

Curriculum of Diploma Programme

in

Mechanical Engineering



**Department of Science, Technology and Technical Education
(DSTTE), Govt. of Bihar**

**State Board of Technical Education
(SBTE), Bihar**

Semester – VI Teaching & Learning Scheme

Course Codes	Category of course	Course Titles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2425601	PCC	Design of Machine Elements	02	01	-	02	05	04
2425602	PCC	Maintenance & Safety of Mechanical & Solar Appliances	03	-	04	02	09	06
2425603	PEC	Programme Electives* (Any One)	03	-	04	02	09	06
2400604	OEC	Open Electives**/ COE (Advanced -Any One)	03	-	04	02	09	06
2425606	PSI	Major Project (Common for all programmes)	-	-	08	04	12	06
2400107	NRC	Professional Ethics	01	-	-	-	01	01
2400408	NRC	Employability Skills Development (Common for All Programmes)	01	-	-	-	01	01
Total			13	1	20	12	46	30

Note: Prefix will be added to course code if applicable (T for Theory Paper, P for Practical Paper and S for Term Work)

Legend:

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- *: Heat and Mass Transfer/ Power Plant Engineering/ Press Tool, Jigs and Fixture/ Hydraulic and Pneumatic Controls/Renewable and Alternate Energy Sources
- ** : Artificial Intelligence (AI)/ IOT/ Drone Technology/ 3D Printing & Design/ Industrial Automation & Control/ Electric Vehicle/ Robotics/ Transformer Manufacturing and Repairing/ Optical Fiber and 5G Communication
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

Semester - VI Assessment Scheme

Course Codes	Category of course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment(TA)		Term work &Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2425601	PCC	Design of Machine Elements	30	70	20	30	-	-	150
2425602	PCC	Maintenance & Safety of Mechanical & Solar Appliances	30	70	20	30	20	30	200
2425603	PEC	Programme Electives* (Any One)	30	70	20	30	20	30	200
2400604	OEC	Open Electives**/COE (Advanced -Any One)	30	70	20	30	20	30	200
2425606	PSI	Major Project (Common for all programmes)	-	-	20	30	50	100	200
2400107	NRC	Professional Ethics	25	-	-	-	-	-	25
2400408	NRC	Employability Skills Development (Common for All Programmes)	25	-	-	-	-	-	25
Total			170	280	100	150	110	190	1000

Note: Prefix will be added to course code if applicable (T for Theory Paper, P for Practical Paper and S for Term Work)

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

*: Heat and Mass Transfer/ Power Plant Engineering/ Press Tool, Jigs and Fixture/ Hydraulic and Pneumatic Controls/Renewable and Alternate Energy Sources

** : Artificial Intelligence (AI)/ IOT/ Drone Technology/ 3D Printing & Design/ Industrial Automation & Control/ Electric Vehicle/ Robotics/ Transformer Manufacturing and Repairing/ Optical Fiber and 5G Communication

Note: ETA & ELA are to be carried out at the end of the term/ semester.

- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

J) Theory Session Outcomes (TSOs) and Units: T2425601

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Describe design & design steps.</p> <p><i>TSO 1b.</i> Identify critical points on stress-strain curves for ductile and brittle materials.</p> <p><i>TSO 1c.</i> Identify the different types of loads and their effect.</p> <p><i>TSO 1d.</i> Calculate the induced stresses in the given machine elements for the given load condition.</p> <p><i>TSO 1e.</i> Determine dimensions of the component under given conditions considering factor of safety.</p> <p><i>TSO 1f.</i> Use theories of failure in designing in the given simple machine component.</p>	<p>Unit-1.0 Fundamentals of Machine Design</p> <p>1.1 Introduction to design, Machine Design philosophy and steps.</p> <p>1.2 Types of loads, concepts of Strength, Stress and Strain; Stress – Strain Diagram for Ductile and Brittle Materials.</p> <p>1.3 Recall of direct and principal stresses and strains. (Simple numerical)</p> <p>1.4 Creep, Creep strain and Creep Curve; (Introduction only)</p> <p>1.5 Cyclic loading, Fatigue; S-N curve; Endurance Limit; (Introduction only)</p> <p>1.6 Factor of Safety and factors governing selection of Factor of Safety;</p> <p>1.7 Stress Concentration: Causes & Remedies; Converting actual load or torque into design load or torque using design factors Like velocity factor, factor of safety & service factor</p> <p>1.8 Introduction to International standards; Advantages of standardization; Use of design data book; Use of standards in design and preferred numbers series</p> <p>1.9 Theories of Elastic Failures; Principal normal stress theory; Maximum shear stress theory & Maximum distortion energy theory.</p>	CO1
<p><i>TSO 2a.</i> Identify the different properties of engineering materials required for the given machine component and loading.</p> <p><i>TSO 2b.</i> Describe procedures for designing simple given machine parts such as C-Clamp, Hand/Foot Lever etc</p> <p><i>TSO 2c.</i> Classify Anti friction bearing.</p> <p><i>TSO 2d.</i> Calculate main design parameters for Ball and Roller contact bearing</p> <p><i>TSO 2e.</i> Select the relevant Ball and Roller bearing for the given load condition.</p>	<p>Unit-2.0 Design of Simple Machine Part & Antifriction Bearing</p> <p>2.1 Properties of Engineering materials; Designation of materials as per IS; Important mechanical properties of materials: Elasticity, Plasticity, Hardness, Ductility, Malleability, Brittleness, Resilience, Toughness,</p> <p>2.2 Design of simple machine parts: Cotter Joint; Knuckle Joint; Turnbuckle; Design of Levers: Hand/Foot Lever & Bell Crank Lever; Design of C- Clamp; Off-set links; Overhang Crank; Arm of Pulley.</p> <p>2.3 Antifriction Bearings: Classification of Bearings; Sliding contact & Rolling contact; Terminology of Ball bearings: Life Load relationship, Basic static load rating and Basic dynamic load rating, limiting speed; Selection of ball bearings using manufacturer's catalogue.</p>	CO2, CO3, CO4, CO5
<p><i>TSO 3a.</i> Describe design procedure for shafts and keys for given loading conditions.</p> <p><i>TSO 3b.</i> Use ASME code of design for different conditions of pulleys.</p> <p><i>TSO 3c.</i> Describe design of different types of couplings.</p> <p><i>TSO 3d.</i> Design Spur gear for given condition.</p>	<p>Unit-3.0 Design of Shaft, Key, Coupling & Spur Gear</p> <p>3.1 Design of Shafts: Types of Shafts; Shaft materials; Standard Sizes; Design of Shafts (Hollow and Solid) using strength and rigidity criteria; ASME code of design for line shafts supported between bearings with one or two pulleys in between or one over-hung pulley;</p>	CO2, CO4, CO5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	3.2 Design of Sunk Keys; Effect of Keyways on strength of shaft; 3.3 Design of Couplings – Muff Coupling, Protected type Flange Coupling, Bush-pin type flexible coupling 3.4 Spur gear design considerations; Lewis equation for static beam strength of spur gear teeth; Power transmission capacity of spur gears in bending.	
TSO 4a. Identify screw threads of a given power screw. TSO 4b. Describe design of spring and its properties. TSO 4c. Describe construction and application of leaf spring.	Unit-4.0 Design of Power Screw, Spring & Leaf Spring 4.1 Design of Power Screws: Thread Profiles used for power Screws -Relative merits and de- merits of each; Torque required to overcome thread friction; Self- Locking and overhauling property; Efficiency of power screws; Types of stresses induced; Design of Screw Jack; Toggle Jack. 4.2 Design of springs: Classification and Applications of Springs; Spring terminology; Materials and Specifications; Stresses in springs; Wahl's correction factor; Deflection of springs; Energy stored in springs; Design of Helical, Tension and Compression springs subjected to uniform applied loads like I.C. engine valves, Weighing balance, Railway buffers and Governor Springs 4.3 Leaf springs: Construction and Application.	CO2, CO5
TSO 5a. Describe design of fasteners, TSO 5b. Describe design of bolts subjected to eccentric loading. TSO 5c. Describe design of different types of welded joints. TSO 5d. Describe merits and demerits of screwed and welded joints. TSO 5e. Describe ergonomics & aesthetic considerations in design of simple machine elements. TSO 5f. Describe aesthetic considerations in design of different machine elements.	Unit-5.0 Design of Fasteners & Ergonomics 5.1 Design of Fasteners: Stresses in Screwed fasteners; Bolts of Uniform Strