errors	Partially carried, but there is noticeable disorganization	Mostly carried correctly, with minor mistakes	Carefully followed, and is executed with high skill and accuracy.	40
3	Impact and Effectiveness of work/task	Fails to make an impact or is ineffective in achieving goals	Minimal impact and fall short of achieving its intended purpose	Moderate impact but could be more effective	Positive impact effectively achieving its purpose	Outstanding impact exceeding expectations	40
4	Presentation and Report submission	Missing critical information, incomplete, or unclear.	Incomplete, poorly organized, or lacks important components.	Includes some key elements but lacks clarity or detail in some areas.	Mostly complete, with minor omissions or organizational issues.	Comprehensive, well-organized, and includes all necessary details.	40
						Average Marks	**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE- Model Practice Question Paper

Program	Mechanical Engineering		**Semester**	V
Course Name	Computer Aided Manufacturing	Course Code : 25ME52IB	**Duration**	180 min
Questions			**CO**	**Marks**
1. Question on preparing the job on CNC turning center by generating the part program and estimating the production cost of given turning component using CAM software. {The component as shown below has to be machined using CNC turning center. Prepare the process planning sheet, also estimate the cost of production for the given details. Raw Material size = $\emptyset 32 \times 120\ mm$. Material Cost = Rs. 120/kg. Density of raw material = 7.8 gm./cc. For turning, cutting speed = 140 m/min., Feed = 0.5 mm/rev.,			CO3, CO4	**30**

Depth of cut = 1.0 mm/per pass and for Threading, cutting speed = 8 m/min. Machining Cost = Rs. 625/hr. Consider missing data suitably.
Also Generate part program and verify the cost of production using CAM software



All dimensions are in mm }

OR

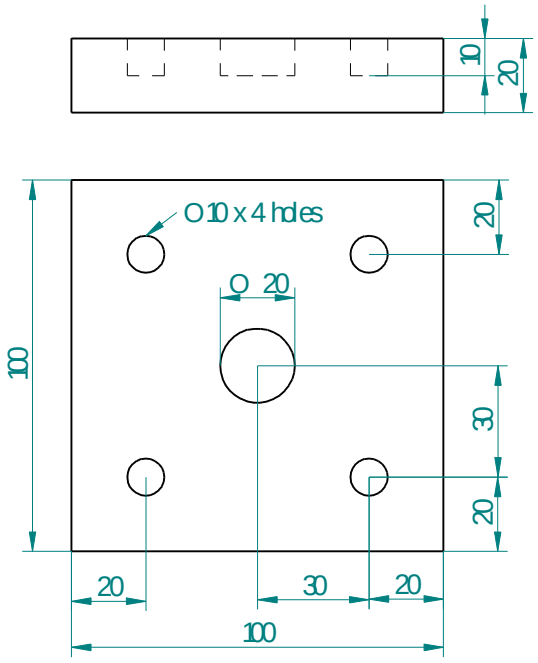
2.

Question on preparing the job on CNC milling center by generating the part program and estimating the production cost of given milling component using CAM software.

{The component as shown below has to be machined using CNC milling center. Prepare the process planning sheet, also estimate the cost of production for the given details.

Raw Material size = 100 × 100 × 20 *mm*. Material Cost = Rs. 75/kg. Density of raw material = 7.7 gm./cc. For drilling, cutting speed = 30 m/min., Feed = 0.1 mm/rev., and Machining Cost = Rs. 400/hr. Consider missing data suitably.

Also Generate part program and verify the cost of production using CAM software



All dimensions are in mm}

Scheme of assessment a. Process planning b. Generation of Part Program (Modelling - 05, Toolpath Generation - 10) c. Estimation of cost of production using CAM software (Material Cost – 05, Machining Cost – 05) d. Produce the job in CNC machine e. Dimensional Checks	= 05 Marks = 15 Marks = 10 Marks = 15 Marks = 05 Marks	
	Total Marks	**50**

1) Signature of the Examiner 1 **2) Signature of the Examiner 2**

12. Equipment/Consumables/software list with Specification for a batch of 30 students

Sl.No.	Particulars	Specification	Quantity
01	CNC Turning Centre (Tutor / Productive)	Approximate Turning Dia.: 100 mm Turning Length: 300 mm Turret head: 8 Stations Automatic Tool Changer Feature Controller: Fanuc Other Features Suitably Selected	01
02	CNC Milling Centre (Tutor / Productive)	Approximate Working Size: 250 x250 mm Working thickness: 50 mm Automatic Tool Changer Feature Controller: Fanuc Other Features Suitably Selected	01
03	CNC Simulation Software	Turning/Milling Environment	30 User
04	CAM Software (Suggested Softwares) ○ Master CAM ○ CAMotics ○ Fusion 360 ○ SolidWorks CAM ○ EdgeCAM ○ GibbsCAM)	Turning/Milling Environment	30 User
05	Desktop Computers	Latest Configuration	30
06	First Aid Kit	Workshop Standard	01

Annexure: Suggestive Model Drawings for Practice

1. Turning Models (All Dimensions are in mm)

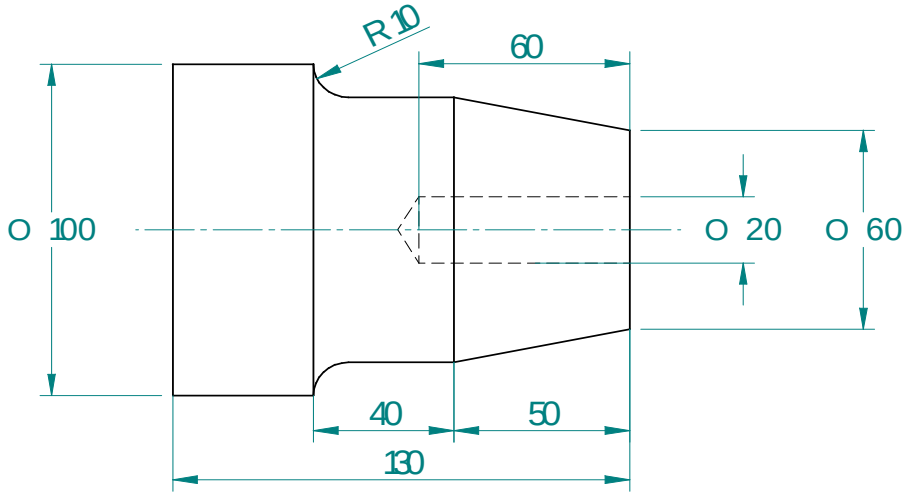


Figure 1.1

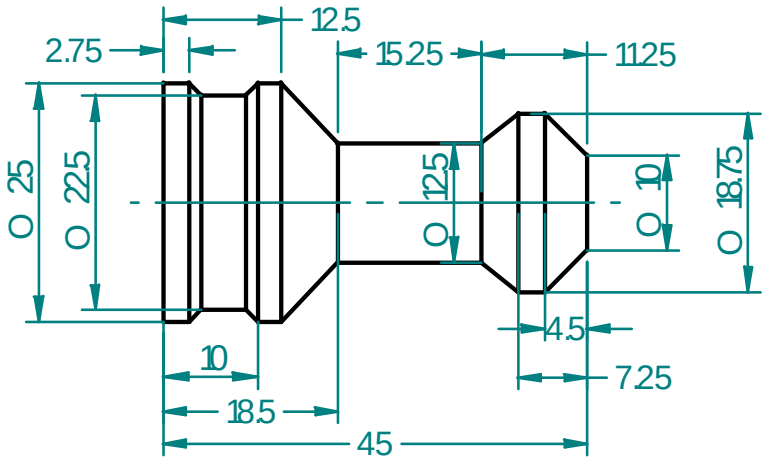


Figure 1.2

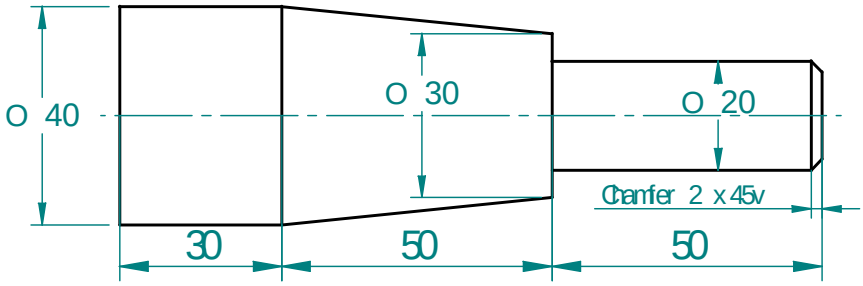


Figure 1.3

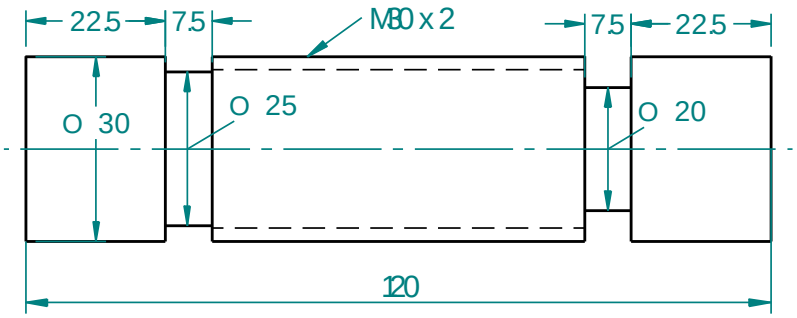


Figure 1.4

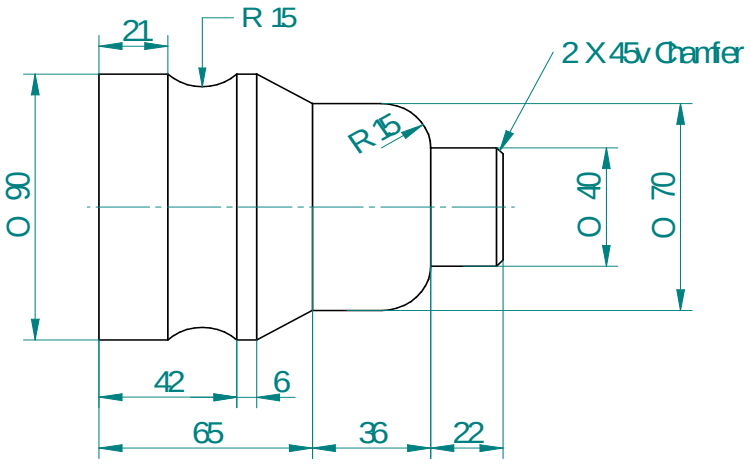


Figure 1.5

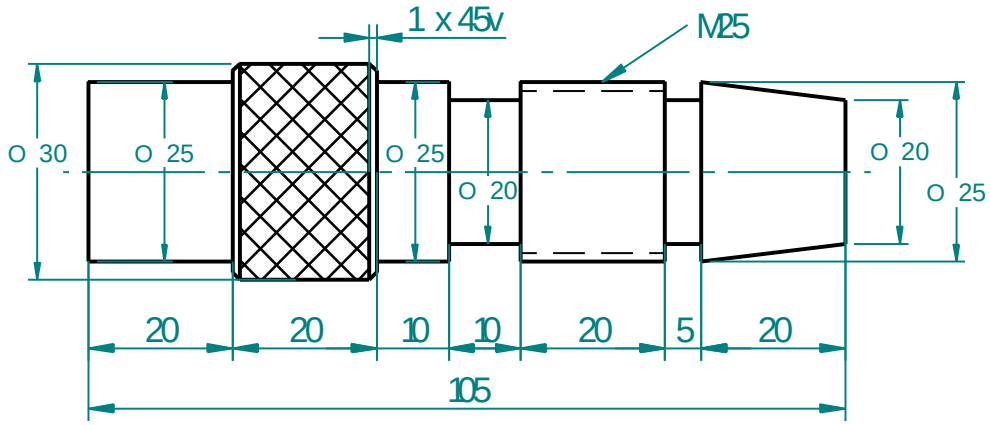


Figure 1.6

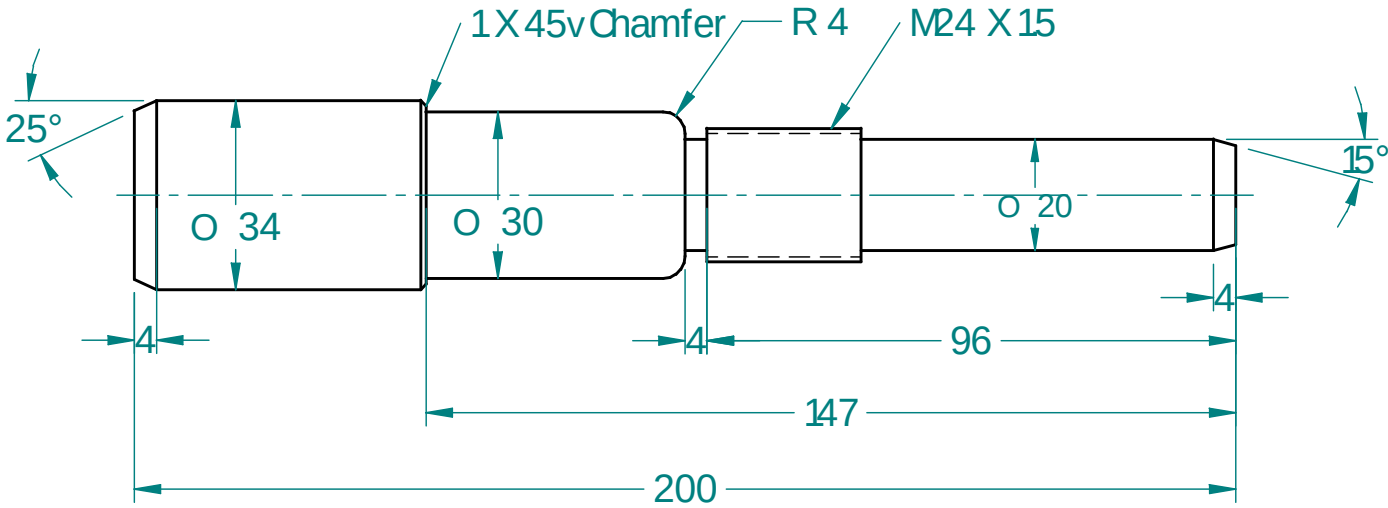
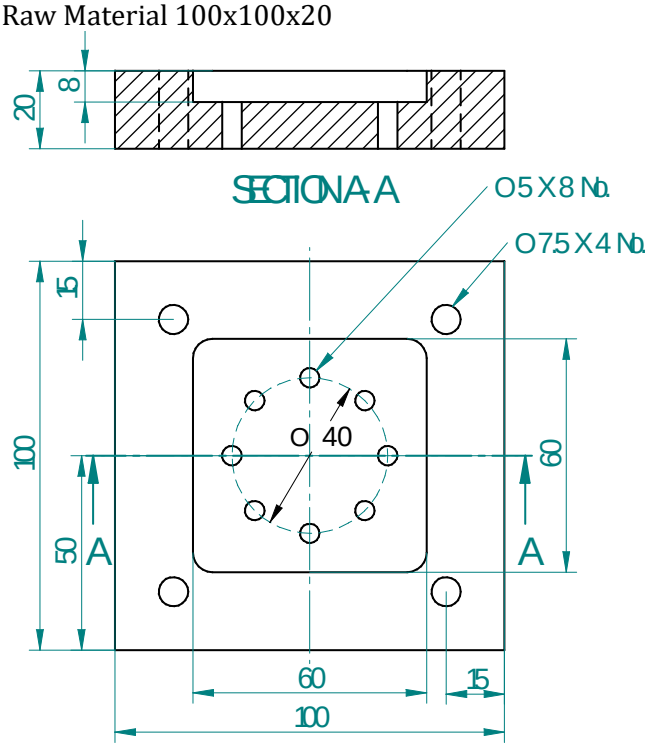


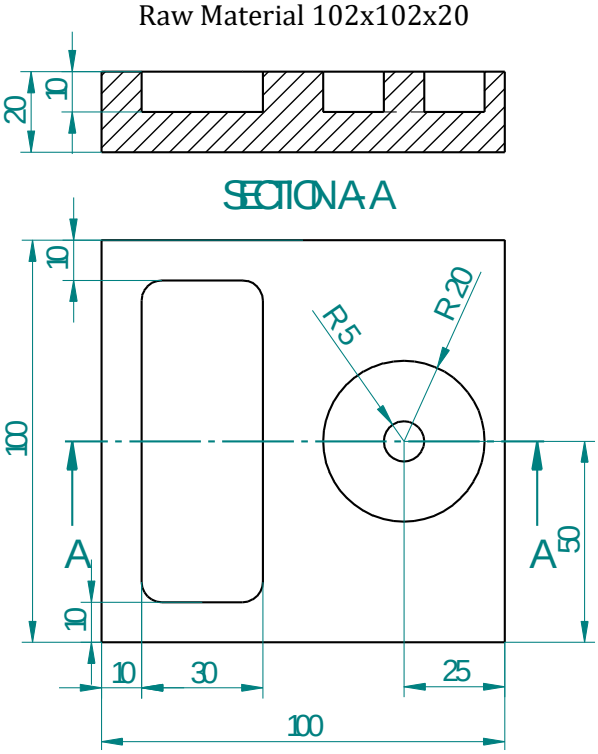
Figure 1.7

2. Milling Models

Raw Material 100x100x20



Raw Material 102x102x20



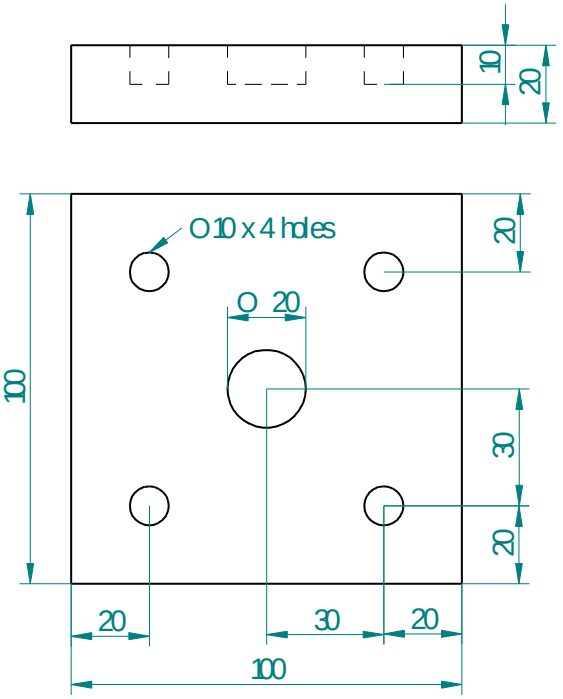
All Dimensions are in mm

Figure 2.1

All Dimensions are in mm

Figure 2.2

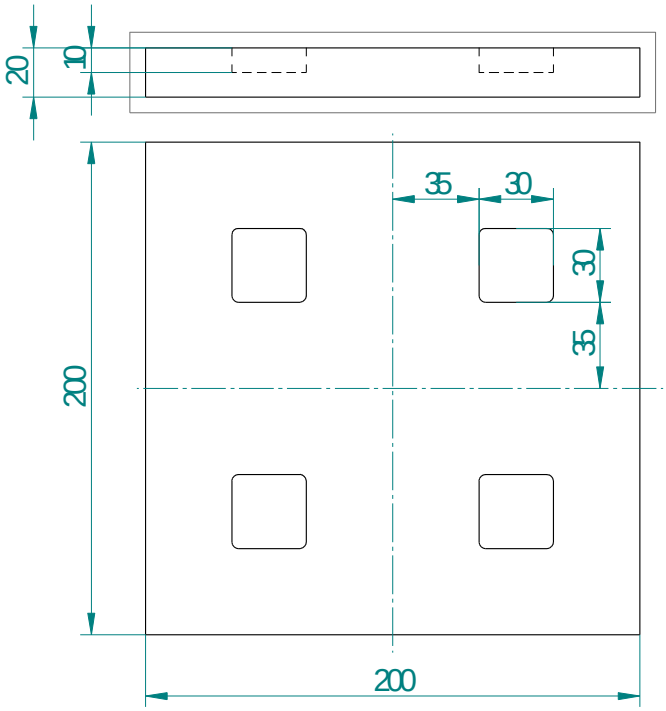
Raw Material 105x105x20



All Dimensions are in mm

Figure 2.3

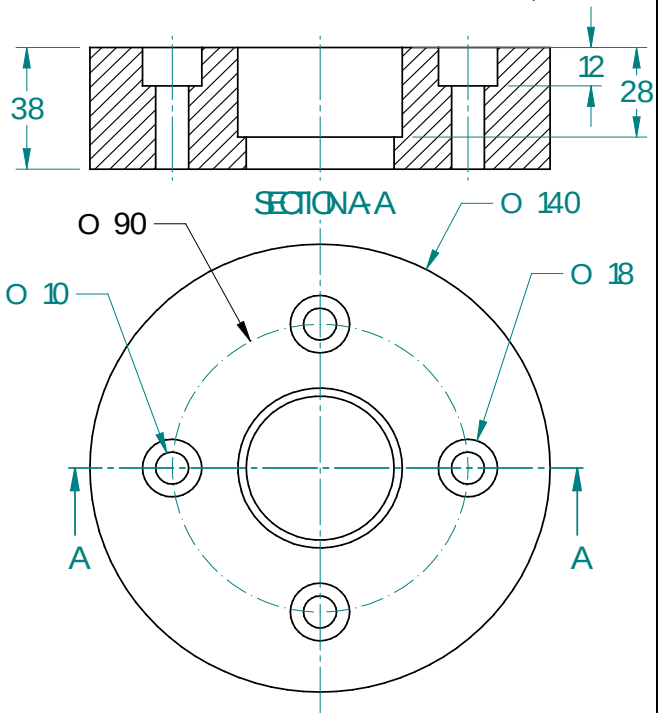
Raw Material 200x200x20



All Dimensions are in mm

Figure 2.4

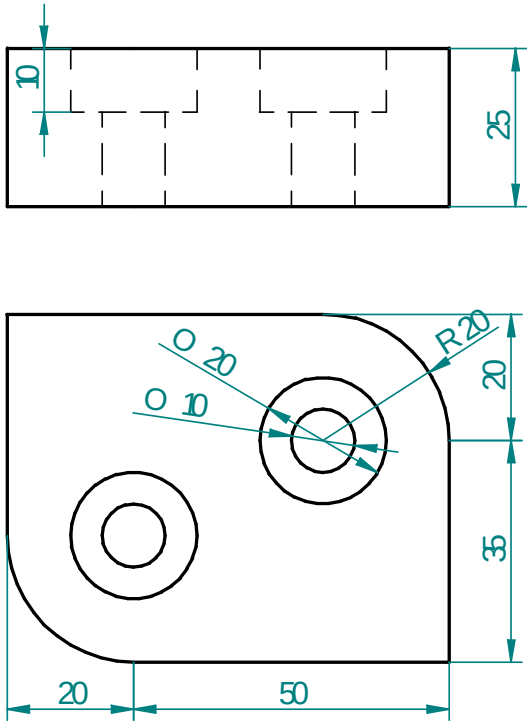
Raw Material Ø142x38



All Dimensions are in mm

Figure 2.5

Raw Material 55x55x25



All Dimensions are in mm

Figure 2.6

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Refrigeration And Air conditioning	**Type of Course**	Integrated
Course Code	25ME52IC	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale:

The curriculum on Refrigeration and Air Conditioning is meticulously designed to bridge the gap between theoretical foundations and hands-on skills required in the HVAC industry. The theoretical components cover essential thermodynamic principles such as COP, Carnot and Bell Coleman cycles, vapour compression and absorption systems, psychrometry, and the impact of refrigerants on the environment. Students are introduced to international protocols by promoting awareness of eco-friendly practices and sustainability. These concepts are reinforced through practical sessions where learners identify, dismantle, and service key components of domestic refrigerators and air conditioners. They gain experience in tasks like COP performance testing, brazing, leak testing, and handling refrigerants, ensuring technical competence.

Moreover, the course encourages forward-thinking through exposure to green building concepts and sustainable cooling technologies such as solar-powered ACs and inverter systems. This integrated approach not only strengthens conceptual understanding but also prepares students for real-world troubleshooting, installation, maintenance, and sustainability practices in modern refrigeration and air conditioning systems.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	**Evaluate** the performance of refrigeration systems by applying the principles of various refrigeration cycles.
CO-02	**Identify** various refrigerants and system components to troubleshoot common issues in domestic and industrial refrigeration applications.
CO-03	**Apply** concepts of air conditioning to assess and improve transport systems.
CO-04	**Adopt** innovative HVAC solutions for green building applications.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,4,5	**Refrigeration** • Necessity of refrigeration, unit of refrigeration, concept of COP (actual and theoretical) • Reversed Carnot cycle and its representation on PV and TS diagram	Demonstrate working of domestic refrigerator and safety precautions to be followed while troubleshooting
2	1	1.5	• Bell Coleman Cycle and its representation on PV and TS diagram with simple numerical • Air refrigeration system- components of air refrigeration system its applications	Identify electrical and mechanical components of domestic refrigerator
3	1	1,2,4	• **Vapour compression cycle** – Principle, main components, representation on PH and TS diagram • Conditions - dry compression, effect of superheating, effect of undercooling.	Conduct performance test on refrigeration kit to determine COP of the refrigerator
4	1	1,2,4	• **Vapour absorption cycle**- principle, main components. • Working of Aqua Ammonia vapour absorption system • Working of Li-Br absorption system. • Comparison between Vapour compression system & Vapour absorption cycles.	Dismantle & assemble the Domestic refrigerator
5	2	1,2,4	**Refrigerants**- desirable properties, classification, designation of refrigerant, selection of refrigerant for relevant applications, vacuumization charging processes, **leak testing methods** and process, Montreal protocol, Kyoto Protocol. concept of ozone layer depletion, greenhouse effect, global warming eco-friendly refrigerants	• Make flare joints and test them with flare fittings • Brazing of Cu to Cu, Cu to steel, Cu to brass • Test leak with soap solution & Braze the leak spots
6	2	1	**Refrigerator components**: **Compressor** – principle of working and constructional details of reciprocating and rotary compressors, hermetically and semi hermetically sealed compressors.	• Identify the components of domestic refrigerator and list their functions. • Identify the types of compressor used in domestic refrigerator.
7	2	1	**Refrigerator components:** **condensers**- principle of working and constructional details of air cooled and water cooled condensers, evaporative condensers - advantages and disadvantages.	• Identify the condenser coil used in domestic refrigerator. • Clean the condenser coils of the Domestic refrigerator and inspect for any damage or obstructions.

8	2	1,4	**Refrigerator components**: **Evaporators** –classification, working of Finned type, bared tube, plate type, shell and tube type evaporators their applications. **Other components**-dryer, solenoid valve, thermostatic switch, defrosting device working and applications.	• Identify the type Evaporator used in domestic refrigerator. • Service the Evaporator cabin of the Domestic refrigerator
9	3	1,4	**Air conditioning**- • **Psychometrics** - Psychometric terms-Dry Air, Moist Air, Saturated Air, Degree of Saturation, Dry Bulb Temperature, Wet Bulb Temperature, Humidity, Absolute Humidity, Relative Humidity, Specific Humidity, Humidity Ratio with simple problems. • **Working of** Split AC & Window AC along with its difference.	• Identify the components of a split AC & window AC system and list their functions. • Servicing of split AC & Window AC.
10	3	1,2,3,4	**Human Comfort-** • Factors affecting human comfort, Comfort parameters, IAQ (Indoor air Quality): Causes & Sources of Indoor Air Quality, Indoor Air Pollutants, Indoor Air Quality Regulations, ASHRAE Guidelines and Standards • **Thermal Insulation-** Basic Materials and Thermal Properties, Moisture Content of Insulation Material, concept of conduction, convection & Radiation, Economic Thickness, Thermal Resistance of Airspaces	Design an air conditioning system for a computer lab (15 ft × 20 ft) with 10 computers. Calculate the heat load and recommend suitable AC components including type of AC (Split/Window), capacity, refrigerant, and basic layout.
11	3	1,2,3,4	**Transport Air Conditioning** - automobile air conditioning, railway air-conditioning, marine air conditioning - aircraft air conditioning	Design a basic air conditioning system for a small passenger car.
12	4	1,5,7	**Green Buildings** • Discuss Green building and its importance in sustainable Planning • Characteristics of green buildings • Concept of REDUCE, REUSE and RECYCLE • Demonstrate Life Cycle Assessment LEED (Leadership in Energy and Environmental Design) Certification, Requirements, Benefits	Prepare Recommendations to convert your institute into a green building or consider any other building under construction
13	4	1,4,5,7	**Eco-Friendly and Sustainable Cooling:** Next-Generation Refrigerants, Solar-Powered AC, Thermally Driven Cooling, Evaporative Cooling, Inverter ACs	Prepare a Report on Advanced Techniques for Eco-Friendly and Sustainable Cooling

4. References

Sl. No.	Author(s)	Title of Books	Publication/Year
1	R S Kurmi and J K Gupta	A Text Book of refrigeration and Air conditioning	S Chand
2	C P Arora	A Text Book of refrigeration and Air conditioning	McGraw-Hill Education/2017
3	S.S Thipse	Refrigeration and Air Conditioning	Jaico publications
4	A. S. Sarao, G.S. Gabbi, Gaurav Aggarwal	Refrigeration and Air Conditioning	Satya Prakashan
5	Dossat Roy Joseph	Principles of Refrigeration	Pearson Education India

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all Practices and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	Refrigeration And Air conditioning			**Test**	I
Course Code	25ME52IC	**Duration**	90 min	**Marks**	50

Name of the Course Coordinator:				
Note: Answer any one full question from each section. Each full question carries equal marks.				
Q. No	**Questions**	**Cognitive Level**	**Course Outcome**	**Marks**
	Section - 1			
1	a. Discuss with the help of TS and HS diagrams the working of vapour compression Refrigeration system.	Apply	CO1	10
	b. Why in practice a throttle valve is used in vapour compression refrigerator rather than an expansion cylinder to reduce pressure between the condenser and the evaporator	Apply	CO1	10
	c. Enumerate the effects of super on COP	Apply	CO1	05
2	a. Discuss with the help of TS and HS diagrams the working of vapour absorption Refrigeration system.	Apply	CO1	10
	b. Differentiate between vapour absorption and vapour compression refrigeration system	Apply	CO1	10
	c. Discuss the effect of under cooling on COP. Why Would you desire large under cooling?	Apply	CO1	05
	Section – 2			
3	a. A Refrigeration working on Bell-Coleman cycle operates between pressures limits of 1 bar and 8.5 bar. Air is drawn from the cold chamber at 100C and it is cooled to 300C before entering the expansion follow the law PV ^ 1.35 = C Determine theoretical COP of the system	Apply	CO1	10
	b. Discuss with block diagram Carnot refrigeration Cycle	Apply	CO1	10
	c. Illustrate how Bell-Coleman Cycle contribute to the cooling effect	Apply	CO1	05
4	a. A Refrigeration working on Bell-Coleman cycle operates between pressures limits of 1 bar and 6 bar. Air is drawn from the cold chamber at 100C and it is cooled to 300C before entering the expansion follow the law PV ^ 1.35 = C Determine theoretical COP of the system	Apply	CO1	10
	b. Illustrate the Working of air refrigeration system with its applications	Apply	CO1	10
	c. Discuss the advantage and disadvantages of air refrigeration system	Apply	CO1	05
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	**V**
Course Name	Refrigeration And Air conditioning			**Test**	**II**
Course Code	25ME52IC	**Duration**	**180 min**	**Marks**	**50**
Name of the Course Coordinator:					

	Questions	**CO**	**Marks**
1.	Conduct performance test on refrigeration kit to determine COP of the refrigerator	CO1	30
2.	Identify the components of refrigerator and list there functions.	CO2	10

3.	Discuss different refrigerants with their impact on environment and suggest suitable measures to overcome it.	CO2	10

Scheme of assessment for Q1 1.observation & Tabular column=10 (5+5) Marks 2. Conduction = 10 Marks 3. Calculation=5 Marks 3. Result =5 Marks	**Scheme of assessment for Q2** 1.Identification of components = 5 Marks 2.List of functions of identified components= 5 Marks	**Scheme of assessment for Q3** 1.List of refrigerants with their impact = 5 Marks 2.List of suitable measures to overcome it = 5 Marks

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Prepare a working model of portable AC
02	Prepare a report on Automotive Air Conditioning.
03	Prepare Recommendations to convert your Home into a Green Buildings
04	Prepare a report on impact of refrigerants on global warming.
05	Prepare a Report on Advanced Techniques for Eco-Friendly and Sustainable Cooling

10. Rubrics for Assessment of Practical exercises and activities (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Content Accuracy	Major errors, lacks key points.	Some inaccuracies or missing details.	Mostly accurate, minor gaps.	Accurate and well-covered.	Fully accurate and detailed.	45
2	Research Depth	Little to no research done.	Limited research or incomplete.	Adequate research, covers basics.	Well-researched, includes examples.	Extensive, insightful research.	42
3	Clarity & Organization	Disorganized and unclear.	Somewhat clear, needs better flow.	Mostly clear with minor issues.	Clear and well-structured.	Very clear, logical, and engaging.	35
4	Visuals & Creativity	No visuals or poorly designed.	Basic visuals, lacks creativity.	Adequate visuals, some creativity.	Good visuals, engaging design.	Exceptional visuals and creativity.	40
5	Overall Quality	Poor quality, lacks professionalism.	Basic quality, needs improvement.	Satisfactory quality, minor flaws.	High quality, polished work.	Professional-level quality.	45
	Average Marks=(45+42+35+40+45)/5=42						**42**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE- Model Practice Question Paper

Program	Mechanical Engineering			**Semester**	**V**
Course Name	Refrigeration And Air conditioning				
Course Code	25ME52IC	**Duration**	180 min	**Marks**	**50**
Answer all the questions					

Questions	**CO**	**Marks**
1. Conduct performance test on refrigeration kit to determine COP of the refrigerator.	1	30
2. Perform the thermal conductivity experiment on a composite wall and determine the thermal conductivity of the given material. Record all observations, calculations, and analyze the results.	3	10
3. Mention any five requirements that the building should satisfy to obtain LEED certificate and mention any five benefits.	4	10

Scheme of assessment **Scheme of assessment for Q1**	**Scheme of assessment for Q2**	**Scheme of assessment for Q3**
1.observation & Tabular column=10 (5+5) Marks 2. Conduction = 10 Marks 3. Calculation=5 Marks 3. Result =5 Marks	1. Conduction= 5 Marks 2. Calculation and results = 5 Marks	1. Five requirements = 5 Marks 2.Five Benefits = 5 Marks
		Total Marks **50**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	**Particulars Required**	**Specifications**	**Quantity**
1	Refrigeration test rig	-	1
2	Thermal Conductivity Setup for thick slab, thick cylinder & composite wall	-	1
3	domestic refrigerator	-	1

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Design for Manufacturing and Assembly	**Type of Course**	Integrated
Course Code	25ME52ID	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale - The DFMA syllabus teaches students how to design products that are cost-effective, easy to manufacture, and simple to assemble. It covers key concepts like reducing part count, standardizing components, and choosing the right manufacturing processes to make production smoother and cheaper. Students will practice applying these ideas through real-world examples and using DFMA software tools to improve product designs.

The course also focuses on other important topics like lean manufacturing, prototyping, and understanding tolerances. Students learn how to make smart design choices that save time and money, while ensuring the product is easy to assemble. Hands-on exercises, such as analyzing products and testing prototypes, help students apply their knowledge to real-life situations, preparing them to design efficient, manufacturable products.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	**Use** DFMA principles to improve product designs by reducing parts, choosing the right manufacturing processes, and making assembly more efficient.
CO-02	**Apply** principles of standardization and cost efficiency to design products that reduce costs, improve assembly, and reduce manual work.
CO-03	**Integrate** tolerancing, DFMA tools, and lean manufacturing to optimize designs, reduce waste, and improve assembly efficiency.
CO-04	**Develop** 3D printing and prototyping to test and improve product designs for manufacturability and assembly.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1		**Introduction to DFMA:** • Definition and Importance of DFMA • Key Principles of DFMA • Impact of DFMA on Cost, Quality, and Time-to-Market	• Analyze a product (e.g., simple household item) and identify areas where DFMA principles could be applied.
2	1		**Manufacturing Process Selection:** • Overview of Common Manufacturing Processes (Casting, Machining, Injection Molding, etc.) • Effect of Material Selection for Manufacturability • Process Constraints in Design • Concept of PFMEA (Process Failure Mode and Effects Analysis)	• Visit a local manufacturing facility or use simulation tools to see process constraints in action.
3	1		**Design for Assembly (DFA) Principles:** • Key DFA Principles: Reducing Part Count, Minimizing Fasteners, Standardizing Parts • Cost-Effective Assembly Design • Strategies for Efficient Assembly: Tooling, Handling, and Insertion	• Using a simple product design, determine how to reduce parts and simplify the assembly process.
4	1		**Part Count Reduction:** • The Role of Part Count in DFMA • Techniques for Part Consolidation: Multi-functional Parts, Modular Design • Effects of Part Count on Production Costs and Assembly Time	Analyze a product (e.g., a toy or small appliance) and propose ways to reduce its part count without compromising functionality.
5	2		**Standardization of Parts:** • Benefits of Using Standardized Components • Commonly Used Standardized Fasteners, Bearings, and Parts • Integration of Standard Components in a Design • Concept of DFMEA (Design Failure Mode and Effects Analysis)	Assemble a product using standard components and compare the time and cost to a custom design.
6	2		**Design for Cost Efficiency:** • Cost Drivers in Manufacturing: Material, Labor, Overhead • Cost Reduction Strategies: Design Simplification, Standardization, and Process Optimization • Calculating Manufacturing Cost Estimates	Using a sample design, estimate the manufacturing cost based on materials, labor, and process selection.
7	2		**Assembly and Handling Efficiency:** • Ergonomics in Assembly Design • Design for Easy Handling: Orientation,	Design and test a product assembly process using minimal manual effort.

			Weight Distribution • Tools and Fixtures for Efficient Assembly	
8	3		**Tolerancing and Fits:** • Geometric Dimensioning and Tolerancing (GD&T) Basics. • Types of Fits (Clearance, Interference, Transition). • Effect of Tolerances in Manufacturing and Assembly.	Using a simple part design, apply and adjust tolerances to optimize manufacturability and assembly.
9	3		**DFMA Software Tools:** • Overview of DFMA Tools (e.g., DFMA by PTC, Creo, SolidWorks, etc.) • Use of DFMA Software for Design Evaluation • Interpreting DFMA Reports	Load a product design and evaluate it for manufacturability and assembly using DFMA software.
10	3		**Product Design for Lean Manufacturing:** • Lean Manufacturing Overview • Eliminating Waste in Design and Assembly • Aligning DFMA with Lean Manufacturing Goals	Identify waste in an existing product design and suggest DFMA changes to eliminate it.
11	4		**Prototyping and Testing DFMA Designs:** • Prototyping Techniques: Rapid Prototyping, 3D Printing, and Traditional Methods	Create a prototype using 3D printing or simple modeling techniques to test DFMA changes.
12	4		Validating DFMA Principles through Prototype Testing	Create a prototype using 3D printing or simple modeling techniques to test DFMA changes.
13	4		Iterative Design and Testing for Manufacturability and Assembly	Create a prototype using 3D printing or simple modeling techniques to test DFMA changes.

4. References:

Sl. No.	Author	Title of Books	Publication/Year
1.	G. K. Lal	Design for Manufacture and Assembly	Pearson India, 2017
2.	R. K. Jain	Manufacturing Processes	McGraw Hill Education, 2014
3.	C. M. Chitale and R. C. Gupta	Product Design and Development	Prentice Hall India, 2016
4.	K. L. Narayana	Engineering Design	Scitech Publications, 2011
5.	V. B. Bhandari	Design of Machine Elements	McGraw Hill Education, 2017
6.	J. E. Shigley (Indian Edition)	Mechanical Engineering Design	McGraw Hill Education, 2011
7.	S. A. Kumar	3D Printing and Additive Manufacturing	Principles and Applications, Springer, 2018
8.	A. B. Gupta	Product Design and Manufacturing	PHI Learning, 2013

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5.	CIE-5 Portfolio evaluation of Practices and Activities through Rubrics	1-13	-	50	
Total					**50 Marks**

6. SEE - Practical Assessment Methodologies

Sl.No	SEE – Practice Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practical	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering		**Semester- V**
Course Name	DFMA		**Test I**
Course Code	25ME52ID	**Duration**- 90 min	**Marks-50**
Name of the Course Coordinator:			
Note: Answer any one full question from each section. Each question carries equal marks.			

Q. No	Questions	CL	CO	Marks
	Section – 1			
1	a. How can DFMA principles be applied to redesign a household appliance to reduce manufacturing costs and assembly time? Provide specific examples of design changes. b. For a mechanical part like a gear, what manufacturing process would you use? How does the material choice affect the process and design? c. Discuss the factors should be considered when selecting materials for manufacturability in a product design. d. How do different manufacturing processes, like casting, machining, and injection molding, differ in terms of their suitability for various product designs?	Apply	1	**7+7+6 +5 = 25 Marks**
2	a. Given a product design, identify areas where DFMA principles could be implemented to improve quality and reduce time-to-market. Discuss the impact of each change on the overall product lifecycle. b. If you're designing a metal part with a complex shape, which manufacturing process would you pick? What factors would you need to consider for efficient production? c. How do process constraints in design affect the choice of manufacturing methods and material selection? d. Discuss the advantages and limitations of using injection molding compared to machining for producing small, complex parts.	Apply	1	**7+7+6 +5 = 25 Marks**
	Section – 2			
3	a. How does reducing the part count in a product design impact assembly time and production costs? Provide an example of a product where part count reduction was beneficial. b. In what ways can efficient tooling, handling, and insertion strategies contribute to a faster and more cost-effective assembly process?	Apply	1	**7+7+6 +5 = 25 Marks**

	c. Discuss the potential effects of reducing part count on production costs, and how does it impact assembly time and overall product cost? d. Discuss the concept of multi-functional parts and how they can be used to reduce part count in a product design.			
4	a. How would you apply DFA principles to redesign a simple electronic device, such as a remote control, to reduce part count and improve assembly efficiency? What specific design changes would you propose? b. Summarize how minimizing the number of fasteners can contribute to a more efficient assembly process. c. How does standardizing parts in a design help reduce assembly complexity and improve manufacturing efficiency? d. Discuss the concept modular design, and how can it help in reducing the number of parts while maintaining functionality?	Apply	1	**7+7+6 +5 = 25 Marks**
Note for the Course coordinator: Each question may have two, three, four and five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	DFMA			**Test**	II
Course Code	25ME52ID	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator: **Note:** Answer any one full question from the following					
Questions				**CO**	**Marks**
1. **a.** Consider the design of a mechanical component such as a **Bracket for mounting an engine**. • Apply DFMA principles to reduce the part count, simplify the assembly process, and optimize manufacturability. • Suggest how the choice of material, process, and part consolidation could reduce overall production costs and improve assembly efficiency.				1	25
b. Consider the design of a **plastic injection molded casing** for an electronic device. • Estimate the total manufacturing cost by analyzing material costs, labor, and the injection molding process. • Identify the factors affecting cost in the design and suggest improvements in material selection or process that would reduce costs while maintaining performance and durability.				2	25
OR					
2. **a.** Consider the design of a mechanical component such as a **Gear box**. • Apply DFMA principles to reduce the part count, simplify the assembly process, and optimize manufacturability. • Suggest how the choice of material, process, and part consolidation could reduce overall production costs and improve assembly efficiency.				1	25
b. For the sample design of a **machined aluminum bracket** - • Estimate the manufacturing cost by considering the material cost, labor cost, and machining process. • Break down the cost for each factor and propose ways to reduce the overall manufacturing cost while maintaining product quality				2	25

Scheme of Evaluation
1. a. • Part Count Reduction - 4 Marks, Simplification of Assembly - 4 Marks, Selection of Material - 6 Marks, Process Selection - 6 Marks, Part Consolidation and Design Optimization – 5 Marks 1. b. • Material Cost Estimation - 7 Marks, Labor Cost Estimation - 7 Marks • Process Cost Estimation - 6 Marks, Cost Reduction Suggestions - 5 Marks
2. a. • Part Count Reduction - 3 Marks, Simplifying the Assembly Process- 3 Marks, Material Selection and Cost Optimization – 5 Marks, Process Selection and Cost Efficiency - 5 Marks, Part Consolidation and Design Optimization - 5 Marks, Assembly Efficiency - 4 Marks 2. b. • Material Cost Estimation - 7 Marks, Labor Cost Estimation - 7 Marks • Process Cost Estimation - 6 Marks, Cost Reduction Suggestions - 5 Marks

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	While designing the plastic housing for an electronic device, multiple small parts, screws, and internal components that need to be assembled. **Question:** • Apply DFMA principles to identify areas where the part count can be reduced in the current design of the plastic housing. • Analyze the choice of material and suggest a more cost-effective material for manufacturing the housing, keeping in mind the required strength, durability, and aesthetic appeal. • Propose strategies for improving the assembly process (e.g., reducing the number of fasteners or simplifying the insertion process). • Estimate how these changes could reduce manufacturing costs and assembly time.
02	You are tasked with redesigning the assembly of a kitchen appliance (e.g., a blender) to make it more cost-effective and easier to assemble. The current design has 15 individual parts that must be fastened together using screws and bolts, leading to high labor costs and a lengthy assembly process. **Question:** • Using DFMA principles, identify potential areas for reducing the number of parts in the appliance's design without compromising its functionality or performance. • Propose a strategy for part consolidation, including multi-functional parts or modular designs, to reduce part count. • How could you apply standardization of parts (e.g., fasteners, bearings) in the redesign to further simplify the assembly process? • Estimate the potential savings in labor costs and production time after applying these changes and explain how the changes would impact overall product quality and cost.
03	Apply 3D printing technology to reduce part count, and ease of manufacturability and assembly.

10. Rubrics for Assessment of Exercises (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Knowledge and Understanding	No understanding of DFMA concepts.	Significant gaps in understanding, struggles to explain concepts.	Basic understanding with gaps in key concepts.	Strong understanding but lacks depth in some areas.	Excellent understanding of DFMA, can explain complex ideas.	40
2	Application and Problem Solving	Cannot solve problems or apply DFMA concepts effectively.	Struggles with problem-solving, incomplete solutions.	Solves problems with standard methods but lacks depth.	Solves problems effectively but not always optimally.	Solves complex problems creatively and efficiently.	40
3	Communication and Presentation	Ineffective communication, ideas poorly organized or unclear.	Unclear and disorganized communication. Visuals/data are not effective.	Adequate communication but lacks clarity in some areas.	Communicates clearly, but some ideas lack precision.	Clear, professional, and effective communication. Uses visuals/data well.	30
4	Critical Thinking and Evaluation	No critical evaluation, lacks alternatives or trade-offs.	Minimal evaluation and unclear suggestions for improvements.	Limited evaluation and few suggestions for alternatives.	Evaluates designs well but may miss some alternatives or trade-offs.	Excellent evaluation of designs, suggests multiple alternatives and assesses trade-offs.	40
5	Collaboration and Teamwork	Does not contribute to teamwork or engage with others.	Limited participation in teamwork, minimal engagement.	Participates in teamwork but is mostly passive or follows others.	Works well with the team, engages in discussions but could take more initiative.	Actively contributes, encourages and values others' input.	50
	Average Marks=(40+40+30+40+50)/5=40						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE–Model Practice Question Paper

Program	Mechanical Engineering	**Semester**	V
Course Name	DFMA	**Marks**	50
Course Code	25ME52ID	**Duration**	180 Min
Note: Answer any one full question. Each full question carries equal marks.			

Q No	Questions	Cognitive Levels	Course Outcomes	Marks
	Section -1			
1	a. Consider the design of a mechanical component - **Fastener**. Apply DFMA principles to reduce the part count, simplify the assembly process, and optimize manufacturability. Suggest how the choice of material, process, and part consolidation could reduce overall production costs and improve assembly efficiency. b. Create a 3D prototype to physically test the design changes. Evaluate the prototype based on factors such as ease of assembly, part interaction, and manufacturability. Compare the modified design to the original design in terms of production efficiency and cost.	Apply	1 2	25 25
2	a. Consider the design of a mechanical component such as a **Gear box**. Apply DFMA principles to reduce the part count, simplify the assembly process, and optimize manufacturability. Suggest how the choice of material, process, and part consolidation could reduce overall production costs and improve assembly efficiency. b. For a simple shaft, apply geometric dimensioning and tolerancing (GD&T) to the design. Adjust the tolerances and analyze how these changes impact manufacturability, assembly ease, and cost. And justify why these changes will improve the overall process.	Apply	1 2	25 25

12. Equipment/softwarelistwithSpecificationforabatchof30students

Sl. No.	Particulars	Specification	Quantity
01	Desktop Computers	Latest specifications	30
02	CAD Software	Solid edge, Solid works or any other similar software's	30
03	3D Printers	Latest	02

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Electric Vehicle Technology	**Type of Course**	Integrated
Course Code	25ME52IE	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale:

The Electric Vehicle Technology aims to provide participants with foundational and advanced knowledge of Electric Vehicle (EV) technology, from basic components to advanced systems. With the global shift toward sustainable transportation, understanding EVs and their systems has become crucial. This course is designed for beginners but also dives into more hands-on, practical knowledge essential for working in EV technology. Students will gain both theoretical insights and practical experience with EV components like motors, batteries, controllers, charging systems, and regenerative braking, making them well-equipped for careers in EV design, maintenance, and development.

By completing this course, students will gain a **holistic perspective on EV technology**, including its challenges, emerging trends, and industry applications. This will equip them with **theoretical knowledge and practical expertise** to work in the rapidly evolving electric mobility sector.

2. Course Outcomes

CO-01	**Evaluate** the fundamentals of Electric Vehicles (EVs), including their types, powertrain components, and key differences from internal combustion engine (ICE) vehicles.
CO-02	**Analyze** EV motor technologies, control strategies, and transmission systems, demonstrating practical applications in motor speed control and efficiency optimization.
CO-03	**Assess** EV battery technologies, charging methods, and Battery Management Systems (BMS), performing practical experiments on battery charging, discharging, and state
CO-04	Implement regenerative braking, thermal management, and EV control systems, optimizing energy recovery, cooling techniques, and vehicle stability control.
CO-05	**Diagnose** and troubleshoot EV faults using OBD-II and other diagnostic tools, compare maintenance requirements with conventional vehicles, and **predict** future trends in EV technology.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	01		**Introduction to Electric Vehicles (EVs)** • **Overview:** Need of electric vehicles, Dependence on oil and oil imports, India GDP loss for oil imports, Pollution levels in India, Greenhouse gases from fossil fuels and global warming, Various Commitments made by India for zero carbon mobility, Technological breakthrough in batteries and how companies like Tesla, Ather changed the mind set of people • **History and evolution of EV technology:** Early development of electric vehicles, why electric vehicle lost market, Advances in battery technology	• Video on Overview to Electric Vehicles (EVs) • Identify and handle different types of tools and workshop equipment in the EV Auto workshop following safety precautions. Document the details.
2	01		**Electric Vehicle Powertrain** • Electric Vehicles – Types, Key differences between these types • Key benefits (environmental, economic, Technological innovation and energy efficiency) and Challenges • Power train components and its functions, Architecture of Electric Vehicle, working principle of fully electric vehicle • Differences between internal combustion engine (ICE) and electric drive trains	• List all the Electric vehicles manufactured in India and abroad and find out their specifications of major components • Dismantle an old electric scooter and place all the components on a platform keeping the wiring intact. Measure the voltages at various points in the circuit. Identify the various components and name them on a panel.
3	02		**Electric Motors** • List different types • Working principles and Comparison of 1. Brushless DC Motor (BLDC) 2. Synchronous Reluctance Motor (SynRM) 3. Switched Reluctance Motor (SRM) 4. Brushed DC Motor (BDC) (Less Common) • Motor Selection Considerations • Brushless DC Motor - Speed control system of brushless DC motor, efficiency, calculation	• Conduct experiment on BLDC motor with PWM-based speed control and analyze speed variations. Also, calculate efficiency by analyzing power input, output, and losses using Hardware/ Simulation
			EV Batteries • Typical battery terminologies • Types and construction features of EV	• Test Li-ion battery charging

4	03		batteries: Lithium-Ion (Li-ion), Solid-State Batteries, Nickel-Metal Hydride (NiMH), Lead-Acid (used less frequently) • Battery shapes, Assembly of a battery pack, related calculations • Battery charging, CC-CV charging. • Charging and discharging characteristics of EV batteries	profile with CC-CV charging. Observe voltage, current, and temperature variations. Also, Measure Charging & Discharging, Characteristics of an EV Battery • Use Hardware/ Simulation
5	03		**EV - Battery Management Systems (BMS)** • Why Li-ion battery needs a BMS, why lead acid batteries worked without BMS? • BMS Architecture - BMS Functional Blocks (Sensing, Control, Protection, Communication), Functions of Voltage Current & Temperature Sensors, Battery Management ICs, Microcontrollers & Communication Modules • Types of BMS: Centralized, Distributed, and Modular • BMS Functionalities – Battery Monitoring, State Estimation, Cell Balancing, Thermal Management, Fault Diagnosis & Protection	• Conduct test on functional blocks in a BMS module and Measure voltage, current, and temperature using Hardware/Simulation • Also, Determine state estimation (SOC, SOH, SOP)
6	03		**Charging Systems and Infrastructure** • EV charging basics: Charging levels (Level 1, Level 2, DC Fast Charging) • Key charging standards- IEC 62196, SAE J1772 • Types of charging connectors used Type 1, Type 2, CCS, CHAdeMO, and J3400 • Connectors used by Indian EV's and ports • Charging stations: Types, Components (AC/DC chargers), Grid integration & power flow in EV charging • Charging infrastructure	• Analyze Charging Levels, Connectors and **charging power flow and grid integration** in an EV charging setup using Hardware/ Simulation
7	04		**Electric Vehicle Control Systems** • EV control systems: 1) Power electronics – Functions of Inverters, DC-DC converters 2) Controllers – Functions of PID, FOC, Vector Control 3) Basics of Pulse Width Modulation (PWM) and motor driving circuits	• Control motor speed using **Pulse Width Modulation (PWM)** and analyze its effect on power efficiency using Hardware/ Simulation

			• Vehicle control: Torque control Strategies, Acceleration and traction control for stability • Sensor integration with motor controllers and BMS • Communication protocols (CAN, SPI, I^2C)	
8	04		**Regenerative Braking Systems in EVs** • Regenerative braking principles and working - Why 100% energy cannot be recovered during regeneration • Impact of regenerative braking on EV efficiency and range • Types of regenerative braking systems used in electric vehicles	• Analyze Regenerative Braking on a BLDC Motor using Hardware/ Simulation
9	04		**Thermal Management Systems in EVs** • Importance of thermal management in EVs • Battery Thermal Management- Cooling Methods, Prevention • Motor & Inverter Thermal Management – Cooling techniques, Inverter cooling • Thermal management for range optimization	• Analyze the importance of **thermal management in EVs** by studying **battery, motor, and inverter cooling techniques**, and their effect on **range optimization** using Hardware/ Simulation
10	02		**Transmission systems in EV's** • Concept and Need for transmission systems in **Electric Vehicles vs. ICE Vehicles.** • EV Transmission System Components- **Electric Motor Characteristics** and role in transmission, **Reduction Gearbox & Differential** • Types and Working of Single-Speed Transmission, Multi-Speed Transmission • Direct Drive Systems vs. Geared Drives. • **Regenerative Braking and Transmission** interaction.	• Analyze Torque-speed behavior in an EV transmission. Compare Single-Speed vs. Multi-Speed Transmissions using Hardware/ Simulation
11	02		**EV Chassis, Suspension, and Safety Systems** • EV Chassis Design & Types - Structural framework, Types, Key Considerations in EV Chassis Design, Differences	• Conduct Chassis Load & Structural Strength Test, Suspension Performance and Crash Safety Analysis using Hardware/ Simulation

			between traditional ICE vehicle chassis vs. EV chassis. • Suspension systems in electric vehicles- Need, Types, Impact of Heavy Batteries • EV safety systems - Crash Safety & Impact Protection in EVs, Active & Passive Safety Features, EV-Specific Safety Systems	
12	05		**Electric Vehicle Diagnostics and Fault Detection, Maintenance and Servicing** • Introduction to EV diagnostics: OBD-II for EVs • Fault detection in electric motors, battery, and control systems • Common issues in EVs and their troubleshooting techniques • EV maintenance requirements vs. conventional vehicles • Battery maintenance, lifespan, and charging practices • Periodic servicing of electric motors and power electronics	• Analyze EV diagnostics, fault detection, and maintenance **using** OBD-II scanning **(Hardware/ Simulation)**
13	05		**Future Trends and Challenges in EV Technology** • Current trends in EV technology: Fast charging, wireless charging, solid-state batteries • EV challenges: Range anxiety, charging infrastructure, battery disposal • The future of electric mobility: Hybrid Vehicles, Autonomous EVs, Connected EVs	• **Case Study:** Emerging EV technologies

4. References

Sl. No.	Author	Title of Book	Publication/Year
1	Pistoia, Gianfranco	Battery Operated Devices and Systems	Portable Electronics to Industrial Products." Elsevier, 2008.
2	Larminie, James, and John Lowry	Electric Vehicle Technology Explained	Wiley, 2012
3	Mehta, V.K	Principles of Electrical Machines.	S. Chand Publishing, 2014.
4	Chan, C.C., and K.T. Chau.	Modern Electric Vehicle Technology	Oxford University Press, 2001.
5	Research Papers and Online Sources:	Advancements in Battery Technology for Electric Vehicle	IEEE Transactions on Transportation Electrification.

6	Research Papers and Online Sources:	EV Industry Reports	Bloomberg NEF, IEA, Tesla, Ather Energy, and Government Policy Reports.
7	Research Papers and Online Sources	Impact of Regenerative Braking on EV Efficiency	Journal of Power Source

5.CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all Practices and Activities through Rubrics	1-13		50	
				Total	**50 Marks**

6. SEE - Practical Assessment Methodologies

Sl.No	SEE – Practice Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practical	180	50	20

7.CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	Electric Vehicle Technology			**Test**	I/III
Course Code	20ME52IE	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Compare the market adoption strategies of Tesla and Ather. What similarities and differences do you observe in their approach?	Apply	01	10
	b. Examine the reasons why early electric vehicles lost market dominance despite being technologically viable. What lessons can modern EV manufacturers learn?	Apply	01	05
	c. Analyze the key differences between Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), and Plug-in Hybrid Electric Vehicles (PHEVs). How do these differences impact their performance and efficiency in real-world applications?	Apply	01	10

2	d. Compare the business models of Tesla and Ather in driving EV adoption. How have their strategies influenced consumer perception and market penetration?"	Apply	01	10
	e. Analyze the key factors that contributed to the decline of early electric vehicles in the automotive market. How can modern EV manufacturers strategically overcome these historical challenges	Apply	01	05
	f. Why do EVs have higher energy efficiency than Internal Combustion Engine (ICE) vehicles? Explain using powertrain differences.	Apply	01	10
Section - 2				
3	a. Do you think solid-state batteries are the future of EVs? Compare them with current Li-ion batteries and justify your answer.	Apply	03	05
	b. **Explain** why Switched Reluctance Motors (SRM) has high torque but need complex control?	Apply	02	05
	c. **Which motor type** would you choose for a low-cost electric scooter? Justify your choice	Apply	02	05
	d. **Why do BLDC motors have higher efficiency** than brushed DC motors?	Apply	02	05
	e. **Analyze the advantages and disadvantages** of using SynRM motors in electric vehicles	Apply	02	05
4	a. Analyze how technological advancements in lithium-ion batteries have contributed to the extended range of modern EVs.	Apply	03	05
	b. A BLDC motor is used in an EV. **How can you calculate its efficiency** using input and output power?	Apply	02	05
	c. **What are the main challenges of using SRM motors in EVs?** How can they be improved?	Apply	02	05
	d. **How does the number of poles in a BLDC motor** affect its speed and torque?	Apply	02	05
	e. **Compare active and passive cooling methods** used in EV motors.	Apply	02	05
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	Electric Vehicle Technology			**Test**	II
Course Code	20ME52IE	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					
Questions				**CO**	**Marks**

Section-I			
4.	Conduct experiment on BLDC motor with PWM-based speed control and analyze speed variations **OR** Analyze Torque-speed behavior in an EV transmission. Compare Single-Speed vs. Multi-Speed Transmissions using Hardware/ Simulation	CO2	25
Section-II			
5.	Analyze Charging Levels, Connectors and **charging power flow and grid integration** in an EV charging setup **OR** Measure Charging & Discharging Characteristics of an EV Battery	CO3	25
Scheme of Assessment Conduction (Simulation) 10 Marks Tabulation 05 Marks Analysis and Interpretation 10 Marks **Total Marks - 25 Marks**			**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

.Sl. No.	Suggestive Activities for Tutorials
01	Case studies of Indian EV's which are converts of ICE and new models (born electric) which are designed to be electric vehicle from scratch.
02	Observe the space and infrastructure requirements of any typical charging station set up in Bangalore city. Also find out the cost involved in setting up charging stations and number of vehicle expected to make break even.
03	Demonstrate how an EV powertrain operates using small-scale components. Participants assemble a basic powertrain by connecting the battery, controller, and motor. Test how throttle input changes motor speed and discuss torque and power delivery.
04	Analyze real-world EV battery choices, performance factors, and their impact on range, charging, and lifecycle.
05	A startup is developing an affordable electric hatchback for urban commuting. The vehicle needs a **200-250 km range per charge**, should support **fast charging**, and have a lifespan of **at least 8 years.** The team must decide which battery type and configuration to use based on available technologies. Make a case study and submit report.
06	A ride-hailing company operates a fleet of 100 electric vehicles (EVs) for city transportation. Recently, some vehicles have been experiencing reduced range, sudden power loss, and longer charging times. The company's maintenance team must diagnose and troubleshoot these issues using OBD-II diagnostics and hardware inspection. Provide a case study report.

10. Rubrics for Assessment of Graded Exercises and Activity (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Technical Knowledge & Understanding	Minimal understanding, major errors in concepts	Basic understanding, but with significant misconceptions	Sufficient knowledge with minor errors	Good comprehension with relevant explanations	In-depth technical understanding with strong conceptual clarity	40
2	Practical Skills & Execution	Unable to conduct experiments	Basic setup attempted but with errors	Can perform practical tasks with guidance	Executes tasks correctly with minor mistakes	Fully proficient in conducting experiments	45
3	Data Collection & Analysis	No data collected or incorrect readings	Incomplete or inconsistent data	Correct data collection, basic analysis	Accurate data with logical analysis and insights	Detailed data collection with in-depth interpretation	40
4	Problem-Solving & Troubleshooting	Unable to identify or address issues	Recognizes problems but cannot solve them effectively	Can troubleshoot with assistance	Effectively identifies and resolves issues	Demonstrates excellent troubleshooting skills	45
5	Report Writing & Presentation	No documentation or poorly structured report	Incomplete or unclear report, lacks structure	Report is complete but lacks depth in explanation	Well-structured report with clear presentation	High-level documentation with in-depth analysis	45
	Average Marks= (40+45+40+45+45)/5=43						**43**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the exercises

11. SEE- Model Practice Question Paper

Program	Mechanical Engineering	**Semester**	V
Course Name	Electric Vehicle Technology	**Marks**	50
Course Code	20ME52IE	**Duration**	180 min
Name of the Course Coordinator:			
Note: Answer any one question from each section. Each question carries 25 marks			

	Questions	**CO**	**Marks**
	Section-I		
1.	a. Test **Li-ion battery charging profile** with CC-CV charging. Observe **voltage, current, and temperature variations.** Also, Measure Charging & Discharging Characteristics of an EV Battery. Use Hardware/ Simulation **OR** b. Analyze Charging Levels, Connectors and **charging power flow and grid integration** in an EV charging setup using Hardware/ Simulation	CO3	25

Section-II			
2.	a. Analyze the importance of **thermal management in EVs** by studying **battery, motor, and inverter cooling techniques**, and their effect on **range optimization** using Hardware/ Simulation **OR** b. Analyze Torque-speed behavior in an EV transmission. Compare Single-Speed vs. Multi-Speed Transmissions using Hardware/ Simulation	CO4	**25**
Scheme of Assessment Preparation and Setup - 06 Marks Execution and Record Data - 09 Marks Analysis and Interpretation - 07 Marks Inference - 03 Marks **Total Marks - 25 Marks**			**50**

12. Equipment/software list with Specification for a batch of 30 students

SL NO	Particulars Required	Specifications	Quantity
1	BLDC Motor with PWM Controller	24V DC, 250W, Hall Sensor Feedback	1
2	Power Analyzer	Measures voltage, current, power, efficiency	1
3	Li-ion Battery Pack	48V, 20Ah with BMS	1
4	Battery Charger	CC-CV, 48V, 10A	1
5	Battery Testing Setup	Voltage, Current, Temperature measurement module	1
6	BMS Module	Supports SOC, SOH, SOP estimation	1
7	Charging Connectors	Type 1, Type 2, CCS, CHAdeMO	1 set
8	PWM Controller	24V DC, Adjustable Duty Cycle	1
9	Regenerative Braking Test Setup	Includes BLDC Motor, Load Bank	1
10	Thermal Management Test Kit	Battery, Motor & Inverter Cooling System	1
11	Transmission Test Rig	Single-Speed & Multi-Speed Transmission	1
12	Chassis Testing Setup	Load, Structural Strength & Crash Safety Test Rig	1
13	OBD-II Scanner	Supports EV Fault Diagnosis	1
14	Suspension Performance Testing Setup	Includes sensors for load & damping analysis	1
	MATLAB/Simulink	MATLAB/Simulink software	

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	IIOT	**Type of Course**	Integrated
Course Code	25ME53IA	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. **Rationale:** The Industrial Internet of Things (IIoT) is transforming industries by integrating digital technologies, advanced sensors, and communication networks. The convergence of physical and digital systems has revolutionized manufacturing and other sectors, making processes smarter and more efficient. For Mechanical Engineering students, learning IIoT equips them with the knowledge to design, implement, and maintain systems for data acquisition, analysis, and automation in real-time industrial environments. Additionally, the application of IIoT in automobiles, including connected car technologies, smart sensors, and safety systems, provides real-world relevance for students aspiring to work in manufacturing or automotive industries. This course covers foundational IIoT concepts, sensors, automation, and their applications, aligning well with Industry 4.0.

2. **Course Outcomes:** At the end of the Course, the student will be able to:

CO-01	**Apply** IIoT technologies to design and implement smart industrial systems, integrating sensors, actuators, and automation to enhance efficiency, productivity, and predictive maintenance.
CO-02	**Develop and integrate** IoT-based monitoring and control systems for industrial and automotive applications, utilizing real-time data acquisition, cloud computing, and analytics to optimize performance.
CO-03	**Implement** IIoT-driven safety and efficiency solutions in automobiles, including connected car technologies, ADAS, ABS, and vehicle-to-vehicle communication to enhance road safety and automation.
CO-04	**Analyze and process** IIoT-generated data using cloud platforms, edge computing, and AI-driven analytics to improve decision-making, energy efficiency, and sustainability in industrial systems.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,3, 4	• **Introduction to IoT & IIoT –** the evolution of IoT & IIoT, Fundamentals, architecture, and key differences between IoT and IIoT**.** • **Applications of IoT & IIoT** – Smart homes, healthcare, agriculture, industrial automation, and manufacturing (Write a block diagrams and data flow lines for each)	**IoT & IIoT Hardware Platforms** • Industry-grade or IIoT (Siemens PLCs, Rockwell Automation, NI Compact RIO etc). • Consumer-grade boards or IoT (Arduino, Raspberry Pi, ESP32, pcDuino, Beaglebone black, Cubie board, Jetson, Google Coral, etc.). • Sensors & Actuators in IIoT & IoT
2	1	1,3 ,4	• **Arduino & Raspberry pi**- Introduction to IoT Architecture using Raspberry Pi and Arduino, Setting up Raspberry Pi or Arduino environment. • **Key Components of IIoT Systems**- Sensors and Actuators, Connectivity/ Communication protocols, Data Processing, IoT Platforms(like ThingSpeak, IBM Watson IoT, and Microsoft Azure)	• Block diagram of an IIoT-based system for Agricultural Greenhouse, Cold Storage Monitoring, and Heating & Ventilation Control, etc highlighting key parameters to be measured and controlled. • Interfacing a DHT11 temperature and humidity sensor with a Raspberry Pi/Arduino, reading sensor data, and sending it to a cloud service (e.g., ThingSpeak) for visualization and analysis (Refer annexure experiment No.1)
3	1	1,3 ,4	**Introduction to Communication Protocols in IIoT** • MQTT, CoAP, and HTTP, Challenges in IIoT Communication. • Overview, Working and Advantages of MQTT (Message Queuing Telemetry Transport), CoAP (Constrained Application Protocol),	• Setting up IoT communication on Raspberry Pi using MQTT, (Refer Experiment No.2) • Setting up IoT communication on Arduino using CoAP Protocol, (Refer annexure experiment No.3)
4	1	1,3 ,4	• HTTP (Hyper-Text Transfer Protocol) protocols. • Security in IIoT Communication- Importance of Security, Encryption, Authentication and Authorization	• Setting up IoT HTTP, Communication for IIoT Data Collection. (Refer annexure experiment No.4) • Secure IoT Communication using SSL/TLS. (Refer annexure experiment No. 5)
5	2	2,3,4	**Smart Factory Concept and IIoT Integration in Manufacturing** • Core Components of Smart Factories – Cyber-Physical Systems (CPS), Sensors and Actuators, Robotics and Automation • Importance of IIoT Applications in Manufacturing – Predictive Maintenance, Production Line	Importance of IIoT Applications in Manufacturing • Setting up IIoT Systems for Predictive Maintenance. (Refer annexure experiment No.6) • Production Line Monitoring with IoT. (Refer annexure experiment No. 7)

			Monitoring and Optimization, Quality Control and Assurance, Energy Management.	
6	2	2,3,4	• The integration of IIoT and robotics in smart manufacturing, focusing on automated assembly lines, smart warehousing, real-time monitoring, and data-driven efficiency optimization. • Technologies Enabling Smart Factories - Cloud Computing and Big Data, Cyber-security, Edge Computing, AI and Machine Learning	• Develop a prototype for an **automated assembly line**, integrating IIoT sensors for real-time monitoring. • Quality Control System Using IIoT (Refer annexure experiment No.8) • Energy Consumption Monitoring in Manufacturing. (Refer annexure experiment No. 9)
7	4	4,5,7	**Cyber-security in IIoT**: • Data encryption, Authentication mechanisms, firewall protection, and Network security. • Overview of cyber-security standards (iso 27001, iec 62443) for industrial automation.	• Implementing secure IIoT communication by encrypting sensor data using AES encryption on a Raspberry Pi and transmitting it securely to a cloud platform for protected data exchange and monitoring (Refer annexure experiment No. 4 & 10)
8	4	4,5,7	**Edge Computing in IIoT:** • Importance, benefits, and applications in industrial environments. • Comparison between Edge Computing and Cloud Computing in IIoT.	• Implement edge-based IIoT processing using a Raspberry Pi for real-time industrial data analysis, enabling local preprocessing, reduced latency, and optimized bandwidth usage before transmitting data to the cloud. (Refer annexure experiment No. 11)
9	3	4, 5	**IIoT in Automotive Industry:** • Overview, Key IIoT Technologies in Automotive – Sensors, Connectivity, Cloud Platforms. • Rain sensors, Anti-lock Braking, Air Pressure Monitoring System	• Simulation of Vehicle-to-Vehicle (V2V) Communication Using • Raspberry Pi (Refer annexure experiment No. 12)
10	3	4, 5	• **Connected Cars:** Concept and Benefits, Vehicle-to-Vehicle (V2V) Communication, Vehicle-to-Infrastructure (V2X) Communication	• Implementation of Lane Departure Warning (LDW) System with Camera and Sensors (Refer annexure experiment No. 13)
11	3	4, 5	▪ **Advanced Driver Assistance Systems (ADAS):** Lane Departure Warning (LDW), Adaptive Cruise Control (ACC), Automatic Emergency Braking (AEB), Blind Spot Detection (BSD), Role of IIoT in ADAS.	• Designing Adaptive Cruise Control (ACC) System with IoT Sensors (Refer Experiment No. 14) • Building a Smart Parking System Using IoT Sensors. (Refer annexure experiment No. 15)

12	4	4,5,7	**Role of Cloud Computing in IIoT** • **Key Features of Cloud in IIoT**- Scalability, Advanced Analytics & AI, Remote Monitoring & Control, Remote Monitoring & Control, Centralized Data Management • **Cloud Computing Architecture in IIoT** - Service provider, Storage, Applications.	• Implementing Cloud-Based Data Storage for IIoT Systems (Refer annexure experiment No. 16)
13	2	2,3,4	**Implementing IIoT in a Real-World Application** • Importance of IIoT in various industries - Healthcare, Smart Cities, Agriculture, Energy, etc. • Identifying real-world problems that can be solved using IIoT • Selection of appropriate sensors, communication protocols, and cloud platforms • Data analytics and visualization techniques for real-world IIoT applications	• Develop a prototype using Raspberry Pi/ Arduino with cloud connectivity • Present their solution with a working demo and project report

Annexure - List of Experiments

1. **Interfacing temperature and humidity sensors with Raspberry Pi/Arduino:** In this practical, students will interface a temperature and humidity sensor (DHT11) with Raspberry Pi/Arduino, read sensor data, and send it to a cloud platform (ThingSpeak) for real-time monitoring.
2. **Setting up IoT Communication on Raspberry Pi using MQTT** : To implement an IoT-based automatic water level monitoring system using MQTT protocol for real-time data exchange between sensors and a pump controller.
3. **Setting up IoT Communication - CoAP Protocol with Arduino:** To implement the CoAP protocol on an Arduino device for smart home automation, enabling remote control of lighting systems via a CoAP server, while understanding request-response mechanisms and the advantages of lightweight UDP-based communication in IoT applications.
4. **HTTP Communication for IIoT Data Collection**: To implement HTTP-based communication on a Raspberry Pi/Arduino for real-time IIoT data collection, by sending liquid flow sensor data from a pipeline system to a web server (e.g., ThingSpeak, Node-RED) for leak detection and flow monitoring.
5. **Secure IoT Communication using SSL/TLS:**To implement secure IIoT communication using SSL/TLS encryption by configuring an MQTT broker (Mosquitto) with certificate-based authentication, ensuring encrypted data transmission between Arduino in a smart factory

environment, where machine status data is securely transmitted to a central monitoring system to prevent unauthorized access and data breaches.

6. **Setting up IIoT Systems for Predictive Maintenance**: To develop a predictive maintenance system using IIoT sensors and Raspberry Pi to monitor a motor's condition (e.g., vibration, temperature, speed), analyze real-time data on a cloud platform (e.g., ThingSpeak), and detect abnormal trends for early failure prediction in industrial environments.
7. **Production Line Monitoring with IoT**:To simulate a smart production line by integrating IIoT sensors with a conveyor belt system, using Raspberry Pi to monitor motor speed, belt position, and efficiency, enabling real-time performance analysis and bottleneck identification for improved industrial automation.
8. **Quality Control System Using IIoT**: To develop an IIoT-based quality inspection system for an automated packaging line, utilizing weight sensors to detect defects, ensure compliance with specifications, and trigger real-time alerts or corrective actions for improved product consistency and efficiency.
9. **Energy Consumption Monitoring in Manufacturing**: To develop an IIoT-based energy management system for monitoring and analyzing real-time energy consumption in a manufacturing setup, enabling energy efficiency optimization and sustainability improvements through data-driven insights.
10. **Cyber-security in IIoT**: Implementing secure IIoT communication in a smart home environment by encrypting sensor data (e.g., door status, lighting, energy usage) using AES encryption on a Raspberry Pi and securely transmitting it to a cloud platform for real-time monitoring and automation.
11. **Edge Computing in IIoT:** In a smart warehouse, a Raspberry Pi is installed to monitor real-time inventory movement using RFID and weight sensors. The edge device processes local stock data, only sending critical updates (e.g., low stock alerts) to the cloud, thereby reducing network congestion, ensuring faster decision-making, and optimizing warehouse operations.

IIoT in the Automotive Industry:

12. **Simulation of Vehicle-to-Vehicle (V2V) Communication Using Raspberry Pi**:- To develop a simulated Vehicle-to-Vehicle (V2V) communication system using Raspberry Pi and wireless modules to exchange real-time traffic data, enabling hazard detection and enhancing vehicle safety
13. **Implementation of Lane Departure Warning (LDW) System with Camera and Sensors**: To develop a basic lane departure warning system using cameras and sensors to detect lane positions, process images, and alert drivers upon unintended lane deviations, enhancing road safety.

14. **Designing Adaptive Cruise Control (ACC) System with IoT Sensors**: To design a basic adaptive cruise control system using IoT sensors to monitor distance, adjust vehicle speed dynamically, and enhance safety by maintaining a safe following distance in varying traffic conditions.
15. **Building a Smart Parking System Using IoT Sensors**: - To develop a smart parking system using IoT sensors to detect available spaces, provide real-time occupancy data, and enhance parking efficiency through an IoT-based dashboard.
16. **Implementing Cloud-Based Data Storage for IIoT Systems** - Students will understand how to collect, process, and store IIoT data in the cloud. They will gain experience in cloud communication using MQTT and HTTP protocols. Learn real-time monitoring and analytics for industrial applications.

4. References:

Sl. No.	Author	Title of Books	Publication/ Year
1	Zaigham Mahmood (Ed.)	The Internet of Things in the Industrial Sector	Springer Publication, 1st Edition, 2017
2	Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat	Industrial Internet of Things: Cyber manufacturing System	Springer Publication, 1st Edition, 2017
3	Ismail Butun (Editor)	Industrial IoT Challenges, Design Principles, Applications, and Security	Springer Publications, 1st Edition, 2019
4	Alasdair Gilchrist	Industry 4.0: The Industrial Internet of Things	Apress Publications, 1st Edition, 2016
5	Rahul Dubey	An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications	Cengage India Publication, 1st Edition, 2020
6	Perry Xiao	Designing Embedded Systems and the Internet of Things (IoT) with the ARM Mbed	Wiley, 1st Edition, 2018
7	Sudip Misra, Chandana Roy, Anandarup Mukherjee	Introduction to Industrial Internet of Things and Industry 4.0	CRC Press, 1st Edition, 2021
8	G. Veneri Antonio	Hands-on Industrial Internet of Things	Packt Publication, 1st Edition, 2018
9	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things	CISCO Press, 1st Edition, 2017
10	Massimo Banzi, Michael Shiloh	Make: Getting Started with the Arduino	Shroff Publisher/Maker Media Publishers, 3rd Edition, 2021
11	Matt Richardson, Shawn Wallace	Getting Started with Raspberry PI	O'Reilly Media, Inc., 1st Edition, 2012

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
Total -50 Marks					

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test Model Question Paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	IIOT			**Test**	I
Course Code	25ME53IA	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No.	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Compare and illustrate the differences between IoT and IIoT by writing a block diagrams of simple home automation system and a smart factory system using relevant components.	Apply	CO1	10
	b. Justify the selection of a suitable IIoT communication protocol (MQTT, CoAP, or HTTP) for a smart energy monitoring system in an industrial plant, considering factors like real-time data transfer, reliability, and network constraints.	Apply	CO1	10
	c. Explain with an example how an IIoT-based quality control system using image processing and sensors can help detect defective products on an assembly line.	Apply	CO1	5
2	a. Compare and illustrate how data flow and processing differ in IoT and IIoT by explaining a smart healthcare monitoring system and an industrial predictive maintenance system.	Apply	CO1	10
	b. Explain an MQTT-based IIoT system for monitoring and controlling a warehouse automation process, ensuring secure data transmission and real-time updates on machine performance.	Apply	CO1	10
	c. Explain with an example how an IIoT-based predictive maintenance system utilizing vibration and temperature sensors can detect potential machine failures and prevent downtime.	Apply	CO1	5
	Section – 2			
3	a. Design an IIoT-based system for an agricultural greenhouse with	Apply	CO1	10

	a block diagram, highlighting the key parameters to be measured and controlled for optimal growth conditions.			
	b. Design an IIoT-enabled robotic system **for an** automated assembly line and explain how real-time monitoring and data analytics improve production efficiency	Apply	CO1	10
	c. Justify the importance of cybersecurity measures (encryption, authentication) in IIoT systems, using an example of a smart factory communication network.	Apply	CO1	5
4	a. Design an IIoT-based monitoring system for a cold storage facility with a block diagram, highlighting the key parameters to be measured and controlled for maintaining optimal storage conditions.	Apply	CO1	10
	b. Develop a basic IIoT-integrated robotic solution **for** material handling in a smart warehouse**,** highlighting how automation reduces errors and increases productivity.	Apply	CO1	10
	c. Justify the importance of edge computing in IIoT systems, using an example.	Apply	CO1	5
Note for the Course coordinator*: Each question may have two or three or four or five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	IIOT			**Test**	II
Course Code	25ME53IA	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one question. Each question carries 50 marks					

	Questions	**CO**	**Marks**
1.	**Setting up IIoT Systems for Predictive Maintenance**: To develop a predictive maintenance system using IIoT sensors and Raspberry Pi to monitor a motor's condition(e.g., vibration, temperature, speed), analyze real-time data on a cloud platform (e.g., ThingSpeak), and detect abnormal trends for early failure prediction in industrial environments.	CO1, CO2	**50**
2.	**Production Line Monitoring with IoT**:To simulate a smart production line by integrating IIoT sensors with a conveyor belt system, using Raspberry Pi to monitor motor speed, belt position, and efficiency, enabling real-time performance analysis and bottleneck identification for improved industrial automation.	CO1, CO2	**50**
	Scheme of Assessment for Section I & II	**CO**	
a.	Develop the program for a given application, integrate with appropriate hardware ***Note****: Includes Aim of the practical, List of Components Required, program and wiring diagram*	CO1, CO2	30
b.	Execution and Accuracy and effectiveness of the output. ***Note****: Includes implementation and output*	CO1, CO2	20
	Total Marks		**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	**IIoT for Remote Patient Health Monitoring -** Deploying IoT-enabled wearable sensors to monitor heart rate, blood pressure, and oxygen levels. Using cloud platforms to send real-time health alerts to doctors and caregivers.
02	**IIoT-Enabled HVAC** -Using temperature and air quality sensors to optimize HVAC systems in office buildings. Automating heating/cooling adjustments based on occupancy and environmental conditions..
03	**Smart Street Lighting System Using IIoT**- Implementing motion and light sensors to control streetlights based on vehicle and pedestrian movement. Analyzing energy savings using real-time monitoring and adaptive brightness control
04	**IIoT in Smart Parking Systems**- Implementing ultrasonic sensors to detect available parking spaces in real-time. Using a mobile app or dashboard to display parking slot availability to drivers**.**
05	**IIoT-Based Smart Water Management in Buildings** -Using ultrasonic sensors and IoT to monitor water levels in tanks and automate pump control. Collecting data on water usage patterns for optimization and sustainability
06	**Smart Warehouse Management System** - Implementing RFID and IoT sensors for real-time inventory tracking and automated stock updates in a warehouse. Analyzing how edge computing can help reduce latency in stock monitoring.

10. Rubrics for Assessment of Activity/ Case Study (Qualitative Assessment)

Sl. No	Dimension	Unsatisfactory	Satisfactory	Good	Very Good	Excellent	Student's Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Understanding of Concepts	Limited understanding of key automation concepts with minimal explanation.	Basic understanding of concepts but lacks depth in analysis.	Demonstrates a good grasp of concepts with relevant explanations.	Shows strong understanding with well-supported insights.	Exceptional comprehension with in-depth analysis and accurate technical explanations.	40
2	Technical Skills/ Implementation	Struggles with basic implementation of tasks	Able to implement tasks with some assistance or errors	Can complete tasks independently with minor errors	Completes tasks accurately with minimal assistance	Demonstrates advanced technical skills with flawless execution	40
3	Depth of Research and References	Minimal or no research; lacks credible references.	Limited research with few relevant references.	Good research with appropriate sources and citations.	Strong research with multiple credible references and detailed information.	Extensive research with high-quality references, demonstrating thorough investigation.	40

4	Report/ Presentation Quality	Report/presentation lacks clarity and detail	Provides basic information, but lacks depth or organization	Well-organized report/ presentation with clear details	Clear, concise, and in-depth with appropriate diagrams	Highly professional presentation with comprehensive details and critical insights	40
						Average Marks	**40**

Note: *Dimension and Descriptor shall be defined by the respective course coordinator as per the activities*

11. SEE- Model Practice Question Paper

Program	Diploma in Mechanical Engineering		**Semester**	V
Course Name	IIoT	**Course Code:** 25ME53IA	**Duration**	180 min

Note*: Answer any one question*

Questions	**CO**	**Marks**
Note*: During the SEE, All questions will be distributed among the group. Each student will be assigned one of the following questions by the examiner, without offering any choice.* 1. Demonstrate how to interface a DHT11 sensor with Raspberry Pi/Arduino and send real-time temperature and humidity data to ThingSpeak. 2. Implement an MQTT-based automatic water level monitoring system to control a pump based on sensor data. 3. Develop a CoAP-based smart home automation system to remotely control lighting using an Arduino and a CoAP server. 4. Set up an HTTP-based communication system to transmit liquid flow sensor data from a pipeline system to a web server for leak detection. 5. Configure an MQTT broker with SSL/TLS encryption for secure machine status data transmission in a smart factory setup. 6. Develop a predictive maintenance system using IIoT sensors to monitor a motor's vibration and temperature, and analyze the data on ThingSpeak. 7. Implement an IIoT-based conveyor belt system to monitor motor speed and belt position for real-time production line efficiency analysis. 8. Design an IIoT-based quality inspection system for an automated packaging line using weight sensors to detect product defects. 9. Develop an IIoT-based energy monitoring system using power sensors to track and analyze real-time energy consumption in a manufacturing setup. 10. Implement AES encryption on a Raspberry Pi to securely transmit smart home sensor data (e.g., door status, lighting) to a cloud platform. 11. Set up an edge computing system using Raspberry Pi in a smart warehouse to process inventory movement data before sending critical updates to the cloud. 12. Develop a simulated V2V communication system using Raspberry Pi to exchange real-time traffic data and detect hazards. 13. Design a lane departure warning system using a camera and sensors to detect lane positions and alert drivers upon unintended deviations. 14. Develop an adaptive cruise control system using IoT sensors to maintain a safe distance between vehicles by adjusting speed dynamically. 15. Implement a smart parking system using IoT sensors to detect available parking spaces and display real-time occupancy data on a dashboard.	CO1, CO2, CO3, CO4	**50**

16. Demonstrate how to collect, process, and store IIoT sensor data in the cloud using MQTT and HTTP protocols for real-time analytics.		
Scheme of Assessment		
a. Develop the program for a given application, integrate with appropriate hardware ***Note**: Includes Aim of the practical, List of Components Required, program and wiring diagram*	CO1, CO2, CO3, CO4	30
b. Execution and Accuracy and effectiveness of the output. ***Note**: Includes implementation and output*	CO1, CO2, CO3, CO4	20
Total Marks		**50**

1) Signature of the Examiner 1 **2) Signature of the Examiner 2**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Qty.
1	Microcontroller Board	Arduino Uno (ATmega328P, 14 Digital I/O, 6 Analog Inputs, USB Interface),	15
		Arduino Nano	10
2	Single-Board Computer	Raspberry Pi 5 Processor-Broadcom BCM2712, Quad-Core Cortex-A76 (64-bit) @ 2.4 GHz, GPU-VideoCore VII, supports OpenGL ES 3.1, Vulkan 1.2, RAM-4GB or 8GB LPDDR4X-4267 SDRAM	10
3	Sensors Kit	Includes DHT11 (Temperature & Humidity), Ultrasonic Sensor (HC-SR04), PIR Motion Sensor, IR Sensor, Soil Moisture Sensor, Water Level Sensor, Vibration Sensor, LDR, Gas Sensor (MQ-2), Current Sensor	15 Sets
4	Industrial IoT Sensors	Temperature (DS18B20), Pressure (BMP280), Air Quality (MQ135), Load Cell (Weight Sensor)	5 Each
5	Actuators	5V & 12V DC Motors, Servo Motors (SG90), Stepper Motors (28BYJ-48)	10 Each
6	Wireless Communication Modules	Wi-Fi (ESP8266/ESP32), Bluetooth (HC-05), LoRa Module, Zigbee	10 Each
7	Edge Computing Device	Nvidia Jetson Nano (Quad-Core Cortex-A57, 4GB RAM, AI Processing)	2
8	Power Supply Units	5V 2A & 12V 2A Adapters	10 Each
9	IoT Cloud Platform	ThingSpeak, AWS IoT, Google Cloud IoT, Azure IoT Hub	
10	Programming Software	Arduino IDE, Python (for Raspberry Pi), Node-RED, MQTT Broker (Mosquitto), CoAP Libraries	Free/ Open Source
11	Simulation Software	Proteus, Tinkercad, Factory I/O (for Smart Factory Simulation)	

12	Networking Equipment	Wi-Fi Router (Dual Band, 300 Mbps), Ethernet Switch (8 Ports)	2 Each
13	Breadboards & Jump Wires	400-Point Breadboards, Male-Female, Male-Male, Female-Female Jumper Wires	30 Sets
14	Miscellaneous	Resistors, Capacitors, LEDs, Transistors, LCD Display (16x2), Relay Modules	As Required

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	AI & ML	**Type of Course**	Integrated
Course Code	25ME53IB	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. **Rationale:** Artificial Intelligence (AI) and Machine Learning (ML) are transforming industries, including mechanical engineering, by enabling automation, predictive maintenance, and optimization of manufacturing processes. Understanding AI and ML fundamentals equips students with the skills necessary to analyze data, make data-driven decisions, and enhance efficiency in mechanical systems. This course introduces key AI and ML concepts, emphasizing their applications in mechanical engineering through practical exercises. By integrating Python programming, students will develop hands-on experience with AI agents, search algorithms, and machine learning models tailored to engineering problems. The course fosters analytical thinking and prepares students for Industry 4.0 advancements.

2. **Course Outcomes:** At the end of the Course, the student will be able to:

CO-01	**Apply** AI search algorithms such as Depth-First Search (DFS) and Breadth-First Search (BFS) to optimize robotic path planning in industrial automation.
CO-02	**Implement** machine learning models, including decision trees and regression algorithms, to analyze mechanical system datasets for predictive maintenance and fault detection.
CO-03	**Develop** clustering models like K-Means to categorize mechanical components based on performance attributes and **optimize** manufacturing processes.
CO-04	**Utilize** reinforcement learning techniques to enhance robotic movement and efficiency in smart manufacturing environments.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1	**Introduction to AI and ML:** Definitions, Scope, and Impact on Mechanical Engineering.	Python refresher: Basic syntax, data structures, and functions (Refer annexure experiment No. 1)
2	1	2,4	**AI Agents:** Types of Agents, Reactive vs. Deliberative Agents, Role in Manufacturing Automation.	Implement a simple AI agent using Python (Refer annexure experiment No. 2)
3	1,3	2,3	**AI Search Algorithms:** Depth-First Search (DFS), Breadth-First Search (BFS), Applications in Robotics and Manufacturing Systems.	Implement DFS and BFS for robotic path planning (Refer annexure experiment No. 3)
4	1	2,3	**Machine Learning Overview**: Definition, Supervised vs. Unsupervised Learning, Industrial Applications.	Load and visualize mechanical system datasets using Python (Refer annexure experiment No 4)
5	2	2,3	**Data Preprocessing:** Handling Missing Values, Feature Scaling, Data Normalization.	Perform feature scaling and missing data handling on mechanical datasets (Refer annexure experiment No. 5)
6	2	2,3,4	**Classification Algorithms:** Decision Trees, k-Nearest Neighbors (k-NN), Application in Fault Detection.	Implement decision tree classifier for material defect classification (Refer annexure experiment No. 6)
7	2	2,3,4	**Regression Models**: Linear Regression, Polynomial Regression, Application in Predicting Mechanical Failures.	Predict component failure using linear regression (Refer annexure experiment No. 7)
8	2	2,3,4	**Unsupervised Learning:** Clustering Techniques (K-Means, Hierarchical), Application in Manufacturing Process Optimization.	Implement K-Means clustering for machine component categorization (Refer annexure experiment No 8)
9	4	2,3,4	**Reinforcement Learning Basics:** Q-Learning, Applications in Robotics and Smart Systems	Simulate reinforcement learning for robotic movement optimization (Refer annexure experiment No. 9)
10	4	2,3,4	**AI in Predictive Maintenance:** Condition Monitoring, Failure Prediction, Industrial Use Cases.	Apply ML to predict bearing failures using dataset (Refer annexure experiment No. 10)
11	3	2,3,4	**AI in Automation:** Robotics, Smart Manufacturing, AI-Driven Quality Control.	Develop a simple AI-based robotic control simulation (Refer annexure experiment No. 11)
12	1,2, 3,4	1,2,3, 4	**Case Studies in Mechanical Engineering using AI & ML**: Real-world Industrial Implementations.	AI-powered automation or maintenance solution – Case studies
13	1,2, 3,4	1,2,3, 4	Course Summary, Future Trends in AI and ML for Mechanical Engineering.	Case Studies

Annexure- List of Exercises:

1. **Python refresher:**

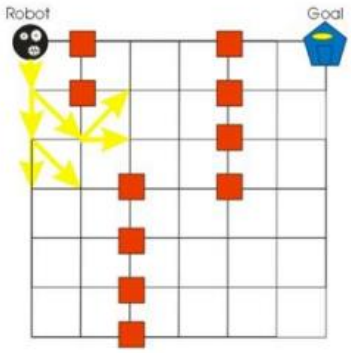
   To understand and implement basic Python programming concepts, including syntax, data structures, and functions, in a mechanical engineering application. The program calculates stress, strain, and safety factor for a given mechanical component based on user inputs.

2. **Implementing a simple AI agent in Python to automate decision-making tasks:**

   Implementing a simple AI agent in Python to analyze stress-strain data from mechanical components (e.g., beams, shafts, or structural members) under load conditions, evaluate the data against predefined material failure criteria (e.g., yield strength, ultimate tensile strength, or safety factors), and recommend actions such as "increase material thickness," "change material type," or "redesign component" based on the analysis results. The agent should also flag critical stress points and provide a summary report of its findings.

3. **AI Search Algorithms: Developing DFS and BFS for robotic path planning:**

   This experiment aims to implement a robotic path planning system in a 2D grid-based environment using Depth-First Search (DFS) and Breadth-First Search (BFS) algorithms. The system will simulate a workspace where obstacles and free paths exist, requiring the robot to navigate efficiently from a user-defined start position to a goal position. The program will take grid dimensions, obstacle positions, start and goal coordinates as inputs and use DFS and BFS to find a feasible path. The output will include the computed paths for both algorithms, a comparison of their performance in terms of path length and search efficiency, and a visualization of the grid with obstacles and paths using a Python-based simulator such as Matplotlib.



   References:

   a. Stout, W. Bryan “Smart Moves: Intelligent Path Finding” Gamasutra.com Feb 12, 1999
   b. S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach Second Edition.

4. **Loading and visualizing mechanical system datasets using Python libraries like Pandas and Matplotlib:**

   The objective of this experiment is to load, analyze, and visualize a mechanical dataset related to CNC spindle vibrations using Python libraries such as Pandas, Matplotlib, and Seaborn. The dataset contains real-time vibration readings, including columns such as Timestamp, Spindle_ Speed (RPM), Vibration Amplitude (mm/s), and Temperature (°C). Students will begin by loading the dataset using Pandas to read the CSV file, followed by preprocessing the data to handle missing values and convert data types. They will then use Matplotlib and Seaborn to visualize the data, creating time-series graphs of Vibration Amplitude over time and analyzing trends and correlations between Spindle _Speed, Vibration Amplitude, and Temperature. This step will help identify patterns and anomalies in the vibration data that may indicate potential faults in the CNC spindle.

5. **Data Preprocessing:**

   The CNC vibration dataset from Experiment 4 contains missing values due to sensor malfunctions and inconsistent readings across different machines. Additionally, vibration values are in different ranges, making direct comparison difficult. This exercise focuses on preprocessing mechanical datasets by handling missing values and applying feature scaling techniques. Students will use Python's Pandas and Scikit-learn libraries to fill missing values using mean/mode imputation and normalize vibration readings using Min-Max scaling and Standardization. The outcome will be a cleaned and normalized dataset, ready for further machine learning analysis such as fault prediction.

6. **Implementing a decision tree classifier for detecting material defects in manufacturing:**

   CNC-machined components using vibration data. Building on previous experiments, students will use a preprocessed CNC vibration dataset containing attributes such as spindle speed, vibration amplitude, and temperature. The dataset will be cleaned and normalized to serve as training data. Students will then implement a decision tree classifier in Python using Scikit-learn, training the model to classify instances as defective or non-defective based on vibration patterns. They will evaluate the model's accuracy using performance metrics such as confusion matrix, precision, recall, and F1-score, and visualize the decision tree to understand key parameters (e.g., vibration amplitude thresholds) that contribute most to defect classification. By the end of the experiment, students will gain hands-on experience in applying machine learning for quality control in manufacturing, enabling early detection of material defects through AI-driven decision-making.

7. **Predicting component failure using linear regression models trained on historical data**

   This experiment focuses on implementing a decision tree classifier to identify material defects in CNC-machined components using vibration data. Building on previous experiments, students will use a preprocessed CNC vibration dataset containing attributes such as spindle speed, vibration amplitude, and temperature. The dataset will be cleaned and normalized to serve as training data. Students will then implement a decision tree classifier in Python using Scikit-learn, training the model to classify instances as defective or non-defective based on vibration patterns. They will evaluate the model's accuracy using performance metrics such as confusion matrix, precision, recall, and F1-score, and visualize the decision tree to understand key parameters (e.g., vibration amplitude thresholds) that contribute most to defect classification. By the end of the experiment, students will gain hands-on experience in applying machine learning for quality control in manufacturing, enabling early detection of material defects through AI-driven decision-making.

8. **Implementing K-Means clustering to categorize mechanical components based on them at Experiment:**

   In a manufacturing facility, mechanical components such as bearings, shafts, and gears exhibit variations in parameters like diameter, weight, surface roughness, and hardness. Proper categorization of these components is essential for quality control, inventory management, and predictive maintenance. However, manual classification is time-consuming and prone to human errors.

This experiment aims to implement the K-Means clustering algorithm to categorize mechanical components based on their physical and operational attributes. Using a dataset containing features such as component weight, hardness, surface roughness, and wear rate, students will apply K-Means clustering to group similar components automatically. The results will help in identifying patterns in mechanical component characteristics, assisting in quality assessment, defect detection, and maintenance planning. The clusters formed will be analyzed using visualization techniques to understand their significance in the manufacturing process tributes.

9. **Simulating reinforcement learning (RL) for optimizing robotic movement in an industrial setting.**

In industrial automation, robotic arms are essential for tasks such as sorting and assembling components. Optimizing the efficiency and accuracy of these operations is crucial for productivity. Traditional programming methods can be inflexible, struggling to adapt to variations in object types and positions. Reinforcement Learning (RL) offers a solution by enabling robots to learn optimal behaviors through interaction with their environment.

This experiment aims to implement a Proximal Policy Optimization (PPO) algorithm to train a simulated robotic arm for a pick-and-place task. Utilizing Python and the OpenAI Gym framework, students will develop an RL agent that learns to identify, grasp, and accurately position objects from a conveyor belt onto designated areas. The training process will involve the agent receiving positive rewards for successful placements and negative rewards for collisions or misplacements. The expected outcome is a policy model that enables the robotic arm to perform pick-and-place operations with high efficiency and precision, demonstrating the practical application of RL in enhancing industrial robotic systems.

This approach is inspired by the methodologies discussed in the article "Reinforcement Learning with a Pick and Place Robotic Arm" on *hlfshell.ai*, which explores the use of PPO in training robotic arms for sorting tasks.

Reference: https://hlfshell.ai/posts/ppo-pick-and-place/?utm_source=chatgpt.com

10. **Applying ML techniques to predict bearing failures using real-world datasets:**

Predicting bearing failures is critical for ensuring the reliability and efficiency of rotating machinery in industries such as manufacturing, automotive, and aerospace. Bearings are subject to wear and tear due to continuous operation, leading to unexpected failures that can cause costly downtime and equipment damage. This study aims to apply machine learning (ML) techniques to analyze real-world bearing datasets, identifying patterns and anomalies that indicate early signs of failure. The primary objectives include collecting and preprocessing vibration, temperature, and acoustic emission data, selecting appropriate ML models (such as decision trees, neural networks, or support vector machines), training models for accurate fault detection and classification, and developing a predictive maintenance framework to minimize unplanned failures. By leveraging ML, the goal is to enhance operational efficiency, reduce maintenance costs, and improve overall system reliability.

References:https://doi.org/10.3390/electronics13020438

11. **Developing an AI-based robotic control simulation for industrial automation:** S

Students are required to prepare a case study report on the development of an AI-based robotic control simulation for industrial automation. The report should highlight the challenges faced in traditional robotic systems, emphasizing their limitations in adaptability and decision-making. It should explore how AI integration enhances flexibility, precision, and efficiency in robotic operations. Additionally, students should discuss the role of simulation platforms in training AI-driven robots, reducing development costs, and improving safety by allowing virtual testing. The report should include real-world applications, relevant case studies, and potential future advancements in AI-driven industrial robotics.

References:

https://blogs.nvidia.com/blog/what-is-robotics-simulation/?utm_source=chatgpt.com

4. References:

Sl. No	Author Name	Title	Publication Details (Edition)
1	Stuart Russell, Peter Norvig	Artificial Intelligence: A Modern Approach	Pearson, 4th Edition, 2020
2	Tom Mitchell	Machine Learning	McGraw-Hill, 1st Edition, 1997
3	Rajesh Kumar, Manju Khari	Artificial Intelligence and Machine Learning in Engineering	Springer, 1st Edition, 2022
4	Giuseppe Coppolino, Francesca Palmieri	Machine Learning Techniques for Smart Manufacturing	Wiley, 1st Edition, 2021
5	Sebastian Raschka, Vahid Mirjalili	Python Machine Learning	Packt Publishing, 3rd Edition, 2019
6	Trevor Hastie, Robert Tibshirani, Jerome Friedman	The Elements of Statistical Learning: Data Mining, Inference, and Prediction	Springer, 2nd Edition, 2009
7	François Chollet	Deep Learning with Python	Manning Publications, 2nd Edition, 2021
8	S. B. Niku	Introduction to Robotics: Analysis, Control, Applications	Wiley, 3rd Edition, 2019

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
Total- 50 Marks					

6. SEE – Practice Assessment Methodologies

Sl. No	SEE – Practice Assessment	Duration (minutes)	Max. Marks	Min. Marks to Pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test Model Question Paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	AI & ML			**Test**	I
Course Code	25ME53IB	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No.	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Identify at least two specific fields within mechanical engineering that benefit from AI applications. Briefly explain how AI improves processes in each field.	Apply	CO1	10
	b. Describe the key differences between reactive and deliberative AI agents. Then, provide a simple example of how a reactive agent could be used in a manufacturing setting.	Apply	CO1	10
	c. Explain in your own words how the Depth-First Search (DFS) algorithm can be used for robotic path planning in a manufacturing setting. Provide a simple example, such as a robot navigating through a maze-like factory layout to reach a specific workstation, and discuss the benefits and limitations of using DFS in this scenario.	Apply	CO1	5
2	a. Discuss how the integration of AI in manufacturing can lead to improvements in process optimization and overall operational efficiency.	Apply	CO1	10
	b. Explain the characteristics of deliberative agents compared to reactive agents. Illustrate your answer with an example from manufacturing automation, such as how a deliberative agent might plan a sequence of actions to optimize the assembly line schedule.	Apply	CO1	10
	c. Describe how the Breadth-First Search (BFS) algorithm can be applied to robotic path planning in a manufacturing environment. Illustrate your explanation with an example—for instance, a robot finding the shortest path through a grid-based factory floor with obstacles—and discuss why BFS might be preferred in situations where the shortest route is critical.	Apply	CO1	5
	Section – 2			
3	a. Define Machine Learning and distinguish between supervised and unsupervised learning. Then, provide one industrial application in mechanical engineering—for example, explain how predictive maintenance is implemented in CNC machines using machine learning techniques.	Apply	CO1	10
	b. Explain the importance of data preprocessing in machine learning. Describe methods for handling missing values, performing feature scaling, and data normalization. Use an example from a mechanical dataset—such as CNC spindle vibration readings—to illustrate	Apply	CO1	10

	how these preprocessing steps can improve the accuracy of a predictive maintenance model			
	c. Design a simple workflow for building a predictive maintenance model in a manufacturing plant that integrates both data preprocessing and machine learning model selection.	Apply	CO1	5
4	a. Describe Machine Learning by differentiating supervised learning from unsupervised learning. Illustrate your answer with a specific example from mechanical engineering, such as the use of machine learning in quality control systems to detect defects in manufactured parts.	Apply	CO1	10
	b. Discuss why data preprocessing is a critical step before applying machine learning techniques in mechanical engineering. Outline procedures for imputing missing data, scaling features, and normalizing values. Support your explanation with an example from a mechanical system dataset (e.g., sensor data from industrial machinery) and describe how proper preprocessing can lead to more reliable fault detection.	Apply	CO1	10
	c. Outline a straightforward workflow for developing a predictive maintenance model in an industrial setting. Briefly describe the role of each stage in ensuring effective fault prediction and maintenance planning.	Apply	CO1	5
***Note for the Course coordinator**: Each question may have two or three or four or five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	AI and ML			**Test**	II
Course Code	25ME53IB	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one question. Each question carries 50 marks					

	Questions	**CO**	**Marks**
1.	**Implementing a simple AI agent in Python to automate decision-making tasks:** Implementing a simple AI agent in Python to analyze stress-strain data from mechanical components (e.g., beams, shafts, or structural members) under load conditions, evaluate the data against predefined material failure criteria (e.g., yield strength, ultimate tensile strength, or safety factors), and recommend actions such as "increase material thickness," "change material type," or "redesign component" based on the analysis results. The agent should also flag critical stress points and provide a summary report of its findings.	CO1, CO2	**50**
2.	**AI Search Algorithms: Developing DFS and BFS for robotic path planning:** This experiment aims to implement a robotic path planning system in a 2D grid-based environment using Depth-First Search (DFS) and Breadth-First Search (BFS) algorithms. The system will simulate a workspace where obstacles and free paths exist, requiring the robot to navigate efficiently from a user-defined start position to a goal position. The program will take grid dimensions, obstacle positions, start and goal coordinates as inputs and use DFS and BFS to find a feasible path. The output will include the computed paths for both algorithms,	CO1, CO2	**50**

	a comparison of their performance in terms of path length and search efficiency, and a visualization of the grid with obstacles and paths using a Python-based simulator such as Matplotlib		
Scheme of Assessment for Section I & II		**CO**	
a.	Develop the program for a given application	CO1, CO2	30
b.	Execution and Accuracy and effectiveness of the output.	CO1, CO2	20
		Total Marks	**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Write a Python program to implement a simple AI agent that analyzes stress-strain data from beams and shafts and recommends design modifications based on predefined material failure criteria.
02	Develop a solution using Depth-First Search (DFS) and Breadth-First Search (BFS) algorithms for robotic path planning in a simulated 2D manufacturing floor with obstacles, and compare their efficiency in finding optimal paths.
03	Create a Python script using Pandas, Matplotlib, and Seaborn to load and visualize a CNC spindle vibration dataset, highlighting trends and anomalies in vibration amplitude, spindle speed, and temperature.
04	Implement a data preprocessing module in Python to handle missing sensor data and perform feature scaling on a mechanical dataset, ensuring it is ready for predictive maintenance analysis**.**
05	Build and evaluate a decision tree classifier in Python using Scikit-learn to detect material defects in manufactured components based on preprocessed vibration data, and visualize the resulting decision tree.
06	Design a K-Means clustering model in Python to categorize mechanical components based on attributes such as weight, hardness, and surface roughness, and use visualization tools to interpret the cluster formations for quality control.

11. Rubrics for Assessment of Activity/ Case Study (Qualitative Assessment)

Sl. No	Dimension	Unsatisfactory (0-10)	Satisfactory (11-20)	Good (21-30)	Very Good (31-40)	Excellent (41-50)	Student's Score
1	Understanding of Concepts	Limited understanding of key automation concepts with minimal explanation.	Basic understanding of concepts but lacks depth in analysis.	Demonstrates a good grasp of concepts with relevant explanations.	Shows strong understanding with well-supported insights.	Exceptional comprehension with in-depth analysis and accurate technical explanations.	40

2	Technical Skills/ Implementation	Struggles with basic implementation of tasks	Able to implement tasks with some assistance or errors	Can complete tasks independently with minor errors	Completes tasks accurately with minimal assistance	Demonstrates advanced technical skills with flawless execution	40
3	Depth of Research and References	Minimal or no research; lacks credible references.	Limited research with few relevant references.	Good research with appropriate sources and citations.	Strong research with multiple credible references and detailed information.	Extensive research with high-quality references, demonstrating thorough investigation.	40
4	Report/ Presentation Quality	Report/presentation lacks clarity and detail	Provides basic information, but lacks depth or organization	Well-organized report/ presentation with clear details	Clear, concise, and in-depth with appropriate diagrams	Highly professional presentation with comprehensive details and critical insights	40
						Average Marks	**40**

Note: *Dimension and Descriptor shall be defined by the respective course coordinator as per the activities*

11. SEE- Model Practice Question Paper

Program	Diploma in Mechanical Engineering		**Semester**	V
Course Name	AI & ML	**Course Code:** 25ME53IB	**Duration**	180 min

Note*: Answer any one question*

Questions	**CO**	**Marks**
Note*: During the SEE, All questions will be distributed among the group. Each student will be assigned one of the following questions by the examiner, without offering any choice.* 1. Write a Python program that implements an AI agent to analyze stress-strain data from mechanical components, flag critical stress points, and recommend design actions based on predefined material failure criteria. 2. Develop a Python script that applies both DFS and BFS algorithms to navigate a 2D grid with obstacles and compare their performance in terms of path length and exploration efficiency. 3. Create a Python program using Pandas, Matplotlib, and Seaborn to load and visualize a CNC spindle vibration dataset, plotting time-series graphs for vibration amplitude, spindle speed, and temperature. 4. Implement a Python solution that preprocesses a CNC vibration dataset by handling missing values with imputation and normalizing the data using Min-Max scaling and standardization. 5. Build a decision tree classifier in Python using Scikit-learn to classify CNC-machined components as defective or non-defective based on preprocessed vibration data, and evaluate its performance using accuracy metrics. 6. Construct a linear regression model in Python to predict mechanical component failures from historical CNC vibration data and analyze the model's predictive accuracy. 7. Apply the K-Means clustering algorithm to categorize mechanical components based on attributes such as weight, hardness, surface roughness, and wear rate, and	CO1, CO2, CO3, CO4	**50**

visualize the resulting clusters. 8. Simulate a reinforcement learning environment using the PPO algorithm to train a robotic arm for a pick-and-place task in a manufacturing setting and assess its performance based on task success rates. 9. Develop an ML-based predictive maintenance model in Python that uses real-world bearing datasets (vibration, temperature, and acoustic data) to forecast bearing failures and validate its performance. 10. Prepare a case study report detailing the development of an AI-based robotic control simulation for industrial automation, emphasizing improvements in adaptability, precision, and safety through virtual testing.		
Scheme of Assessment		
a. Develop the program for a given application and execute it	CO1, CO2, CO3, CO4	30
b. Accuracy and effectiveness of the output.	CO1, CO2, CO3, CO4	20
Total Marks		**50**

1) Signature of the Examiner 1 **2) Signature of the Examiner 2**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Qty.
1	Desktop Computers	Intel i7/Ryzen 7 CPU, 16GB RAM, 512GB SSD, NVIDIA GTX 1660 GPU, Windows 10/Linux OS	30
2	Network Switch	24-port Gigabit Ethernet Switch	1
3	UPS	5kVA UPS for power backup	1
4	Lab Server	Intel Xeon processor, 32GB RAM, 1TB SSD, Linux OS for centralized data and software hosting	1
5	Software	Anaconda Python Distribution, PyCharm Community Edition (free) and other open-source libraries	
6	Internet Connectivity	High-speed Internet connection with secure firewall setup	1 (Lab connection)

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Heating Ventilation And Air-Conditioning	**Type of Course**	Integrated
Course Code	25ME53IC	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale:

Human comfort plays a vital role either in industries or at home or in office or Apartment building. This is made possible through regulation of heat, airflow, ventilation, and air conditioning. Comfortable office climate increases the level of productivity and increases morale amongst the workers and employees. Studies on corporate workplace behavior and employee motivations suggest that workers are more enticed to keep coming to work if their office is properly cooled and/or heated. Having the proper temperature at work is an added advantage for building a solid team at work. Controlling the temperature of air inside the designated "Air Conditioned" space along with control of moisture, filtration of air and containment of air borne particles, supply of outside fresh air for control of oxygen and carbon dioxide levels in the air-conditioned space, and finally control of the movement of air or draught, is a very desirable factor. These conditions can be achieved using an HVAC system. The need for hands-on workers to implement and service that high tech HVAC systems is growing and henceforth, is the Specialization pathway - Heating Ventilation and Air-Conditioning (HVAC)

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Estimate the Heating and cooling Load for an HVAC application & validate using E-20 forms
CO-02	Apply the knowledge of air conditioning to provide HVAC solution
CO-03	Design the duct for an HVAC application using Building Information Modeling software.
CO-04	Provide innovative HVAC solutions for green buildings and familiarize tender documentation.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1,4	• **Introduction to HVAC.** Applications of HVAC • Concept of heat, specific heat, latent heat, temperature, work, power, energy, enthalpy, Entropy • Psychometrics - Psychrometric terms- Dry Air, Moist Air, Saturated Air, Degree of Saturation, Dry Bulb Temperature, Wet Bulb Temperature, Humidity, Absolute Humidity, Relative Humidity, Specific Humidity, Humidity Ratio	• Simple problems on Psychrometry, Use Psychrometric chart and measure properties of air • Plot Psychrometric processes using Psychometric chart. Psychrometric processes – Sensible heating, Sensible Cooling, Humidification and De- Humidification • Working on Psychrometric Chart with software tool.
2	1	1,4	• **Human Comfort-** • Factors affecting human comfort, Comfort parameters, IAQ (Indoor air Quality): Causes & Sources of Indoor Air Quality, Indoor Air • Pollutants, Indoor Air Quality Regulations, ASHRAE Guidelines and Standards • **Thermal Insulation-** Basic Materials and Thermal Properties, Moisture Content of Insulation Material, concept of conduction, convection & Radiation, Economic Thickness, Thermal Resistance of Airspaces • Shading Of Glass- Indoor Shading Devices, External Shading Devices,	• Study experiment on Fenestration- Types of Window Glass (Glazing), single galzing and double galzing .
3	1	1,4	• Estimate HVAC load in terms of TR concept of Sensible heat gain, Latent heat gain • Calculate sensible heat gain through building structure by conduction • Calculate heat gain from solar radiation • Calculate Solar (Sensible)heat gain through outside walls and roofs • **Explain Concept of Solar Air temperature** • Calculate Solar heat gain through Glass surface • Calculate Heat gain through Infiltration • Calculate heat gain through Ventilation	• Practice problems on heat load calculation.
4	1	1,3,4	• Calculate heat gain from Occupants • Calculate Heat gain from Appliances • Calculate Heat gain from lighting equipment's • Calculate Heat gain from power	• Estimate HVAC load for a Single story building plan & 1 BHK using E20 or any similar forms.

			equipment's • Calculate Heat gain through ducts • Conversion of Tons of Refrigeration (TR) to British Thermal Units (BTU) Conversion of Tons of Refrigeration (TR) to KW/hr Conversion of British Thermal Units (BTU) to KW/hr	
5	1	1,3,4	• Estimate HVAC load for any given Conference room • Estimate HVAC load for any given laboratory	• Estimate HVAC load for any given Conference room using E20 or any similar forms. • Estimate HVAC load for any given laboratory using E20 or any similar forms.
6	2	1,2,4	• Air-Conditioning System and Equipment • Vapor Compression Cycle-Components of AC System • Types of Compressor, Condenser, Expansion Valve and Evaporator Coil. • Types of AC System - Air cooled / Water Cooled/ DX / Chilled Water • Types of Air Conditioning Equipment - Unitary, Split System, Package AC, Chilled Water (AHU, FCU & FAHU) • VRV or VRF System	• Demonstrate working of AC/Refrigeration (using Refrigeration test rig or Air conditioning test rig) or Working models • Visit any commercial building to understand Centralized AC system near your institute, prepare a simple block diagram (showing AC Unit, Ducting, Fan location, control systems) and submit a report
7	3	1,4	• Air Distribution System- Ducting and Air Terminals • Ducting - Classification, Material and Shapes • Duct Insulation-Types, Material and Properties • Duct Acoustics - Types, Material and Properties • Plenum Box Sizing • Duct gauge selection, Comparison between different shapes of duct • Air Distribution Terminals-Types of Air Terminals & its applications	• Introduction to BIM Software, Exploring the User Interface Model- New • Practice to Navigate the ribbon interface. • Practice to Utilize user interface features. • Practice to Use settings and menus • Practice on Import and reuse existing drawings from other formats. • Practice on Manipulating the properties of parameters
8	3	1,2,4	• Duct Designing method- Velocity Reduction method, Equal friction Method, Static Regain Method • Problems on duct designing using Velocity Reduction method	• Design the Duct system for any Conference room layout using BIM software
9	3	1,2,4	• Problems on Duct designing using Equal friction Method	• Design the Duct system for any laboratory layout using BIM software
10	3	1,2,4	• Problems on Duct designing using Static Regain Method	• Design the Duct system for any 1 BHK using BIM software

11	3	1,4	• Building Management System(BMS): • The BMS system and its components • The architecture & different levels of the BMS system • The BMS riser diagram	• Visit nearby / virtual tour of a structure equipped with BMS and prepare a report.
12	4	1,4,5	• Green Buildings and HVAC • Discuss Green building and its importance in sustainable Planning. • Characteristics of green building • concept of REDUCE, REUSE and RECYCLE • Demonstrate Life Cycle Assessment • LEED (Leadership in Energy and Environmental Design) Certification, Requirements, Benefits	• Prepare Recommendations to convert your institute into a green buildings or consider any other building under construction
13	4	1,4	• Tender documentation	• conducting mock tender process

4. References

Sl. No.	Author(s)	Title of Books	Publication/Year
1	Arthur A. Bell Jr. and W. Larsen Angel	HVAC Equations, Data, and Rules of Thumb	McGraw-Hill Education/2016
2	Roger W. Haines	HVAC Systems Design Handbook	McGraw-Hill Education/2010
3	R S Kurmi and J K Gupta	A Text Book of Refrigeration and Air conditioning	S Chand
4	C P Arora	A Text Book of Refrigeration and Air conditioning	McGraw-Hill Education/2017
5	Bimal Prof. Kumar	A Practical Guide to Adopting BIM in Construction Projects by Prof Bimal Kumar	Whittles Publishing/2016
BIM handbook: A guide to building information modelling for owners, managers, designers, engineers and contractor			
ASHRAE® HANDBOOK on Heating, Ventilating, and Air-Conditioning APPLICATIONS			

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1.	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

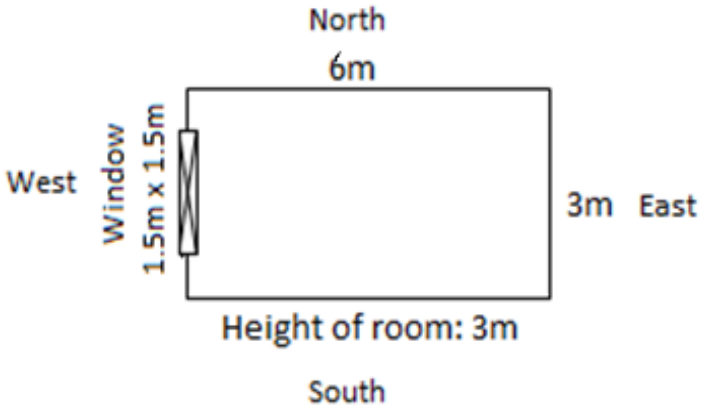
6. SEE – Practice Assessment Methodologies

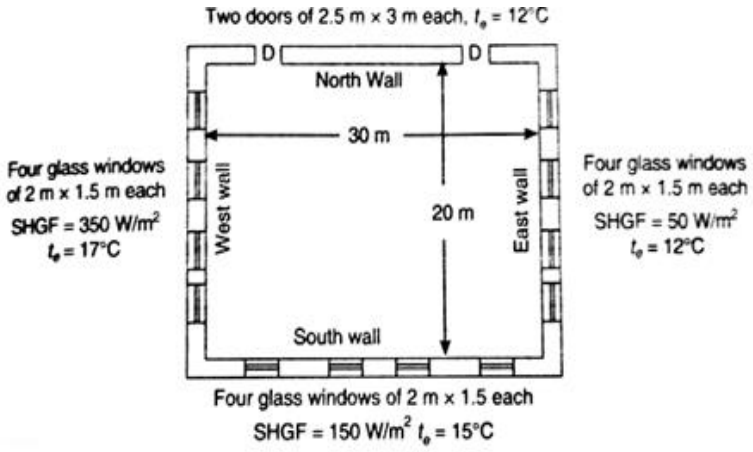
Sl. No	SEE – Practice Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practice	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			Semester - V	
Course Name	Heating Ventilation And Air-Conditioning			Test	I
Course Code	25ME53IC	Duration	90 min	Marks	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	CL	CO	Marks
	Section - 1			
1	a) Psychometric chart has significant role in HVAC system. What does these lines represent on a Psychometric chart? I. Vertical and uniform space lines. II. Curved line. III. Non-Uniformly spaced inclined straight lines. IV. Non-Uniformly spaced horizontal lines. V. Uniformly spaced inclined straight lines. b) A school is experiencing health complaints from students due to poor indoor air quality. Explain what Indoor Air Quality (IAQ) is and discuss the possible causes and sources of air pollution inside the school. c) Due to increasing global warming, conservation of energy and increasing the efficiency of the HVAC systems is of foremost importance. Glazing of windows plays an important role in reducing the demand for energy for cooling the space. Explain the concept of glazing and different methods of glazing.	Apply	CO1	5+10 +10= 25
2	a) A building in a cold climate is experiencing high heating costs. As an energy consultant, suggest insulation materials with suitable thermal properties to improve energy efficiency and reduce heat loss. Discuss the key thermal properties to consider in your recommendations. b) The Thermal resistance of insulating material depends on the thickness of the insulation. The higher the thickness of insulation, the higher the investment cost and R value and vice versa. Hence Illustrate the economical thickness of Thermal Insulation by Total Cost Method. c) The objective of the HVAC system is to provide human comfort by adding or removing Heat from the space. The amount of heat that has to be removed or added (Heat/ Cool load estimation) depends upon the heat received by the boundary (walls) or Outside Air. The heat gets transferred through different modes. Hence classify the different modes of heat transfer with their governing laws.	Apply	CO1	5+10 +10= 25

Section – 2				
3	An air-conditioned room that stands on a well-ventilated basement measures 3 m wide, 3 m high and 6 m deep. One of the two 3m walls faces west and contains a double-glazed glass window of size 1.5 m by 1.5 m, mounted flush with the wall with no external shading. There are no heat gains through the walls other than the one facing west.  Calculate the Sensible, Latent, Total heat gains on the room, room Sensible heat factor (SHF) and also determine the cooling capacity required in TR (Tons of Refrigeration) from the following information. Neglect the heat gain by infiltration and ventilation. (Use E20 form or any other similar form or any other method). Insideconditions:25°Cdrybulb,50%relativehumidity Outside conditions: 43 °C dry bulb, 24 ° C wet bulb U-value for wall: 1.78W/m2K , U-value for floor: 1.2W/m2K U-value for roof: 1.316 W/m2K , U-value for glass: 3.12W/m2K Effective temperature difference (ETD) for wall: 25°C Effective temperature difference (ETD) for roof: 30°C Solar Heat Gain (SHGF max)ofglass:300W/m2 Internal Shading Coefficient (SC) of glass: 0.86 Occupancy 4 people: (90 W sensible heat/person) and (40 W latent heat / person) , Lighting load: 33W/m2 of floor area Appliance load: 600W (Sensible) 300 W (latent) Since the room stands on a well-ventilated basement, assume the conditions in the basement to be the same as that of the outside (i.e., 43 °C DBT, 24 °C WBT), also the floor is not exposed to solar radiation, assume the Effective temperature difference for the floor is same as temperature difference between the outdoor and indoor.	Apply	CO1	25

4	A laboratory measuring 30m x 20m x 4m high as shown in the figure is to be air conditioned. The north wall has A two doors of 2.5m x 3 m each. The south wall has four glass windows of 2m x 1.5m each. The east and west walls also have four windows of the same size. The lighting load is 15 W fluorescent per m2 floor area. The Solar heat gain factor (SHGF) for south glass is 150 W/m2, east glass is 50 W/m2 and west glass is 350 W/m2. The overall heat transfer coefficients for walls are 2.5 W/m2K, roof is 2 W/m2K, floor is 3 W/m2K, door is 1.5 W/m2K and widows are 6 W/m2K. The corrected equivalent temperature differences for north wall is 12 °C, south wall is 15 °C, east wall is 12 °C, west wall is 17 °C, roof is 20 °C and floor is 2.5 °C. There are 100 persons with sensible heat 75 W/person and latent heat 55 W/person. The outdoor condition is 43 °C DBT and indoor condition is 25 °C DBT. Use a factor of 1.25 for fluorescent light. Determine room sensible heat, room latent heat, room total heat and cooling capacity in TR. Neglect the heat gains due to infiltration and ventilation.  	Apply	CO1	25
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Sem**	V
Course Name	Heating Ventilation And Air-Conditioning			**Test**	II
Course Code	25ME53IC	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer all the questions.					
	Questions			**CO**	**Marks**
1.	For DBT 32 degree & RH(ø)=40%C find out the a) Humidity ratio b) WBT c) Vapor density d) Enthalpy **(OR)** Perform the thermal conductivity experiment on a thick slab and determine the thermal conductivity of the given material. Record all observations, calculations, and analyze the results.			CO1	10

2.	Estimate HVAC load for a Single storey building plan & 1 BHK as shown in figure using E20 or any similar forms. for the following conditions **Inside conditions** 25°C dry bulb, 50 percent RH, Wi=0.00992 kg water/kg air **Outside conditions:** 43°C dry bulb, 24°C wet bulb, W0= 0.0105k water/kg air U-value for wall: 1.75 W/m2 K , U-value for roof: 1.33W / (m2) * K U-value for floor 1.3W / (m2) * K , Effective Temp Difference (ETD) for wall: 22°C, Effective Temp Difference (ETD) for roof: 26°C , U-value for glass: 2.9 W/m2 K, Solar Heat Gain (SHG) of glass 275W / (m2) Internal Shading Coefficient (SC) of glass: 0.8, Occupancy: 6 (100 W sensible heat/person) (150 W latent heat/person), Lighting load: 50W / (m2) of floor area, Appliance load: 650 W (Sensible) + 310W (latent), Infiltration: 0.4 Air Changes per Hour, Barometric pressure: 101 kPa, Note: hfg of water = 2501 kJ/kg, Take CPM = 1.02176 x 103kj/kgK  	CO1	40

Scheme of assessment for Q1	Scheme of assessment for Q2
1.Finding individual parameters=(2*4=8 Marks) 2.Representing the above in psychometric chart = (2 Marks) **(OR)** 1. Writing Observation & Tabular Column=5+5=10 Marks 2. Conduction of an Experiment = 20Marks 3. Calculation & result = 10 Marks	1. Theoretical calculation =40 Marks 2. Validating the above using E 20 Forms= 20 Marks

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Prepare a working model of portable AC
02	Conducting mock tender process
03	Prepare Recommendations to convert your Home into a Green Buildings
04	Prepare a report on impact of refrigerants on global warming.
05	Prepare a Report on Advanced Techniques for Eco-Friendly and Sustainable Cooling
06	Prepare a report on Automotive Air Conditioning.

10. Rubrics for Assessment of Activity (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Content Accuracy	Major errors, lacks key points.	Some inaccuracies or missing details.	Mostly accurate, minor gaps.	Accurate and well-covered.	Fully accurate and detailed.	45
2	Research Depth	Little to no research done.	Limited research or incomplete.	Adequate research, covers basics.	Well-researched, includes examples.	Extensive, insightful research.	42
3	Clarity & Organization	Disorganized and unclear.	Somewhat clear, needs better flow.	Mostly clear with minor issues.	Clear and well-structured.	Very clear, logical, and engaging.	35
4	Visuals & Creativity	No visuals or poorly designed.	Basic visuals, lacks creativity.	Adequate visuals, some creativity.	Good visuals, engaging design.	Exceptional visuals and creativity.	40
5	Overall Quality	Poor quality, lacks professionalism.	Basic quality, needs improvement.	Satisfactory quality, minor flaws.	High quality, polished work.	Professional-level quality.	45
	Average Marks=(45+42+35+40+45)/5=**42**						**42**

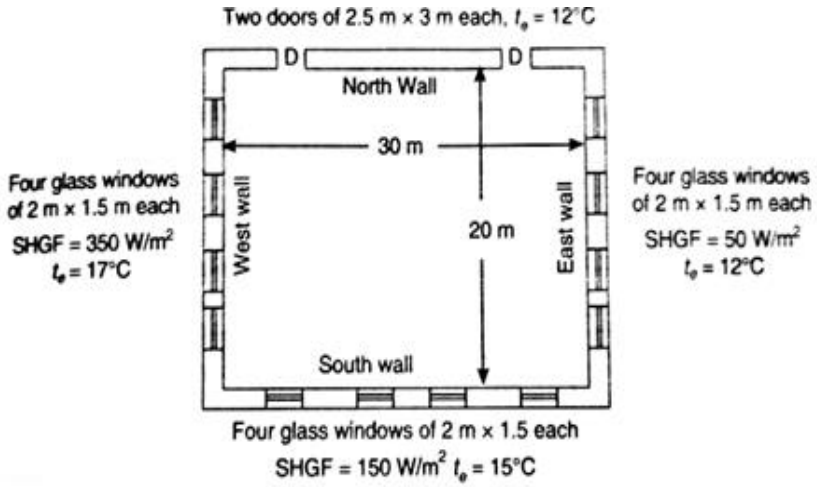
Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11.SEE- Model Practice Question Paper

Program	Mechanical Engineering			**Semester**	V
Course Name	Heating Ventilation And Air-Conditioning				
Course Code	25ME53IC	**Duration**	180 min	**Marks**	50

Answer the following questions

Questions	CO	Marks
1. Perform the thermal conductivity experiment on a composite wall and determine the thermal conductivity of the given material. Record all observations, calculations, and analyze the results.	CO1	10
2. Calculate total heat and cooling capacity in TR. & Design Duct system for given laboratory layout using BIM software. A laboratory measuring 30m x 20m x 4m high as shown in the figure is to be air conditioned. The north wall has A two doors of 2.5m x 3 m each. The	CO3	40

south wall has four glass windows of 2m x 1.5m each. The east and west walls also have four windows of the same size. The lighting load is 15 W fluorescent per m2 floor area. The Solar heat gain factor (SHGF) for south glass is 150 W/m2, east glass is 50 W/m2 and west glass is 350 W/m2. The overall heat transfer coefficients for walls are 2.5 W/m2K, roof is 2 W/m2K, floor is 3 W/m2K, door is 1.5 W/m2K and widows are 6 W/m2K. The corrected equivalent temperature differences for north wall is 12 °C, south wall is 15 °C, east wall is 12 °C, west wall is 17 °C, roof is 20 °C and floor is 2.5 °C. There are 100 persons with sensible heat 75 W/person and latent heat 55 W/person. The outdoor condition is 43 °C DBT and indoor condition is 25 °C DBT. Use a factor of 1.25 for fluorescent light. Determine room sensible heat, room latent heat, room total heat and cooling capacity in TR. Neglect the heat gains due to infiltration and ventilation.  		

Scheme of assessment for Q1	**Scheme of assessment for Q2**
1. Conduction of an Experiment = 5 Marks 2. Calculation & result = 5 Marks	3. Total heat and cooling capacity in TR= 20 Marks 4. Duct Design using BIM software= 20 Marks

Total Marks	**50**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars Required	Specifications	Quantity
1	Computers	Latest Configuration	30
2	BIM Software	-	30
3	Thermal Conductivity Setup for thick slab, thick cylinder & composite wall	-	1
4	Refrigeration test rig or Air conditioning test rig	-	1

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Finite Element Analysis	**Type of Course**	Integrated
Course Code	25ME53ID	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale -

This course on Finite Element Analysis (FEA) provides students with a comprehensive understanding of the theory and practical application of FEM in solving complex engineering problems. Starting with the basics of FEM, including its methods, advantages, and applications, the course covers essential topics such as mesh generation, stiffness matrices, boundary conditions, and the use of FEA software.

Students will focus on structural analysis with 1D elements like bars and trusses, exploring axial deformation and deriving stiffness matrices. The course also addresses heat transfer and fluid flow analysis, teaching students how to apply FEM for solving 1D problems in these areas using FEA software. By combining theory with hands-on practice, students will gain both the computational and analytical skills necessary to model, simulate, and solve real-world engineering problems.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Understand the fundamental principles of the finite element method (FEM) and its application to solving engineering problems.
CO-02	Apply FEM principles to structural problems and solve by selecting suitable elements, constructing stiffness and force matrices, and applying appropriate boundary conditions.
CO-03	Solve structural problems using 1D, 2D, or 3D elements by applying appropriate boundary conditions and analyze using FEA software
CO-04	Apply FEM principles to heat transfer and fluid flow problems and analyze using FEA software

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1	**Introduction to FEM and FEA –** • Introduction to Finite Element Methods (FEM),Need-Back Ground • Methods employed in FEM, Steps in FEM • Advantages and Disadvantages, Limitations, Applications of FEM	**Introduction to FEA software –** Practice on FEA software interface, commands in FEA software. (Eg: Ansys, Abaqus, Hypermesh)
2	1	1	**Discretization of the Problem -** • Division of Structures into Elements (Mesh Generation) • Types of Element and Applications - o 1D Elements (Beam and Bar Elements) o 2D Elements (Triangle and Quadrilateral Elements) o 3D Elements (Tetrahedral and Hexahedral Elements) o Special Elements (Axisymmetric, Shell, and Solid Elements) • Nodes and Degrees of Freedom (DOF)	**Basic Steps in Finite Element Analysis** • Preprocessing (Modeling and Meshing) • Solution Process (Assembly of Stiffness Matrices) • Post processing (Results Interpretation)
3	1,2	1	**Stiffness Matrix –** • Stiffness Matrix - Properties of stiffness matrix • Global Stiffness Matrix • Assembly of Global Stiffness Matrix	**Finite Element Analysis Software -** • Creating Models, Mesh Generation, Boundary Conditions
4	1,2	1	**Boundary Condition –** • Boundary Conditions- Methods –Types • Issues with inaccurate boundary conditions.	**Exploring FEA Software -** Running Simulations and Analyzing Results
5	2,3	1,2, 4	**Structural applications –** • Introduction to 1D Elements in Structural Applications. • Types of Structural Elements (1D, 2D, and 3D) • Role of 1D Line Elements in Structural Analysis	Solving simple structural problems using 1D elements in FEA software.
6	2,3	1,2, 4	**Axial Deformation of 1D Elements (Bar and Truss Elements) –** • Axial Deformation and Stiffness in Bar Elements • Stress-Strain Relationship for Axial Load • Constitutive Law for 1D Elements	Validating simple structural problems using 1D line elements in FEA software
7	2,3	1,2, 4	• Derivation of Stiffness Matrix for Bar and Truss Elements • Calculation of Nodal Forces and Displacements • Boundary Conditions (Fixed, Pinned, and Roller Supports) • Solving simple bar and Truss problems using FEM Method	Validating simple structural problems using 1D elements in FEA software.

8	3	1,2, 4	Solving simple structural problems using 1D elements in FEM method and validating using FEA software.	
9	3	1,2, 4	Solving simple structural problems (Plate with a hole) by using 2D elements SOM method and in FEA software.	
10	4	1,2, 4	**Heat transfer Analysis –** • Heat transfer fundamentals. • Advantages of using FEM in heat conduction problems over analytical methods.	Solving simple 1D Heat Conduction problems in FEM method and validating using FEA software.
11	4	1,2, 4	• Finite Element Discretization for 1D Heat Transfer • Solve simple problems by FEM Method for Composite walls, Fins applications	Solving simple 1D Heat Conduction problems in FEM method and validating in FEA software.
12	4	1,2, 4	**Fluid Flow Analysis –** • Fluid flow fundamentals. • Advantages of using FEM in fluid flow problems over analytical methods.	Solving simple 1D Fluid flow problems in FEM Method and validating using FEA software.
13	4	1,2, 4	• Finite Element Discretization for 1D Fluid flow problems	Solving simple 1D Fluid flow problems in FEM Method and validating using FEA software.

4. References:

Sl. No.	Author	Title of Books	Publication/Year
1.	T R Chandrupatla, A D Belegundu	Introduction to Finite Elements in Engineering	Prentice Hall, Pearson Education / 2001
2.	Nitin S Gokhale, Sanjay S Deshpande et. Al	Practical Finite Element Analysis	Finite to Infinite / 2025
3.	S S Rao	Finite Element Method in Engineering	Elsevier Publication/ 2017
4.	Olek C Zienkiewicz, Robert L. Taylor, Sanjay Govindjee	The Finite Element Method: Its Basis and Fundamentals	Butterworth-Heinemann Inc / 2024
5	SrinivasPaleti, Sambana, Krishna Chaitanya, Datti, Rajesh Kumar	Finite Element Analysis Using Ansys	PHI Publication

5. CIE Assessment Methodologies

Sl.No	CIE Assessment	Test Week	Duration (minutes)	Max marks	
1	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
Total					**50Marks**

6. SEE - Practice Assessment Methodologies

Sl.No	SEE – Theory Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practical	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering		Semester- V	
Course Name	Finite Element Analysis		Test	I
Course Code	25ME53ID	**Duration-** 90 min	Marks-50	
Name of the Course Coordinator:				
Note: Answer any one full question from each section. Each question carries equal marks.				

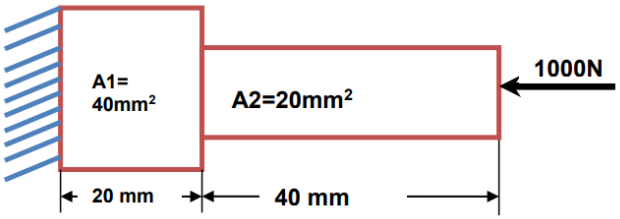
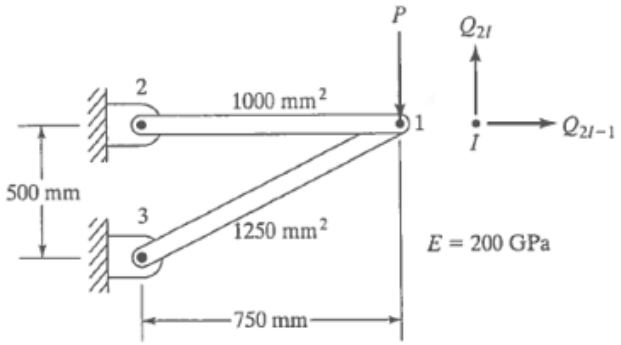
Q. No	Questions	CL	CO	Marks
	Section – 1			
1	a. Explain how FEM can be applied to analyze the load-bearing capacity of a complex bridge. Discuss the advantages and limitations of using FEM for such structural analysis. b. Explain the concepts of **nodes** and **degrees of freedom (DOF)** in FEM. How do these concepts affect the accuracy and efficiency of the finite element analysis? c. Describe the different types of **elements** used in FEM. Provide examples of each element type and explain the scenarios where each type is typically used.	L3	1	**8** **8** **9**
2	a. Explain how **FEM** differs from traditional analytical methods in solving structural problems. What are the key reasons for adopting FEM in modern engineering analysis? b. Discuss the **steps of discretizing** the problem using FEM and analyze its advantages for complex geometries and irregular boundary conditions. c. Discuss role and applications of **special elements** such as axisymmetric, shell, and solid elements in solving problems with complex geometries.	L3	1	**8** **8** **9**
	Section – 2			
3	a. Explain how the **stiffness matrix** is used to analyze the deformation of a structure. How does the stiffness matrix help calculate the displacement and internal forces in a system of elements? b. Describe the steps involved and how individual element stiffness matrices are combined to form the global system. c. How does **boundary conditions** affect the stiffness matrix and the overall analysis of a structure? Explain the process of applying these boundary conditions to a structural model.			**8** **8** **9**
4	a. Discuss the significance of the **stiffness matrix** in Finite Element Method (FEM) analysis? How does it help in determining the displacements and forces within a structure? b. Describe the process of **assembling the global stiffness matrix** from the individual element stiffness matrices. How is this important for solving large structural problems? c. Discuss the potential issues with **inaccurate boundary conditions** in FEM? How does improper boundary conditions lead to incorrect displacement or stress results in a structure?			**8** **8** **9**
Note for the Course coordinator: Each question may have two, three, four and five subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	Finite Element Analysis			**Test**	II
Course Code	25ME53ID	**Duration**	180 min	**Marks**	50

Name of the Course Coordinator:
Note: Answer any one full question from the following

Questions	**CO**	**Marks**
1. Apply finite element formulations to solve the given One dimensional structural problem and Validate using Ansys. *Find Nodal Displacements Stresses and reaction forces for the following Structural problem using Link1 Element. Given data: A_1 = 40mm², A_2 = 20mm², Young's modulus =2x10⁵ N/mm². Validate the obtained results using Analysis Software*  	CO2, CO3	50
OR		
2. Apply finite element formulations to solve the given One Dimensional Structural problem and Validate using Ansys. *For the pin-jointed configuration shown in figure. a) Calculate the reaction forces. b) Nodal displacements c) Element stresses. Validate the obtained results using Analysis Software*  	CO2, CO3	50

Scheme of Evaluation		
1. • Solve by FEM Method • Validate Using FEM software	CO2 CO3	25 25
2. • Solve by FEM Method • Validate Using FEM software	CO2 CO3	25 25

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl.No.	Suggestive Activities for Tutorials
01	Simulate the **dynamic response** of a **bridge** to **wind-induced vibrations** using FEM. Analyze the **displacement** and **stress variations** over time, and discuss the impact of **dynamic loading** on the structure's performance.
02	Using FEM, analyze a **combination of beams and trusses** under static loading conditions. Report the **displacement** and **reaction forces** and identify critical stress areas in the structure.
03	Using FEM, perform a **time history analysis** on a **building structure** subjected to an **earthquake load**. Analyze its **dynamic response** and compare it to the results of a **static analysis**.
04	Using FEM, simulate the **thermal and mechanical loadings** on a **3D structure** (e.g., pressure vessel). Report the effects of combined **thermal expansion** and **mechanical loading** on the structural integrity of the component.

10. Rubrics for Assessment of Practical Exercises/Activities (Qualitative Assessment)

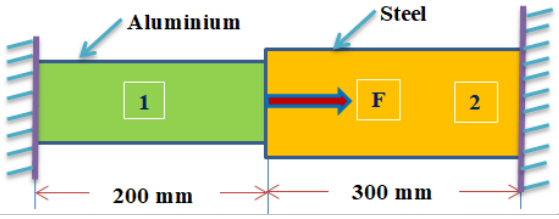
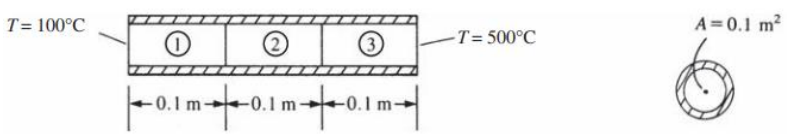
Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Student Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Problem Understanding & Setup	Errors in model setup	Significant errors in model setup or boundary conditions	Basic understanding with setup issues	Good setup, minor issues in boundary conditions	Thorough model setup, correct boundary conditions	40
2	Modeling & Mesh Generation	Poor mesh definition	Significant errors in elements	Mesh too coarse/fine, some issues with elements	Generally good mesh with minor issues	Well-defined mesh, correct element types, refined	40
3	Boundary Conditions	Incorrect results	Poor boundary conditions affecting results	Some errors in boundary conditions	Mostly correct, minor inconsistencies	Correctly applied boundary conditions	40
4	Solution & Results Analysis	Incorrect results	Poor analysis and interpretation	Results correct but minimal analysis or explanation	Correct results, some analysis depth lacking	Accurate analysis, clear interpretation of results	40
5	Software Proficiency	Poor software use	Significant errors	Basic proficiency, some issues with commands	Good proficiency with minor issues	Excellent software use, clear documentation	40
6	Practical Record submission	Poor report	Lacking clarity or structure	Basic report with missing or unclear explanations	Clear report with minor details missing	Clear, concise, well-documented report	40
	Average Marks=(40+40+40+40+40)/5=40						**40**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. SEE–Model Practical Question Paper

Program	Mechanical Engineering	**Semester**	V
Course Name	Finite Element Analysis	**Marks**	50
Course Code	25ME53ID	**Duration**	180 Min

Note: Answer any one full question. Each full question carries equal marks.

Q No	Questions	Cognitive Levels	Course Outcomes	Marks
	Section -1			
1	Apply finite element formulations to solve the given One Dimensional Bar problem and Validate using Ansys. *An axial load F = 300 x 10^3 N is applied at 20°C to the rod as shown. The temperature is raised to 60°C. Determine the nodal displacement, stress in the element, reaction forces.* ***Aluminum*** / ***Steel*** $E_1 = 70 \times 10^9$ N/m² / $E_2 = 200 \times 10^9$ N/m² Poisson's Ratio = 0.3 / Poisson's Ratio = 0.3 A=900mm² / A=1200mm² $\alpha_1 = 23 \times 10^{-6}$ °C / $\alpha_2 = 11.7 \times 10^{-6}$ °C ***Given Data:*** 	Apply	CO2,CO3	50
2	Apply finite element formulations to solve the given One Dimensional Heat transfer problem and Validate using Ansys. *For the composite wall idealized by the 1-D model shown in figure below, determine the interface temperatures. For element 1, let K_1 = 5 W / m°C, for element 2, K_2 = 10 W /m°C and for element 3, K_3 = 15 W /m°C. The left end has a constant temperature of 200°C and the right end has a constant temperature of 600°C.* 	Apply	CO4	50

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Quantity
01	Desktop Computer	Latest configuration	30 Nos
02	Analysis Software	Any	30 Nos

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	V
Course Name	Drone Technology	**Type of Course**	Integrated
Course Code	25ME53IE	**Contact Hours**	91 Hrs./Sem. 7Hrs/Week
Teaching Scheme	L: T:P: 3:0:4	**Credits**	5
CIE Marks	50	**SEE Marks**	50 (Practice)

1. Rationale:

This course is structured to provide students with a progressive learning experience in drone technology, encompassing fundamentals, system design, fabrication, propulsion, avionics, flight techniques, maintenance, regulations, and future applications. The curriculum balances theory and hands-on practical learning to develop both conceptual knowledge and industry-relevant technical skills. By the end of the course, students will be equipped with the ability to design, build, operate, and optimize drones for diverse real-world applications.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Recognize Drone Fundamentals – Explain the history, classifications, and applications of drones across various industries.
CO-02	Design and Fabricate Drone Structures – Apply CAD modeling, material selection, and manufacturing techniques for optimized drone frames.
CO-03	Integrate Propulsion & Avionics – Configure and test motors, propellers, power systems, and sensors for efficient flight performance
CO-04	Operate and Maintain Drones – Perform flight maneuvers, inspections, safety checks, and preventive maintenance for drone longevity.
CO-05	Analyze Future Trends & Regulations – Evaluate emerging drone technologies, automation, industry regulations, and career pathways.

3. Course Content

WEEK	CO	PO	Theory	Practice
1	1	1	**Introduction to Drones and Categories** • **History and Evolution of Drones** – Key milestones in drone technology from military to commercial applications. • **Applications of Drones** – Use in agriculture, logistics, construction, security, and environmental monitoring. • **Drone Selection Criteria** – Choosing drone types based on size, endurance, payload, and purpose.	• **Video Demonstration:** Different drone models and their capabilities in real-world applications. • **Case Study:** Research and document all types of drones that can be used for disaster management.

2	1	1,4	**Fundamental Mechanical Principles** • **Forces Acting on a Drone** – Lift, drag, thrust, and weight affecting stability, maneuverability, and efficiency. • **Multirotor Principles** – How multiple propellers generate lift, maintain balance, and enable controlled flight. • **Fixed-Wing and VTOL Drones** – Flight dynamics, advantages, and operational differences between these drones.	• **Video Demonstration:** Explore the pros and cons of using a Tail-Sitter type configuration drone for surveillance and delivery purposes. • **Experiment:** Examine and document how the performance changes when using a quad copter vs a octo copter setup using a thrust stand.
3	1	1,4	**Drone System – Components** • **Structural Components –** Role of frames, arms, and landing gear in drone durability and stability. • **Electronic Components** – Functions of motors, ESCs, flight controllers, receivers, and transmitters. • **Wiring and Connectivity** – Understanding wiring diagrams, signal pathways, and power distribution.	• **Case Study:** Determine the wiring schematics of an agricultural spraying drone. • **Experiment:** Observing the drone assembly process and understanding component integration.
4	2	1,2,4	**Frame Design Requirements** • **Structural Systems and Design** – Rigid frame structures optimized for durability and performance. • **Engineering Drawings** – CAD-based drone frame design, layout planning, and dimensioning. • **Load Distribution Considerations** – Managing stress points and weight for enhanced stability and aerodynamics.	• **Experiment:** Design a simple drone frame with mounting holes for main electronic components using CAD software and conduct simple stress and strain analysis on the frame.
5	2	1,2,4	**Materials & Fabrication Techniques** • **Manufacturing Techniques** – Overview of 3D printing, CNC machining, injection molding, Vacuum bagging composites. • **Material Selection and Properties** – Choosing suitable materials based on strength, weight, flexibility, and durability. • **Design for Manufacturing (DFM) in Drones** – Optimizing designs for cost, efficiency, and ease of assembly	• **Experiment :** Compare material strength, flexibility, and weight efficiency of 3D printable materials for a landing gear of a Nano drone by designing and printing a simple landing gear using 3D printing
6	2	1,2,4	**Drone Innovations in Structural Design** • **Gimbal Systems and Stabilization** – Techniques for reducing vibrations and stabilizing payloads. • **Foldable Arms and Modular Designs** – Enhancing portability, repairability, and adaptability. • **IP Ratings and Durability Standards** – Protection against water, dust, and extreme weather conditions.	• **Assignment:** Research on waterproof drones and their impact on commercial applications. • **Video Demonstration and Case Study:** Explore the applications of vision-based drone payloads in agriculture and study vibration effects on these systems

7	2	1,2,4	**Analysis and Optimization of Design** • **FEA Analysis: Stress and Strain** – Simulating stress points to improve structural endurance. • **Resonance and Frequency Optimization** – Avoiding destructive vibrations for improved stability. • **Topology and Generative Design Optimization** – AI-driven techniques for lightweight, strong structures	• **Experiment:** Design a basic drone arm in open-source CAD software, conduct vibration analysis, and evaluate the advantages of fixed structures.
8	3	1,2,4	**Propulsion Systems & Power System** • **Motor Selection and Working** – Brushed vs. brushless motors and calculating their efficiency in drones. • **Propeller Design** – Effect of blade count, pitch, and material on thrust. • **Battery Technologies** – LiPo vs. Li-ion batteries, power management, and safety.	• **Experiment and case study:** Evaluate power efficiency across different motor and propeller configurations and document the difference in propulsion systems used in payload delivery drones vs. surveillance drones.
9	3	1,2,4	**Avionics & Sensors and Configuration** • **Role of Avionics in Flight** – Systems for navigation, automation, stability, and real-time flight monitoring. • **Key Sensors in Drones** – IMU, GPS, LiDAR, and optical flow for positioning, stabilization, and obstacle detection. • **Software Configurations** – Setting flight parameters, calibrating sensors, and tuning performance using Ardupilot or INAV.	• **Video Demonstration or Case Study:** Analyze the key differences between an accelerometer and a gyroscope in an IMU • **Experiment:** Configure basic parameters and calibrate sensors using open-source drone configuration software.
10	4	1,2,4	**Basic Flight Techniques & SOPs** • **Prop Wash, Ground Effect, and Vortex Ring State** – Airflow effects influencing drone stability and control. • **Pre-Flight Checklist and Safety** – Performing system checks and ensuring emergency readiness. • **Takeoff, Hovering, Maneuvers, and Landing** – Mastering basic flight movements and smooth landings.	• **Video Demonstration:** Observe different types of flight modes based on the type of drone used as per their application. • **Experiment:** Practice basic flight maneuvers using a drone flying kit/simulator.
11	4	1,2,4	**Drone Maintenance and Lifecycle Management** • **Inspection and Preventive Maintenance** – Routine checks to ensure optimal drone performance and longevity. • **Repair and Component Replacement** – Identifying and replacing faulty parts for continued operation. • **Extending Drone Lifespan** – Reducing wear through battery management and protective measures.	• **Case Study:** Analyzing real-world drone maintenance strategies used in commercial and industrial applications. • **Video Demonstration:** Conducting a complete inspection, diagnosing faults, and replacing or repairing key drone components.

12	5	1,2,4	**Future Scope and Uses** • **Drone Taxi and Heavy-Lift Cargo Drones** – Structural challenges in passenger and freight drones. • **Ornithopter, Cyclocopter, and Morphing Drones** – Bio-inspired designs and their mechanical complexities. • **Advanced Propulsion Systems** – Solar, hybrid, hydrogen, and ion-powered flight technologies	• **Case Study:** Research and document the use of drone taxis or heavy-lift drones in defense applications. • **Video Demonstration:** Research Educational labs pioneering unique drone applications like indoor drone swarms and construction drones.
13	5	1,2,4	**Drone Regulations, Safety Protocols, and Career Opportunities** • **Failsafe Systems and Safety Measures** – Return-to-home, emergency landing, and risk mitigation. • **DGCA Regulations and Compliance** – Legal requirements, privacy considerations, and operational guidelines. • **Career Paths and Certifications** – Opportunities in drone technology and related industries.	• **Video Documentation:** Observing DGCA-compliant drone operations and safety measures. • **Assignment:** Preparing a report on career prospects in drone industries.

4. References

Documentation and Websites:

- PX4 Documentation:https://px4.io
- Betaflight Documentation:https://betaflight.com
- Oscar Liang's Blog:https://oscarliang.com
- GetFPV Learn Website: https://getfpv.com/learn
- Joshua Bardwell YouTube Channel:https://youtube.com/joshuabardwell

Sl. No.	Author	Title of Book	Publication/Year
1	Austin, R.	Unmanned Aircraft Systems: UAV Design, Development, and Deployment	John Wiley & Sons, 2011
2	Beard, R. W., & McLain, T. W.	Small Unmanned Aircraft: Theory and Practice	Princeton University Press., 2012
3	Chao, H. C., & Cao, Y.	Autonomous Robotic Systems: Unmanned Aerial Vehicles and Micro Aerial Vehicles	Springer, 2015
4	Cook, M. V	Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control	Butterworth-Heinemann, 2012
5	Michel, T.	Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance	CRC Press, 2018

5. CIE Assessment Methodologies

Sl. No	CIE Assessment	Test Week	Duration (minutes)	Max. Marks	
1	CIE-1Theory Test	4	90	50	Average of all CIE=50 Marks
2	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all practices and Activities through Rubrics	1-13	-	50	
				Total	**50 Marks**

6. SEE - Practice Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration (minutes)	Max marks	Min marks to pass
1.	Semester End Examination-Practical	180	50	20

7. CIE Theory Test model question paper

Program	Mechanical Engineering			**Semester -** V	
Course Name	Drone Technology			**Test**	I
Course Code	25ME53IE	**Duration**	90 min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q. No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a. Compare and contrast the early defense grade drones with modern commercial drones.	Apply	CO1	05
	b. Explain three major classifications of drones based on their flight mechanisms	Apply	CO1	05
	c. Analyze the role of drones in disaster management and emergency response	Apply	CO1	10
2	a. Discuss the advantages and limitations of using drones in industrial automation	Apply	CO1	05
	b. Explain the concept of drone swarms and their applications in defense and surveillance.	Apply	CO1	05
	c. Prepare a labeled block diagram of an unmanned aerial system and explain each component.	Apply	CO1	10
	Section - 2			

3	a. What are the key differences between fixed-wing and VTOL drones in terms of flight mechanics?	Apply	CO2	05
	b. How do the arms of a drone influence its flight stability and motor placement?	Apply	CO2	05
	c. Draw and explain a basic drone wiring diagram. Label key components, signal pathways, and power distribution connections.	Apply	CO2	10
4	a. Explain the impact of drag on drone efficiency. How can drone design reduce drag?	Apply	CO2	05
	b. Explain the role of a flight controller in maintaining drone stability and executing flight maneuvers.	Apply	CO2	05
	c. With a neat diagram, explain the working of a flight controller in a drone. Discuss its key components and how it processes sensor inputs for stability and maneuverability.	Apply	CO2	10
Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	Mechanical Engineering			**Semester**	**V**
Course Name	Drone Technology			**Test**	**II**
Course Code	25ME53IE	**Duration**	180 min	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one question from each section. Each question carries 25 marks					

	Questions	**CO**	**Marks**
	Section-I		
1.	Using a thrust stand, compare the performance of a quadcopter and an octocopter setup in terms of thrust generation, efficiency, stability, and power consumption. Analyze how the number of propellers affects flight characteristics **OR** Design a landing gear system for a sub-2Kg drone that can withstand the impact from a specified drop height while remaining lightweight and structurally durable.	CO1	**25**
	Section-II		
2.	Design a simple drone frame with mounting holes for main electronic components using CAD software. Perform a basic stress and strain analysis to evaluate structural integrity **OR** Compare material strength, flexibility, and weight efficiency of different 3D-printable materials for a nano drone's landing gear by designing, printing, and testing a simple landing gear structure	CO2	**25**
	Scheme of Assessment Experimental Setup/Design 10 Marks Observations and Data 05 Marks Analysis and Interpretation 10 Marks **Total Marks - 25 Marks**		**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl. No.	Suggestive Activities for Tutorials
01	Measure and compare the energy consumption of different propulsion systems using a Propulsion System Testing Kit, experimenting with various propellers to optimize performance for a 300-gram drone.
02	Design drone arms that accommodate motor mounts while optimizing heat dissipation
03	Use readily available household materials to analyze structural integrity and weight distribution in drone frames
04	Create and prototype different foldable arm mount mechanisms for compact storage and transport.
05	Design and 3D print print-in-place hinges for a payload dropping mechanism.
06	Pre-Flight & Post-Flight Inspection Students inspect drones before and after a flight using a structured checklist.

10. Rubrics for Assessment of Practical Exercises and activities (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Needs Improvement	Satisfactory	Good	Excellent	Student's Score
		(1-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Technical Skills	Major errors, incorrect execution.	Frequent mistakes, required significant help.	Some mistakes, required guidance	Minor errors, needed little assistance.	Smooth execution, minimal errors.	40
2	Experimentation & Analysis	Inaccurate results, Poor understanding.	Limited analysis, frequent errors, weak documentation.	Some mistakes, weak analysis, incomplete records.	Mostly accurate, some minor errors, well-documented.	Accurate results, proper documentation, strong interpretation.	45
3	Application & Problem-Solving	No structured approach lacks understanding, irrelevant solutions.	Unclear reasoning, weak connections to real-world applications.	Basic approach, partially correct solutions.	Good problem-solving, some real-world applications.	Well-structured solutions, strong real-world connections,	40
4	Research & Case Studies	Poor research, unclear or incorrect findings, lacks depth.	Minimal research, missing key details, weak analysis.	Limited research lacks depth but covers basics.	Good analysis, some real-world examples, well-organized.	Well-researched, real-world applications, strong depth.	45
5	Teamwork & Communication	Minimal involvement, poor teamwork	Some participation, but weak collaboration and unclear communication.	Limited contribution, needed encouragement, average communication.	Good participation, some collaboration gaps,.	Highly engaged, contributed effectively, clear communication.	45
	Average Marks= (40+45+40+45+45)/5=43						**43**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the exercises

11. SEE- Model Practice Question Paper

Program	Mechanical Engineering	**Semester**	V
Course Name	Drone Technology	**Marks**	50
Course Code	20ME53IE	**Duration**	180 min
Name of the Course Coordinator:			
Note: Answer any one question from each section. Each question carries 25 marks			

	Questions	**CO**	**Marks**
	Section-I		
1.	Design a basic drone arm using open-source CAD software (like FreeCAD or Blender), conduct vibration analysis on the design, and evaluate the advantages of using fixed structures for the arm in terms of stability and durability. **OR** Evaluate the efficiency of various motor and propeller combinations in terms of power consumption, thrust generation, and overall energy efficiency. Then, compare propulsion systems used in payload delivery drones versus surveillance drones.	CO3	**25**
	Section-II		
2.	Conduct basic flight maneuvers and improve flight control using a drone flying kit or simulator, focusing on control inputs, understanding flight dynamics, and developing coordination. **OR** Set up basic parameters and calibrate sensors such as accelerometer, gyroscope, magnetometer, and barometer using open-source drone configuration software.	CO4	**25**
	Scheme of Assessment Preparation and Setup - 06 Marks Execution and Data Collection - 09 Marks Analysis and Interpretation- 10 Marks **Total Marks - 25 Marks**		**50**

12. Equipment/software list with Specification for a batch of 30 students

Sl. No.	**Equipment/Software**	**Specifications**	**Quantity**
1	Drone Model Assembly and Wiring Kit	Modular drone kit with plug-and-play wiring and connection features	5
2	Propulsion System Testing Kit	Thrust stand with motor assembly, real-time data feedback, Li-ion/LiPo battery, charger, and power meter	4
3	Open-Source Drone Sensor Kit	IMU sensor calibration kit with accelerometer, gyroscope, and microcontroller	8

4	CAD and Analysis Software	Open-source software for 3D mechanical drawing and static analysis	1
5	Drone Flying Kit	Sub-250-gram drone with indoor stability sensors for flight training	2
6	Mission Planning Software	Open-source UAV mission planning software (Mission Planner, Ground Control)	1
7	3D Printer	FDM printer with PLA and TPU filaments	1

Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	Mechanical Engineering	**Semester**	**V**
Course Name	Project Management and Entrepreneurship	**Type of Course**	Integrated
Course Code	25ME54I	**Contact Hours**	8 Hrs/Week 104 Hrs/Sem
Teaching Scheme	L:T:P 4:0:4	**Credits**	6
CIE Marks	50	**SEE Marks**	50 (Theory)

1. Rationale:

Studying **Project Management skills** provides a comprehensive understanding of the methodologies, tools, and practices that drive the success of projects. It develops critical competencies in planning, executing, controlling, and closing projects, making it a vital skill set for anyone aiming for leadership roles in their career. These competencies help both individuals and organizations achieve their strategic goals, optimize resources, and deliver successful outcomes, thus contributing to long-term success and career advancement.

Further Studying **Entrepreneurship** provides individuals with the knowledge, and mindset needed to identify opportunities, take risks, and create meaningful impact through business ventures. It fosters innovation, personal growth, and critical business skills, while also contributing to economic development and job creation. Whether aiming to start a business or work in innovative companies, entrepreneurship education prepares individuals to navigate the challenges of the modern business world and create value in dynamic environments.

2. Course Outcomes: At the end of the Course, the student will be able to:

CO-01	**Develop** comprehensive plans, including defining objectives, scope, creating Work Breakdown Structures (WBS), and estimating resources.
CO-02	**Use** project tools such as Gantt charts, CPM, (PERT), Risk assessment, Monitoring and controlling to manage project timelines and budgets.
CO-03	**Demonstrate** leadership and team management skills, and Apply project monitoring techniques to track project progress and performance.
CO-04	**Identify** the viable business opportunities through entrepreneur skills.
CO-05	**Create** comprehensive business plans, including marketing, operations, and financial strategies.

3. Course Content

WEEK	CO	PO	Lecture (4 Hours per Week)	Practice (4 Hours per Week)
1	1	1,5,6,7	**Introduction to Project Management** • Key concepts of Project: features, scope, time, cost, quality, risk, and stakeholders. • Project Management and its importance. • Project manager and his role. • Project lifecycle: Initiation, planning, execution, monitoring, and closure.	**Understanding Project Management** **Objective:** Role play of a project team. **Activity**: Divide students into small groups and ask them to do a role play of different members in a project like project manager, facilitator, engineer, consultant, stake holders, client etc.
2	1	1,5,6,7	**Project Initiation and Planning** • Defining project goals and objectives. • Stakeholder analysis and management. • Developing a project charter. • Creating a Work Breakdown Structure (WBS).	**Team Project Planning** **Objectives:** Planning, task delegation, goal setting. **Activity:** Divide students into small groups and assign them a project (e.g., organizing an event or developing a small product or similar event familiar to the students). Each group creates a project plan, including objectives, scope, WBS, timelines, and deliverables.
3	2	1,5,6,7	**Scheduling and Resource Management** • Project scheduling and timelines. • Tools: Gantt charts, Critical Path Method (CPM), and PERT. • Simple problems on project scheduling tools. • Resource allocation and management. • **Case study:** Resolving resource conflicts in a project.	**Gantt chart Creation** **Objectives:** Scheduling, prioritization, use of project management tools. **Activity:** Students design a Gantt chart for a mock or real project, outlining tasks, timelines, and dependencies.
4	2	1,5,6,7	**Risk Management and Communication** • Project risks: Identifying and analyzing project risks. • Risk mitigation strategies. • Communication in Project Management – Importance and developing a communication plan.	**Risk Management** **Objectives:** Critical thinking, problem-solving, risk assessment **Activity**: Provide students with case studies of successful and failed projects. Ask them to analyze what worked, what didn't, and suggest improvements regarding risk management and communication plan.

5	2	1,5,6,7	**Monitoring, Control and Quality Management** • Project monitoring tools and techniques. • Change management in projects – Concept, Benefits with Examples. • Quality assurance and Quality control in Projects.	**Time Management Challenge** **Objectives:** Time management, multitasking **Activity:** Students Conduct a root cause analysis and manage their schedules to complete a project with multiple overlapping deadlines.
6	3	1,5,6,7	**Leadership and Team Management** • Leadership styles in project management. • Building and managing high-performing teams. • Conflict resolution - Techniques. • Emotional Intelligence - Importance.	**Role-Playing Scenarios** **Objectives:** Communication, conflict resolution, leadership **Activity:** Students take on specific project roles (e.g., project manager, team member, client) and simulate project scenarios such as resolving conflicts, managing deadlines, or dealing with scope changes.
7	3	1,5,6,7	**Closing a Project and Review** • Closing phase: Documentation, handover, and lessons learnt. • Project Audit • Conducting project reviews and retrospectives.	**Presentation and Reporting** **Objectives:** Reporting, presentation skills **Activity:** Students present project updates or final outcomes to a client, simulating stakeholder meetings. After completing a project, students conduct a retrospective analysis to reflect on what went well, what didn't, and how to improve in the future.
8	3	1,5,6,7	**Introduction to Entrepreneurship** • Entrepreneurship - Meaning and Importance. • Entrepreneurs – Characteristics, Types. • Importance of entrepreneurship in economic development. • Case studies of successful entrepreneurs	**SWOT Analysis** **Objective**: To introduce students to the SWOT analysis tool. **Activity:** Ask students to choose a business idea (either their own or one you provide) and conduct a SWOT analysis and discuss how it helps to assess business viability.

9	4,5	1,5,6,7	**Idea Generation and Validation** • Identifying Opportunities • Analyzing market trends • Recognizing problems as opportunities • Brainstorming innovative ideas	**Business Idea Generation** **Objective**: To encourage students to think creatively and develop a workable business idea. **Activity:** Divide students into small groups and ask them to come up with 3 to 5 unique business ideas based on different industries (e.g., technology, sustainability, healthcare etc.) on solving problems, addressing market gaps, or enhancing existing products/services. Each group should present their ideas and receive feedback / suggestions.
10	4,5	1,5,6,7	**Business Planning and Strategy** • Business Models – Types, Lean canvas model, Key resources, activities, and partnerships. • Business Plan: i) Components of a business plan ii) Setting clear objectives iii) Understanding target audiences and market segmentation iv) Value proposition development v) Writing a simple business plan	**Business Plan Development** **Objective:** To provide students with hands-on experience in creating a business plan. **Activity:** Give students a template for a business plan (including sections like market analysis, financial projections, marketing strategy, and operational plan). Students should come up with a business plan (within 1 hr) for a hypothetical business. Each group should present their plans and receive feedback / suggestions.
11	4,5	1,5,6,7	**Marketing and Sales** • Market Research: i) Understanding the target audience ii) Competitor analysis iii) Developing a marketing strategy • Branding and Marketing i) Building the brand identity ii) Digital marketing basics iii) Social media strategies iv) Developing a Unique Selling Proposition (USP) v) Creating a simple marketing plan	**Market Research Simulation** **Objective:** To simulate the process of conducting market research and identifying customer needs. **Activity:** Provide students with a hypothetical product (e.g., a new type of sports drink, eco-friendly packaging or any product familiar to the student). • Ask them to conduct market research by interviewing "customers" (other students in the class). • Have them prepare a questionnaire or survey to gather

			• Sales techniques and customer relationship management.	feedback on potential customer interest, price sensitivity, and purchasing habits? • After collecting data, students will analyze it and use the insights to refine their product or pitch.
12	4,5	1,5,6,7	**Financial Planning and Management** • Basics of Business Finance i) Understanding startup costs ii) Revenue streams and pricing iii) Profit margins and break-even analysis iv) Financial statements: Income Statement, Balance Sheet, Cash Flow. • Funding Your Business i) Sources of funding: loans, investors, grants ii) Pitching to investors iii) Financial forecasting-Concept, listing of methods. **Case study:** Analyze a startup's financials	**Financial Planning Exercise** **Objective:** To help students understand the financial aspects of starting and running a business. **Activity:** Provide students with a fictional business (e.g., a coffee shop or online store or similar business familiar to the students) and a set of financial data, including startup costs, monthly expenses, and expected revenue. • Ask them to create a basic budget or financial projection for the business over the first year. • Discuss key financial concepts such as cash flow, break-even point, and profit margins. • At the end of the exercise, review the financial projections as a group and analyze the sustainability of the business.
13	4,5	1,5,6,7	**Scaling and Sustaining the Business** • Growth strategies (Ansoff Matrix). • Managing risks and pivoting. • Exit strategies: mergers, acquisitions, or IPOs. • Intellectual Property Rights. • Business scaling challenges. **Case studies:** Stories of scaling from small businesses to global brands.	**Elevator Pitch Competition** **Objective**: To practice delivering a concise and convincing business pitch. **Activity:** Ask students to prepare a 30-60 second "elevator pitch" for their business idea. • The pitch should include the problem they are solving, their solution, target market, and how their business is unique. Then provide feedback on the clarity, creativity, and persuasiveness of the pitch.

4. References:

Sl. No.	Author	Title of Book
1	Donald F. Kuratko	Entrepreneurship: Theory, Process, and Practice"
2	Eric Ries	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses
3	Stanley E. Portny	"Project Management for Dummies"
4	Steve Blank and Bob Dorf	The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company
5	Bruce R. Barringer and R. Duane Ireland	Entrepreneurship: Successfully Launching New Ventures
6	Guy Kawasaki	The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything
7	Michael E. Gerber	The E-Myth Revisited: Why Most Small Businesses Don't Work and What to Do About It
8	Alexander Osterwalder and Yves Pigneur	Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers
9	Clayton Christensen	The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail
10	Simon Sinek	Start with Why: How Great Leaders Inspire Everyone to Take Action
11	Jessica Livingston	Founders at Work: Stories of Startups' Early Days
12	Jeffrey K. Pinto	Project Management: Achieving Competitive Advantage
13	Scott Berkun	The Art of Project Management
14	Jack R. Meredith and Samuel J. Mantel Jr.	Project Management: A Managerial Approach
15	Brant Cooper and Patrick Vlaskovits	The Lean Entrepreneur: How to Accomplish More by Doing Less
16	Harold Kerzner	Project Management: A Systems Approach to Planning, Scheduling, and Controlling
17	Scott Berkun	*Making Things Happ*
18	Adam Josephs and Brad Rubenstein	*Risk Up Front*
19	Patrick Lencioni.	*The Five Dysfunctions of a Team*
20	by Jonah Berger.	*"Contagious: How to Build Word of Mouth in the Digital Age"*
21	Karen Berman and Joe Knight	*"Financial Intelligence for Entrepreneurs"*
22	Eric Ries	"The Lean Startup"
23	Peter Thiel.	"Zero to One"
24	Eric Ries,	*"The Lean Startup"*
25	Peter Thiel.	*"Zero to One"*
26	Simon Sinek	*"Leaders Eat Last"*
27	Templates: Project Charter and WBS (see PMI.org or MS Office templates). Templates: Risk Register and Communication Plan. Templates: Project Closure Checklist. Templates for business plans (e.g., from SCORE or SBA). Tools: Google Trends, SEMrush (for market analysis). Tools: Excel templates for financial planning. Tools: Business Model Canvas, Value Proposition Canvas	
28	Video: "How to Write a Project Charter" (YouTube or similar).	

	Video: "Introduction to Gantt Charts." Video: "Managing Project Risks" (LinkedIn Learning or YouTube). Video: "Project Monitoring Techniques." Video: "How to Lead Teams Effectively." Video: "Project Monitoring Techniques." Video: "How to Lead Teams Effectively Video: "How to Close a Project Effectively." Videos: Simon Sinek's TED Talk *"Start with Why."* Videos: TED Talks like "How to Build Your Creative Confidence" by David Kelley. Videos: TED Talks like "How to Build Your Creative Confidence" by David Kelley.

5. CIE Assessment Methodologies

Sl.No.	CIE Assessment	Test Week	Duration (minutes)	Max Marks	
1.	CIE-1 Theory Test	4	90	50	Average of all CIE=50 Marks
2.	CIE-2 Practice Test	7	180	50	
3	CIE-3 Theory Test	10	90	50	
4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of Practical Exercises and Activities through Rubrics	1-13	-	50	
Total					**50 Marks**

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE-1 Theory Test Model Question Paper

Program	Mechanical Engineering			**Semester - V**	
Course Name	Project Management and Entrepreneurship			**Test**	I
Course Code	25ME54I	**Duration**	90min	**Marks**	50
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					
Q. No	**Questions**		**Cognitive Level**	**Course Outcome**	**Marks**
Section-1					

1	a) Define project management and explain its importance in modern organizations. b) List and briefly describe the components of the project management triangle. c) Explain the importance of stakeholder management in a project.	Apply	CO1	**8+9+8 =25 Marks**
2	a) What is a Work Breakdown Structure (WBS), and how does it aid in project planning? b) What is risk management in project management? Describe the steps involved c) Using examples, discuss techniques to prevent and manage scope creep in projects	Apply	CO1	
Section-2				
3	a) Discuss the role of communication in project management. How can poor communication impact a project? b) Provide an example of a project risk scenario and suggest how it could be mitigated.	Apply	CO1	**12+13 = 25 Marks**
4	a) A key stakeholder withdraws support in mid-project. How would you handle the situation? b) A client requests additional features halfway through the project. What processes would you follow to manage this change?	Apply	CO1	
***Note for the Course coordinator**: Each question may have one, two or three sub divisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.*				

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE-2 Practice Test model question paper

Program	Mechanical Engineering			**Semester**	V
Course Name	Project Management and Entrepreneurship			**Test**	II
Course Code	25ME54I	**Duration**	180 min	**Marks**	50
Name of the Course Coordinator:					

Questions	**CO**	**Marks**
You are managing the setup of a new production line in a manufacturing unit for a consumer goods company. The project involves the following tasks: 1. **Procurement of Equipment**: 4 weeks 2. **Installation of Equipment**: 3 weeks 3. **Recruitment and Training of Staff**: 5 weeks 4. **Trial Production Run**: 2 weeks 5. **Quality Assurance Testing**: 1 week 6. **Full-Scale Production Launch**: 1 week The tasks have the following dependencies:	CO2	50

1. **Installation of Equipment** can begin only after the **Procurement of Equipment** is completed. 2. **Recruitment and Training of Staff** can run in parallel with **Procurement of Equipment** but must be completed before the **Trial Production Run.** 3. **Trial Production Run** depends on the completion of both **Installation of Equipment** and **Recruitment and Training of Staff.** 4. **Quality Assurance Testing** follows the **Trial Production Run**. 5. **Full-Scale Production Launch** depends on the successful completion **of Quality Assurance Testing.** □ The deadline for completing the project is 12 weeks.		
Scheme of assessment 1. Develop a Gantt chart to represent the timeline and dependencies of the tasks in this project. – **30 marks** 2. If the Procurement of Equipment is delayed by 2 weeks due to supply chain issues, how will it impact the overall timeline and Prepare a revised plan to mitigate this delay.- **20marks**		
Total Marks		**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

- The students shall do minimum of one suggested activities
- List is an Example and not inclusive of all possible activities of the course.
- Student and Faculty are encouraged to choose activities that are relevant to the topic.

Sl.No.	Suggestive Activities for Tutorials
1	**Resource Allocation Exercise** • **Activity:** Assign students a limited budget and resources for a hypothetical project and ask them to allocate budget and resources effectively.
2	A small bakery owner wants to expand their business through franchising. Prepare a project Report incorporating the following • How should they structure their franchising model? • What are the potential risks and rewards of franchising? • How can they maintain consistent quality and brand reputation across franchise locations?
3	**Role-Playing: Negotiation and Deal-Making** **Objective:** To practice entrepreneurial negotiation skills in a controlled environment. **Activity:** • Pair students and assign each student a role (e.g., an entrepreneur negotiating with an investor or supplier). • Provide them with specific objectives (e.g., securing funding, negotiating a contract, etc.), and allow them to engage in a negotiation process. • Afterward, students can reflect on the experience, discussing what strategies worked, challenges they faced, and how they could improve their negotiation skills.

4	**Startup Cost Estimation Game** **Objective:** To estimate the different costs involved in starting a business and the importance of budgeting. **Activity:** • Provide each student or group with a list of various expenses required to start a business (e.g., equipment, marketing, staffing, location). • Ask them to estimate the cost of each item, keeping track of their total startup budget. • Afterward, reveal the correct costs and have students compare their estimates with the actual figures. • Discuss the importance of accurate financial planning and how underestimating costs can lead to challenges in launching a business.
5	**Business Model Canvas Challenge** **Objective:** To develop a business model using a structured approach. **Activity:** • Introduce the Business Model Canvas framework, which includes key sections such as value proposition, customer segments, channels, and revenue streams. • Ask students to fill in a Business Model Canvas for a business idea, using post-it notes or digital tools. • Afterward, have each student or group present their business model, and provide constructive feedback on how to improve it.
6	**Entrepreneurial Risk Management Exercise** **Objective:** To highlight the risks entrepreneurs face and the importance of risk management. **Activity:** • Provide a list of potential risks that an entrepreneur might encounter, such as market risk, financial risk, and operational risk. • Ask students to identify strategies to mitigate each type of risk (e.g., conducting market research, obtaining insurance, diversifying revenue streams). • Have each group present their strategies, and discuss how they can be applied to real-world entrepreneurial ventures.

10. Rubrics for Assessment of Portfolio evaluation/Tutorials (Qualitative Assessment)

Sl. No.	Dimension	Unsatisfactory	Need Improvement	Satisfactory	Good	Excellent	Students Score
		(0-10)	(11-20)	(21-30)	(31-40)	(41-50)	
1	Clarity of Objectives and Goals	No Clear, specific, and measurable goals.	Unclear, undefined, or missing goals.	Vague or somewhat unclear goals.	Clear but slightly less specific or measurable goals.	Clear, specific, and measurable goals aligned with the project or business vision.	40
2	Feasibility & Planning	No feasibility analysis	Incomplete feasibility analysis.	Basic feasibility analysis with some gaps.	Solid analysis but may lack depth in some areas..	Thorough and detailed analysis covering financial,	40

						technical, and market feasibility.	
3	Implementation Strategy	No clear action plan	Unrealistic approach.	General or incomplete action plan.	Action plan is clear but may lack some key details.	Well-structured, realistic action plan with detailed timelines and resources.	45
4	Risk Management & Financials	No risk analysis	Unrealistic financials.	Minimal risk analysis or incomplete financial projections.	Good risk management, some financial details included.	Comprehensive risk management plan and detailed financial projections.	40
5	Innovation & Presentation	No innovation or Very Poor presentation quality.	Lack of innovation or Poor presentation quality.	Basic ideas with limited creativity and presentation errors.	Some creative ideas, clear presentation.	Highly creative solutions and a professional, well-organized presentation.	35
	Average Marks = (40+40+45+40+35)/5 =						**40**

Note: *Dimension and Descriptor shall be defined by the respective course coordinator as per the activities*

11 Equipment/software list with Specification for a batch of 30 students

Sl. No.	Particulars	Specification	Quantity
01	Computers	Latest configuration	30

Government of Karnataka
Department of Technical Education

C-25 Diploma Curriculum

INTERNSHIP

AND

CAPSTONE PROJECT

GUIDELINES

FOR

FACULTY, STUDENTS AND EXAMINERS

INTERNSHIP

Introduction

The students of Polytechnic Programs will have an opportunity to be part of one of the most challenging educational experiences in the year-3, The students will be trained in the specialization pathways of their interest in fifth semester, followed by 13-week internship or a Capstone Project work in sixth semester.

An internship is a professional learning experience which offers meaningful, practical work relevant to a student's field of study or career interest. It gives the students an opportunity for exploring the various career choices and acquire varied skills. It also offers an opportunity to bring out the innovative, creative ideas and energy into the workplace. This effectively aims at developing talent and potentially builds a pipeline for future Job prospects that may be ready for challenging roles in future. Internship has become very crucial for students to gain on-field experience which acts as an advantage for the students who do not have corporate experience.

Internships allow students to examine new situations, work techniques, problem-solving tactics, interpersonal skills, understanding of timelines and targets which would otherwise not be possible unless they were on board. Companies which plan to offer job placements to students also prefer hiring the interns for a short period as a trial wherein they have an opportunity to assess their ability and select them based on their observations over a considerable amount of time. This alternative gives the recruiter a better understanding of the candidate's worth in comparison to the assessment made in couple of interview sessions. Even for the interns it is a win-win situation as they get an opportunity to learn the corporate work culture in advance and later demonstrate their skills at their workplace

Outcomes

After completing Internship, Interns will be able to,

- Apply the theoretical knowledge and skill during performance of the tasks assigned in internship
- Demonstrate soft skills such as time management, positive attitude and communication skills during performance of the tasks assigned in internship
- Document the Use case on the assigned Task

Facilitating the Interns by an Internship Provider

- Orient intern in the new workplace. Give interns an overview of the organization, Explain the intern's duties and introduce him or her to co-workers
- Develop an internship job description with clear deliverables and timeline
- Allow the interns in meetings and provide information, resources, and opportunities for professional development
- The interns have never done this kind of work before, they want to know that their work is measuring up to organizational expectations, hence provide professional guidance and mentoring to the intern
- Daily progress report of Intern is to be evaluated by industry supervisor. examine

what the intern has produced and make suggestions. Weekly supervision meetings can help to monitor the intern's work.

Duties & Responsibilities of the Faculty (Cohort Owner):

- To facilitate the placement of students for the internship
- To liaison between the college and the internship provider
- To assist the Industrial Training Supervisor during assessment

Instructions to the Interns(Students):

- Students shall report to the internship provider on the 1st day as per the internship schedule
- Intern is expected to learn about the organization, its structure, product range, market performance, working philosophy etc
- The interns shall work on live (On Job) projects assigned by the internship provider.
- The Intern shall record all the activities in the daily log book and get the signature of the concerned training supervisor
- Intern shall have 100% attendance during internship programme. In case of un-avoidable circumstances students may avail leave with prior permission from the concerned training supervisor of the respective internship provider. However, the maximum leave permitted during internship shall be as per company norms where they are working and intern shall report the leave sanctioned details to their college cohort owner
- The interns shall abide all the Rules and Regulations of internship provider
- Intern shall follow all the safety Regulations of internship provider.
- On completion of the internship, intern shall report to the college and submit the internship certificate mentioning duration of internship, evaluation of interns by internship provider, Student's Diary, report to the cohort owner.

Assessment

The Internship will be assessed for 100 marks through formative and summative assessment tools, in formative assessment the internship will be evaluated for 50 marks and in summative assessment internship will be evaluated for 50 marks

The Formative Assessment- (Continuous Internal Evaluation- CIE)

The Formative Assessment is conducted for 50 marks throughout the course in three developmental phases as CIE-I, CIE II and CIE-III. Students shall complete CIE-I before taking CIE-II and complete CIE-II before taking CIE-III, otherwise will not be eligible to take Semester End Examination.

Continuous Internal Evaluation- CIE - I conducted at the end of 4th week		
Sl No	**Assessment parameter**	**Marks**
1	Submit a report to the training supervisor and copy to the cohort owner focusing on: • Overview of the organization • Vision and mission of the organization • Organization structure • Roles and Responsibilities of personnel in the organization • Products and market performance	30
2	Give a presentation on the above	20
	Total	**50**

Note:

CIE-1 shall be assessed by the Faculty (Cohort owner) for 50 marks using appropriate Rubrics.

Continuous Internal Evaluation- CIE - II conducted at the end of 8th week		
Sl No	**Assessment of On Job Training (OJT)**	**Marks**
1	On select job role of his/her interest in an organization or role assigned by the training supervisor for next Four weeks and submit a report to the training supervisor and copy to cohort owner focusing on: 1. Intern's ability to apply the skill and technical knowledge on OJT 2. Intern's performance on assigned tasks and project 3. Extent of Intern's ability to add value to the organization through internship	30
2	Document a Use case on a task where he is working as intern	20
	Total	**50**

Note:

1. CIE-II shall be assessed by the Industrial Training Supervisor using companies' assessment Tools/Rubrics.
2. Faculty (Cohort owner) shall assist the Industrial Training Supervisor during assessment of CIE-II.

Continuous Internal Evaluation- CIE -III conducted at the end of 13th week		
Sl No	**Assessment of On Job Training (OJT)**	**Marks**
1	On select job role of his/her interest in an organization or role assigned by the training supervisor for next Five weeks and submit a report to the training supervisor and copy to cohort owner focusing on: 1. Intern's ability to apply the skill and technical knowledge on OJT 2. Intern's performance on assigned tasks and project 3. Extent of Intern's ability to add value to the organization through internship	30
2	Documenting of another Use case on a task where he is working as intern	20
	Total	**50**

Note:

1. CIE-III shall be assessed by the Industrial Training Supervisor using companies' assessment Tools/Rubrics
2. Faculty (Cohort owner) shall assist the Industrial Training Supervisor during assessment of CIE-III
3. Average Marks obtained in the above Three CIE's (CIE-I, CIE-II & CIE-III) shall be recorded as Formative assessment for 50 Marks.

The Summative assessment- Semester End Examination (SEE)

During the semester end examination, students shall demonstrate the outcomes of their Internship to the Panel of Examiners comprises of a Cohort owner and an external Subject Expert The evaluation criteria are as follows

Sl No	SEE Evaluation Criteria	Marks
1	Presentation shall include: 1. Overview of the organization, vision, mission, structure, roles and responsibilities of personnel's, products, market Performance etc. - (10marks) 2. The role performed in the organization during OJT and Intern's ability to apply the skill and technical knowledge – (20 marks)	30
2	Evaluation of comprehensive Internship Report with special focus on organization profile, OJT and contribution made to the organization	20
	Total	**50**

Note: Cohort owner and External subject expert shall assess the intern separately using an appropriate rubrics and average marks to be tabulated

FORMATS

Department of Technical Education

FORMAT – 1

Student Internship Application

(Complete and submit to the Training and Placement Officer)

Student Name			
Student e-mail Id			
Mobile			
Name of the Institute			
Name of the Program			
Specify the Specialization Pathway			
Overall CGPA			
Internship Preferences	Location	Core area	Organization
Preferance-1			
Preferance-2			
Preferance-3			
Cohort owner Signature: Date			
Student Signature: Date			

Department of Technical Education

FORMAT - 2

Request Letter from Institute to Internship Provider

(To be forwarded by the Training and Placement Officer/Student)

Date:

To,

.....

.....

.....

Subject: Request for 13 weeks Semester long internship training of Diploma in ---------- engineering Program

Dear Sir/ Madam,

This is to certify your good office to allow Mr/ Ms---------- student of our polytechnic perusing sixth semester diploma in ---------- engineering and trained in ---------- specialization pathway in boot camp mode to render on-the-job internship training in your prestigious company

As per the requirement of Diploma in ---------- engineering program, he/she is required to complete 520 hours of internship related to his/her specialization

Your support in this regard is highly appreciated

With warm regards,

Signature of Training and Placement Officer

Department of Technical Education

FORMAT - 3

Agreement

This Agreement is between the student, cohort owner and internship provider. It shall serve to clarify the educational purpose of the internship and to ensure an understanding of the total learning experience among the student, cohort owner and Industrial training supervisor

Part I: Contact Information

Student

Name: _____ Student ID_____Class Year:_____

College Address: _____State:_____

Phone: _____ Email: _____

Industrial Supervisor

Name: _____ Designation: _____

Company/Organization: _____

Address: _____State_____Pin_____

Phone: _____ Email: _____

Cohort owner

Name: _____ Designation: _____

Phone: _____ Email: _____

College Address: _____

Academic Credit Information

Program: _____

Pathway:_____ Credits: 16

Beginning Date: _____ Ending Date: _____

Hours per Week: 40

Part II: The Internship

Internship Objectives:

Describe What do the interns intend to learn, acquire skill through this internship? Try to use concrete, measurable terms in listing the learning objectives under each of the following categories:

- Knowledge
- Skills

Job Description:

Describe in as much detail as possible intern's role and responsibilities while on internship. List duties, project to be completed, deadlines, etc. Describe How interns' technical knowledge can be applied at the site of the internship and how they can create value to the organization through internship

Supervision: Describe in as much detail as possible the supervision to be provided/needed at the work site. List what kind of instruction, assistance, consultation interns will receive from whom, etc

Evaluation: Describe How will interns work performance be evaluated? By whom? When?

Part III: Agreement

This Agreement may be terminated or amended by student, cohort owner or industry training supervisor at any time upon 7days written notice, which is received and agreed to by the other parties.

Student _____ Date _____

Cohort owner _____ Date _____

Industry Training Supervisor _____ Date _____

Department of Technical Education

FORMAT 4

Student's Daily Log Book

Day-1	Date:
Time of Arrival	Time of Departure
Dept/Division	Nature of work
Name of the Supervisor With designation and email ID	
Remarks of the Training supervisor:	
Record Main actives of the day (including observation, sketches, discussions, etc) **Signature of Industry Supervisor**	

Note: Prepare a A4 size hard bound Intern work book using this format with college and student details

Department of Technical Education

FORMAT 4

Internship Report template

The student, after the completion of internship should submit a comprehensive Internship report, the contents of the report shall be arranged in the following order:

1. Cover Page
2. Inside Title Page
3. Internship Certificate issued by the organization
4. Acknowledgements
5. Executive Summary
6. Table of Contents
7. List of Figures
8. List of Tables
9. Abbreviations/ Notations/ Nomenclature
10. Text of the Report
    - **Chapter 1:** Company Profile
    - **Chapter 2**: Describe in as much detail as possible intern's role and responsibilities while on OJT. List duties, project completed, etc. Describe How interns' technical knowledge can be applied at the site of the internship and how they can create value to the organization through internship
11. Student Profile/Resume
12. Photo Gallery
13. Appendices

General Guidelines

Report Size - Report may contain maximum of about 50 pages including Proto gallery and appendices.

Paper Size - Use A4 size paper

Paper Quality - White bond paper weighing 85 g/m2 or more should be used. Photographs or images with dense colors may be printed in single side on glossy paper.

Margins - A margin of 40 mm is to be provided on left and 30 mm on right sides, whereas top and bottom margins should be 30 mm. No print matter should appear in the margin except the page numbers. All page numbers should be centered inside the bottom margin, 20mm from the bottom edge of the paper.

Font - Times New Roman (TNR) 12-point font has to be used throughout the running text. The captions for tables and figures should have font size of 11 and foot notes should be set at font size 10. Font sizes for various levels of headings are given in the table below

CHAPTER 3

TITLE PAGE-CENTERED TNR 17-POINT BOLD ALL CAPS

3.1. Section Heading
Left aligned with number, TNR 17 points, bold and leading caps

3.1.1. Second level section heading
Left aligned with number, TNR 14 points, bold and sentence case**.**

3.1.1.1 Third level section heading
Left aligned with number, TNR 12 points, bold and sentence case.

Fourth-level section heading
Numbered subsections beyond third level are not recommended. However, fourth-level subsection headings may be included without numbering, TNR 12-point font, left aligned and italicized
Running text should be set in 12-point TNR and fully justified. First line of paragraph should have indentation of 15 mm**.**

Line Spacing - The line spacing in the main text should be 1.5, for quotations, figure captions, table captions, figure legends, footnotes, equations, tables, figures, and quotations Single line spacing should be given.

Table / Figure/equation Format-

Tables and figures shall be numbered chapter-wise. For example, second figure in Chapter 3 will be numbered Figure 3.2. The figure can be cited in the text as Figure 3.2, Tables shall be numbered similarly (Table 2 in Chapter 3 will be numbered Table 3.2) and shall be cited in the text as Table 3.2. Figure caption shall be located below the figure. Table number and caption shall be located above the table.

Appendices

Include data tables, drawings, background calculations, specification lists for equipment used, details of experimental configuration, and other information needed for completeness,

Page Numbering

Page numbers for the prefacing materials (Inside title page, certificate, acknowledgements, executive summary, table of contents, etc.) of the report shall be in small Roman numerals and should be centered at the bottom of the pages.

The numbering of the prefacing material starts from the Inside Title Page. However, the number is not printed on the Inside Title Page. Each new item of the prefacing materials listed above should start on a fresh paper on right page. If the content of the prefacing material exceeds one page, it has to be printed on both sides of the paper by starting from the right-side page. For example, if the item „Table of Contents" extends for 5 pages, it should be printed in fresh paper on right side page with second page of the „Table of Contents" on the back of the paper and then continued. The page numbers of the prefacing material will be printed in small Roman numerals continuously counting blank pages also. However, the numbers are not printed on the blank pages

The body of the report starting from Chapter 1 should be paginated in Arabic numerals and should be centered at the bottom of the pages. The pagination should start with the first page of Chapter 1 and should continue throughout rest of the report. Each side of a sheet of paper should be counted as a separate page, even if the back side of a sheet of paper is blank. The odd numbered pages are always on the right and even-numbered pages are always on the left. If the end of a chapter is in odd page (right side page) the next chapter should start on odd page i.e., on a fresh paper, and should be numbered as odd only by counting the blank even page also. However, the page number is not printed on the blank pages.

Each of the items - Inside cover page, Certificate, Acknowledgements, executive summary, Table of Contents, List of Figures, List of Tables, Abbreviations, Notations, Nomenclature, each new Chapter, References, and each new Appendix should start on an odd page i.e., on the right side

Non-Paper Material

A report may contain non-paper material, such as specimen, CDs and DVDs, Pen drive if necessary. They have to be accommodated in a closed pocket in the back cover page of the report. The inclusion of non-paper materials must be indicated in the Table of Contents. All non-paper materials must have a label each clearly indicating the name of the candidate, student Register number and the date of submission**.**

Binding

Two hard bounded copies of the project Report shall be submitted for evaluation; the cover page should be printed on sky blue card of 300 g/m2 or above**.** One copy is used for Semester End Examination and after the exam it should be maintained in the concerned Head of the department and another copy is maintained at cohort owner

Electronic Copy

An electronic version (PDF) of the project report should be submitted to the cohort owner and Head of the department. The file name should contain, student name, Register number and date of submission.

CAPSTONE PROJECT

GUIDELINES
FOR
FACULTY (COHORT OWNER), STUDENTS AND EXAMINERS

CAPSTONE PROJECT

How to design and deliver

The students of Polytechnic Programs will have an opportunity to be part of one of the most challenging educational experiences in the year-3. The students will be trained in the specialization pathways of their interest in fifth semester followed by an internship or a capstone project work in sixth semester. Those students who want to do a capstone project, requires to do developmental work on real-world problems which would motivate them to produce practical solutions. It is an opportunity for the students to use the problem-solving tools and techniques to solve the problems while doing the capstone project. With this approach, the learning process is gained through 'by-doing' experience and the students are expected to apply both the Capstone Project Management Skills and Technical Skills gained in previous years of polytechnic courses, which will enable them to participate and prepare for future employment.
Working under the guidance of a Cohort owner, students may shape the direction of what they want to be, as well as gain better understanding of the responsibilities they need to shoulder when they undertake a capstone project. Teamwork will be inculcated with the development of good and professional relationships with their cohort owner and team members. The undertaken capstone project can also be used as a basis for employment or Startup by fully exploiting the learning process they have gone through, the skills they have gathered and the experience they have gained from the capstone project.
The guidelines are prepared for Cohort owner, students and examiners enabling them to execute their respective roles and responsibilities in an effective manner.

Aims of Capstone

1. Promote integration and synthesis within the program of study.
2. Promote meaningful connections between the program of study and career experiences.
3. Improve learner's career preparation and pre professional developments.
4. Demonstrate professional identity as learner's transition from academic to professional World.

Job Alignment and Professional Scenario

While developing a capstone the goal should always to;

1. Use a real world professional scenario- built out with employer engagement where ever possible.
2. Align skills to be assessed to a job.
3. Explicitly and intentionally developed important learner's skills, competencies and perspectives that are tacitly developed in the curriculum and required in the workplace.
4. Give learner's the freedom to showcase their learning though a demonstrable artifact or output e.g. Technical Product, System, Service that resolves a real world problem.

Employer Engagement

Support in capstone development:

- Provide a problem statement
- Provide a case study background
- Review and feedback on case studies/scenarios developed

Support in class

- Mentor learner's during the capstone
- Support cohort owners during class-workshop seminars

Presentation of Capstone

- Sit on presentation panel for learners to give feedback.

Outcomes

On successful completion of the capstone project, students will be able to:

- Write Capstone project scope document
- Prepare a capstone project execution plan
- Manage the capstone project from start to finish meeting stated milestones and timelines
- Test and validate the findings
- Demonstrate interpersonal skills, teamwork, and effective use of appropriate technology required for the capstone project

Responsibilities of the Head of the Department

The Head of the Department shall coordinate in Executing the Capstone projects, their responsibilities can be summarized as follows:

- To ensure that the Capstone project scope document is relevant to the specialization pathway opted by the students in Fifth semester
- To assign Cohort owner to the students
- To maintain a centralized capstone project hub repository to facilitate capstone project management and keeping track of all capstone projects and design changes

Responsibilities of the Faculty (Cohort owner):

Students will be supervised by Cohort owner; their responsibilities can be summarized as follows:

- To guide the students in writing the Capstone project scope document
- To guide the students in preparing capstone project execution plan
- To interact with the students once in a week to review the progress of the capstone project work, these sessions shall reinforce/review the concepts, findings and focus on addressing issues relevant to weekly meetings.
- To guide the students in managing the capstone project from start to finish, meeting the stated milestones and timelines

- To guide the students in preparing the capstone project report
- Develop appropriate Rubrics and evaluate the capstone project work as per assessment criteria
- To oversee the capstone project work until the submission of the final report, and Semester End Examination
- Maintain all the documents related to the capstone project work

Responsibilities of the Students

Students are also required to exercise self-discipline, self-management, job co-ordination, teamwork, and trustworthiness to ensure the success of the capstone project.

The expected responsibilities are:

- To write the Capstone project scope document
- To prepare a capstone project execution plan
- To adhere to the weekly meeting schedule with the cohort owner for the purpose of updating their progress and seeking advice on capstone project matters (Attendance is compulsory as per regulation) and submit weekly report
- To Manage the capstone project from start to finish meeting stated milestones and timelines
- To report immediately to the cohort owner any difficulties encountered that would interrupt the work.
- To submit all reports on time

Group Member Roles and Contributions

The Capstone project groups often function more effectively when group members have designated roles. Each capstone project group shall consist of not more than **four students**. The Three core roles and responsibilities are:

- **Capstone project Lead**: One student in the group shall act as a capstone project lead, who is responsible for keeping the group on task, distributing the workload, meeting deadlines, and ensuring smooth group communication and coordination as well as accountability with the cohort owner and capstone project requirements
- **Documenter Lead**: One student in the group shall act as a documenter lead, who is responsible for recording group discussions and decisions, documenting various aspects of the capstone project's progress, and ensuring well-formed reports and capstone project documents are produced.
- **Development Lead**: Two students in the group shall act as a Development lead, who are responsible for overseeing the collaborative aspects of the capstone project, troubleshooting major technical problems.

The entire capstone project team should be engaged in discussions, documentation, and development of the capstone project. All members are expected to contribute towards the capstone project.
Groups will a have to rotate the roles among members for different stages of the capstone project. This will allow members to gain experience through being responsible in different areas of capstone project management.

Assessment of the capstone project work

This section is addressed to the Faculty (Cohort owner) and examiners. It provides information on assessment criteria for the capstone project work. It also provides guidance to students about what examiners will be looking for in evaluating the capstone projects. The Capstone project work will be assessed for 100 marks through formative and summative assessment tools, in formative assessment the capstone project will be evaluated for 50 marks and in summative assessment capstone project will be evaluated for 50 marks

The Formative Assessment- (Continuous Internal Evaluation- CIE)

The Formative Assessment is conducted for 50 marks throughout the course in three developmental phases as CIE-I, CIE II and CIE-III. Students shall complete CIE-I before taking CIE-II and complete CIE-II before taking CIE-III, otherwise they will not be eligible to take Semester End Examination

Continuous Internal Evaluation- CIE - I conducted at the end of 4th week		
Sl No	**Assessment of parameter**	**Marks**
1	Writing the Capstone project scope document	10
2	**Capstone project Planning**: • Work Breakdown Structure (WBS) - 05 marks • Time-line Schedule - 10 marks • Cost Breakdown Structure (CBS) - 10 marks • Risk Analysis - 10 marks	35
3	Identification of Methodology (Including Literature survey)	05
	Total	**50**

Continuous Internal Evaluation- CIE - II conducted at the end of 8th week		
Sl No	**Assessment of parameter**	**Marks**
1	**Capstone project Details:** • Description of Technology Used • Details of Hardware devices • Details of software products • Programming languages • Descriptions of the components in the system • Component diagrams and required design if any • Construction or Fabrication details • Any other information needed to execute the capstone project	50
	Total	**50**

Continuous Internal Evaluation- CIE - III conducted at the end of 13th week		
Sl No	**Assessment of Parameter**	**Marks**
1	**Testing and validation**: Details of laboratory experiments/programming/modelling/simulations/ analysis/fabrication/construction etc.,	30
2	Results and inference	20
	Total	**50**

Note: Average Marks obtained in the above Three CIE's (CIE-I,CIE-II & CIE-III) shall be recorded as Formative assessment for 50 Marks.

The Summative assessment- Semester End Examination (SEE)

During the Summative assessment, students shall demonstrate the outcomes of their Capstone project work to the Panel of Examiners comprising a cohort owner and an external Subject expert

The evaluation criteria are as follows:

Sl No	Parameters	Marks
1	Power point presentation on outcomes of the Capstone project work	20
2	Demonstration the Capstone project work	20
3	Capstone project Report -Format and Technical writing skill	10
	Total	**50**

Plagiarism

Plagiarism is the act of obtaining or attempting to obtain credit for academic work by representing the work of another as one's own without the necessary and appropriate acknowledgment. If a student is in doubt of the nature of plagiarism, he/she should discuss the matter with the supervisor. If a student is caught committing plagiarism, disciplinary action will be taken against the student

Keeping in view the policy of plagiarism, and avoid piracy of intellectual property, the student needs to follow the citation policy:

- When 10 words are taken together from some established core work, citation becomes essential.
- When the copied content reaches 40 words in accumulation, the fragment needs to be kept under inverted comma (“_”) in italic.
- It is necessarily required to cite reference in case of any content adopted from anywhere other than internet open sites. It is also that, even in case of open site internet source or any other source the copied contents if found more than 35 percent in aggregate during plagiarism detection, the work shall not be considered for further process and asked to resubmit the report again for the evaluation

Copyright

The Polytechnic institutions shall be the owner for all findings, designs, patents, and other intellectual property rights.

FORMATS

Department of Technical Education

Capstone project

Format- 1

Capstone project Scope Document

Capstone project Scope Document

The capstone project scope clearly describes what the capstone project will deliver and outlines all the work required for completing the capstone project.

Capstone project Title:

Group Members:

Problem Statement: Objectives:

Capstone project description:

Capstone project Deliverables:

Key milestones:

Constraints:

Estimated Capstone project Duration: Estimated

Capstone project cost:

Date

Signature of the student Signature

of the cohort owner

Department of Technical Education

Capstone project

Format- 2

Work Breakdown Structure

Capstone project Name: <State the Title of the capstone project >

Capstone project Members: <List of group members>

Capstone project Objective(s): < statements describing the capstone project's objective(s)>

Work Breakdown Structure - Deliverables

1. Identify the deliverables (in the scope statement) to be produced in the capstone project.
   This highlights the work to be done.
2. Decompose each large deliverable into a hierarchy of smaller deliverables. This involves taking a deliverable and breaking it down into lower and lower levels of detail.
3. The lowest level of detail is called a 'work package' which consists of activities and tasks.

Date

Signature of the student Signature

of the cohort owner

Department of Technical Education

Capstone project

Format- 3
Time - line Schedule

Capstone project Name: <State the Title of the capstone project >

Capstone project Members: <List of group members>

1. Identify the activities and tasks needed to produce each work package.
2. Identify resources for each task (e.g., time, knowledge, monetary costs etc.)
3. Estimate how long it will take to complete each task. Consider constraints - resources, time, knowledge
4. Determine which tasks are dependent on other tasks and develop a critical path.
5. Develop a schedule of all activities and tasks - weekly and monthly. Work out when eachtask is scheduled to begin and end. Use a Gantt chart.

Date

Signature of the student

Signature of the cohort owner

Department of Technical Education

Capstone project

Format- 4
Cost Breakdown Structure

Capstone project Name: <State the Title of the capstone project >

Capstone project Members: <List of group members>

A cost breakdown structure (CBS) breaks down cost data into different categories, and helps you manage costs efficiently. It is a crucial part of the capstone project planning and management process, as it allows you to gain better insight into how much you spend and what you spend your capstone project budget on. When you have a solid structure in place, you can have better control of your capstone project costs to avoid going over budget.

1. **Analyze your Work Breakdown Structure**
   - Before you can identify your costs, you must first determine what your capstone project entails.
   - You can do this by looking at your work breakdown structure in detail, and work out the components that will contribute to the capstone project costs.
2. **Estimate the labor cost of work**
   - The next step is to estimate the labor cost of work for each task or activity you have identified in your WBS.
   - The time it takes for your team members to finish each work package in the WBS contribute to your labor costs.
   - Once you have estimated the labor costs of work for all the tasks, you can use them to work out the final cost of labor for your capstone project.
3. **Estimate the cost of materials**

The next step is to look at the cost of the materials needed to complete each task you identified in your WBS. These costs include

- Raw material costs
- Equipment and parts purchased for this capstone project
- Anything rented for the purpose of the capstone project

4. **Overhead costs.**
   - Ensure your CBS also includes an appropriate allocation to overhead costs.
   - Overhead include various costs that aren't related to specific tasks, but are necessary for the capstone project to take place.
5. **Build contingency into your CBS**
   - No matter how accurate your estimates are, you should still allow for some contingency in your cost breakdown structure in the CBS

6. Final-check

- The last step in creating a cost breakdown structure is to check your estimates against your available budget.
- If it your estimate is within the available budget, then you can be confident that the financial aspect of your capstone project will be smooth sailing
- If your CBS comes in higher than the available budget, you can look at ways to control costs.

Date

Signature of the student

Signature of the cohort owner

Department of Technical Education

Capstone project

Format- 5
Capstone project Execution Document

Capstone project Name: <State the Title of the capstone project >

Capstone project Members: <List of group members>

- Main Deliverables -

1) **Design:** descriptions of the components in the system, Component diagrams, and required design if any.
2) **Description of Technology Used:** provide details of Hardware devices, software products, programming languages etc.
3) **Fabrication**: fabrication or construction details
4) **Testing and validation**: provide the details of Methodologies/ laboratory experiments/ computer programming/ modelling/ simulations/ analysis/ findings etc
5) **Results and inference**

Date

Signature of the student

Signature of the cohort owner

Department of Technical Education
Capstone project

Format- 6
Weekly Meeting Record

<For Cohort Owner Use>

Capstone project Title:		
Group Members	1) 2) 3) 4)	□Present □Present □Present □Present
Date		
Meeting venue		□On Time
Documents Submitted	□ Status Report	□On Time
Issues Group Working on		
Assessment of Progress	□Excellent □Good □Satisfactory □Fair □Poor	
Notes/ Concerns/ Comments		

Signature of the Cohort owner

Department of Technical Education

Capstone project

Format- 7
Weekly Status Report

Capstone project Name: <State the Title of the capstone project >

Capstone project Members: <List of group members>

Status:

Briefly describe and illustrate the progress.

Highlights

List any items of note. Breakthroughs, accomplishments, major decisions, or changes in the capstone project plan Are you on schedule, ahead of schedule or behind schedule?

Risks or Issues List

In the following table, list any risk or issue that is critical for the success of the capstone project. This could be anything from "*we need to get data*" to "*how do we ensure that the system is usable*" to "*performance is unacceptable*". This should be a complete historical list that is kept from the beginning of the capstone project until the end.

Status should be one of *New*, *ongoing*, *Closed*.

The resolution column should be filled in if the issue or risk has been taken care of.

A capstone project may be expected to have around 1-3 active issues or risks that are being managed (new or ongoing) at any given time. If you have more than three, then either you have a capstone project in serious trouble or your criteria for what is "critical to success" is too loose.

Date	Risk or Issue	Description	Resolution	Status

Contd..

Tasks in Progress or Completed:

List the tasks that each member of the capstone project worked on up to the present time.

Task Name	Description	Team Member Responsible	Percentage Complete

Upcoming Tasks:

List the tasks that each capstone project member is planning to work on in the upcoming Task.

Task Name	Description	Team Member Responsible

Date:

Signature of the students

Department of Technical Education

Capstone project

Format- 8

Student's Daily Log Book

Capstone project Name: <State the Title of the capstone project >

Capstone project Members: <List of group members>

Day-1	Date:
Capstone project Name:	
Name of the student	
Name of the Cohort owner:	
Remarks of the Cohort owner:	
Record Main actives of the day (including observation, sketches, discussions, etc): Signature of the Cohort owner	

Note: Prepare a A4 size hard bound Student's Diary/ Daily Log book using this format with college and student details

Department of Technical Education

Capstone project

Format- 9

Capstone project Report Template

The contents of the capstone project report shall be arranged in the following order:

1. Cover Page
2. Inside Title Page
3. Certificate signed by the Cohort owner and HOD
4. Declaration signed by the Candidate
5. Acknowledgements
6. Executive Summary
7. Table of Contents
8. List of Figures
9. List of Tables
10. Abbreviations/ Notations/ Nomenclature
11. Text of the Report
    - Chapter 1
    - Chapter 2
    - --
    - --
    - Chapter... n
12. References
13. Appendices
14. non-paper materials (if any)

The different Chapters in the capstone project report shall have the following content,

Chapter 1

- Introduction
- Scope of the capstone project

Chapter 2

Capstone project planning

- Work breakdown structure (WBS)
- Timeline Development – Schedule
- Cost Breakdown Structure (CBS)
- Capstone project Risks assessment

Requirements Specification

- Functional
- Non-functional (Quality attributes)

- User input
- Technical constraints

Design Specification

- Chosen System Design
- Discussion of Alternative Designs
- Detailed Description of Components/Subsystems
- Component 1- n

Chapter 3

Approach and Methodology

Discuss the Technology/Methodologies/use cases/ programming/ modelling/ simulations/ analysis/ process design/product design/ fabrication/etc used in the capstone project

Chapter 4

Test and validation

i. Test Plan
ii. Test Approach
iii. Features Tested
iv. Features not Tested
v. Findings
vi. inference

Describe what constitute capstone project success and why? Discuss the product/service tests that will confirm the capstone project succeeds in doing what it intended to do.

Chapter 5

Business Aspects

Discuss the novel aspects of this service or product. Address why a company or investors should invest money in this product or service.

- Briefly describe the market and economic outlook of the capstone project for the industry
- Highlight the novel features of the product/service.
- How does the product/service fit into the competitive landscape?
- Describe IP or Patent issues, if any?
- Who are the possible capstone projected clients/customers?

Financial Considerations

- Capstone project budget
- Cost capstone projections needed for either for profit/nonprofit options.

Conclusions and Recommendations

- Describe state of completion of capstone project.
- Future Work
- Outline how the capstone project may be extended

General Guidelines

Report Size - Report may contain maximum of about 100 pages including references and appendices.

Paper Size - Use A4 size paper

Paper Quality - White bond paper weighing 85 g/m2 or more should be used. Photographs or images

with dense colors may be printed in single side on glossy paper.

Margins - A margin of 40 mm is to be provided on left and 30 mm on right sides, whereas top and bottom margins should be 30 mm. No print matter should appear in the margin except the page numbers. All page numbers should be centered inside the bottom margin, 20mm from the bottom edge of the paper.
Font - Times New Roman (TNR) 12-point font has to be used throughout the running text. The captions for tables and figures should have font size of 11 and foot notes should be set at font size 10. Font sizes for various levels of headings are given in the table below

CHAPTER 3

TITLE PAGE-CENTERED TNR 17-POINT BOLD ALL CAPS

3.1. Section Heading
Left aligned with number, TNR 17 points, bold and leading caps

3.1.1. Second level section heading
Left aligned with number, TNR 14 points, bold and sentence case.

3.1.1.1 Third level section heading
Left aligned with number, TNR 12 points, bold and sentence case.

Fourth-level section heading

Numbered subsections beyond third level are not recommended. However, fourth-level subsection headings may be included without numbering, TNR 12-point font, left aligned and italicized

Running text should be set in 12-point TNR and fully justified. First line of paragraph should have indentation of 15 mm.

Line Spacing - The line spacing in the main text should be 1.5, for quotations, figure captions, table captions, figure legends, footnotes, and references. The equations, tables, figures, and quotations Single line spacing should be given.

Table / Figure/equation Format-

Tables, figures, and equations shall be numbered chapter-wise. For example, second figure in Chapter 3 will be numbered Figure 3.2. The figure can be cited in the text as Figure 3.2, Tables shall be numbered similarly (Table 2 in Chapter 3 will be numbered Table 3.2) and shall be cited in the text as Table 3.2. Figure caption shall be located below the figure. Table number and caption shall be located above the table.

Listing of the References:

Referencing is a way to give credit to the writers from whom you have borrowed words and ideas. By citing the work of a particular scholar, you acknowledge and respect the intellectual property rights of that researcher. As a student or academic, you can draw on any of the millions of ideas, insights and arguments published by other writers, many of whom have spent years researching and writing. All you need to do is acknowledge their contribution to your assignment.

References are to be listed after last chapter. They are to be listed in alphabetical order and numbered. Within a reference the line spacing should be single. Each reference should be separated by one blank line. The reference number should be left aligned. The text of the reference should have an indentation of 10 mm. The reference format to be followed for journal articles, text books, conference proceedings etc. are given below.

Journals

1. Parkas, K. (2011). Feedback and optimal sensitivity: Model reference transformations, multiplicative semi norms, and approximate inverses. IEEE Transactions on Automatic Control, 26(2): 301–320.

Text books

1. Myers, D. G. (2007). Psychology (1st Canadian ed.). Worth: New York.

Conference proceedings

1. Payne, D.B. and Gunhold, H.G. (1986). Digital sundials and broadband technology, In Proc. IOOC-ECOC, 1986, pp. 557-998.

Reports

1. Milton, M and Robert, L. (2004). Atmospheric carbon emission through genetic algorithm, Environment and Technical Report No.3., Indian Meteorological Department., New Delhi

Online journals with a DOI (Digital Object Identifier)

1. Krebs, D.L. and Denton, K. (2006). Explanatory limitations of cognitive developmental approaches to morality. Psychological Review, 113(3): 672- 675. doi: 10.1037/0033- 295X.113.3.672

Online journals without a DOI

1. Vicki, G.T., Thomae, M., Cullen, A. and Fernandez, H. (2007). Modeling the hydrological impact on Tropical Forests. Forest Ecology, 13(10): 122-132. Retrieved from http://www.uiowa.edu/~grpproc/crisp/crisp.html

Online books

1. Perfect, T.J. and Schwartz, B. L. (Eds.) (2002). Applied metacognition. Retrieved from http://www.questia.com/read/107598848 (--If DOI is available, use the DOI instead of a URL

Chapters from a book

1. Krebs, D.L. and Denton, K. (1997). Social illusions and self-deception: The evolution of biases in person perception. In J. A. Simpson & D. T. Kenrick (Eds.), Evolutionary social psychology (pp.21-48). Hillsdale, NJ: Erlbaum

Appendices

Include data tables, drawings, background calculations, specification lists for equipment used, details of experimental configuration, and other information needed for completeness,

Page Numbering

Page numbers for the prefacing materials (Inside title page, dedication, certificate, declaration, acknowledgements, executive summary, table of contents, etc.) of the report shall be in small

Roman numerals and should be centered at the bottom of the pages.

The numbering of the prefacing material starts from the Inside Title Page. However, the number is not printed on the Inside Title Page. Each new item of the prefacing materials listed above should start on a fresh paper on right page. If the content of the prefacing material exceeds one page, it has to be printed on both sides of the paper by starting from the right- side page. For example, if the item „Table of Contents" extends for 5 pages, it should be printed in fresh paper on right side page with second page of the „Table of Contents" on the back of the paper and then continued. The page numbers of the prefacing material will be printed in small Roman numerals continuously counting blank pages also. However, the numbers are not printed on the blank pages

The body of the report starting from Chapter 1 should be paginated in Arabic numerals and should be centered at the bottom of the pages. The pagination should start with the first page of Chapter 1 and should continue throughout rest of the report. Each side of a sheet of paper should be counted as a separate page, even if the back side of a sheet of paper is blank. The odd numbered pages are always on the right and even-numbered pages are always on the left. If the end of a chapter is in odd page (right side page) the next chapter should start on odd page i.e., on a fresh paper, and should be numbered as odd only by counting the blank even page also. However, the page number is not printed on the blank pages.

Each of the items - Inside cover page, Certificate, Acknowledgements, executive summary, Table of Contents, List of Figures, List of Tables, Abbreviations, Notations, Nomenclature, each new Chapter, References, and each new Appendix should start on an odd page i.e., on the right side

Non-Paper Material

A report may contain non-paper material, such as specimen, CDs and DVDs, Pen drive if necessary. They have to be accommodated in a closed pocket in the back cover page of the report. The inclusion of non-paper materials must be indicated in the Table of Contents. All non-paper materials must have a label each clearly indicating the name of the candidate, student Register number and the date of submission.

Binding

Two hard bounded copies of the capstone project Report shall be submitted for evaluation; the cover page should be printed on sky blue card of 300 g/m2 or above. One copy is used for Semester End Examination and after the exam it should be maintained in the concerned Head of the department and another copy is maintained at cohort owner

Electronic Copy

An electronic version (PDF) of the capstone project report should be submitted to the cohort owner and Head of the department. The file name should contain title of the capstone project, student Register number and date of submission.

Government of Karnataka
Department of Technical Education
Board of Technical Examinations

C-25 SEE Theory Question Paper Pattern

Course Name: Course Code:
Time: 3 Hours Max. Marks :100

Instructions:

For Part-A questions, only the first written answers will be considered for evaluation.

PART A

I. Select the correct answer from the choices given: 15X1 = 15 Marks

1. Multiple Choice Question-1
   A.
   B.
   C.
   D.
2. Multiple Choice Question-2
   A.
   B.
   C.
   D.
3. Multiple Choice Question-3
   A.
   B.
   C.
   D.
4. Multiple Choice Question-4
   A.
   B.
   C.
   D.
5. 5. Multiple Choice Question-5

   A.

   B.

   C.

   D.

6. Multiple Choice Question-6

   A.

   B.

   C.

   D.

7. Multiple Choice Question-7
    A.
    B.
    C.
    D.
8. Multiple Choice Question-8
    A.
    B.
    C.
    D.
9. Multiple Choice Question-9
    A.
    B.
    C.
    D.
10. Multiple Choice Question-10
    A.
    B.
    C.
    D.
11. Multiple Choice Question-11
    A.
    B.
    C.
    D.
12. Multiple Choice Question-12
    A.
    B.
    C.
    D.
13. Multiple Choice Question-13
    A.
    B.
    C.
    D.

14. Multiple Choice Question-14

    A.

    B.

    C.

    D.

15. Multiple Choice Question-15

    A.

    B.

    C.

    D.

II. Fill in the blanks by choosing appropriate answer from those given in the bracket: (Answer-1, Answer-2, Answer-3, Answer-4, Answer-5) 5X1 = 05 Marks

1. Question-1
2. Question-2
3. Question-3
4. Question-4
5. Question-5

PART B

III. Answer any FIVE questions: 5X2 = 10 Marks

1. Question-1
2. Question-2
3. Question-3
4. Question-4
5. Question-5
6. Question-6.
7. Question-7
8. Question-8

PART C

IV. Answer any FIVE questions: 5X3 = 15 Marks

1. Question-1
2. Question-2
3. Question-3
4. Question-4

5. Question-5
6. Question-6
7. Question-7
8. Question-8

PART D (Section I)

V. Answer any FIVE questions: 5X5 = 25 Marks

1. Question-1
2. Question-2
3. Question-3
4. Question-4
5. Question-5
6. Question-6
7. Question-7
8. Question-8

PART D (Section II)

VI. Answer any THREE questions: 10X3 = 30 Marks

1. Question-1
2. Question-2
3. Question-3
4. Question-4
5. Question-5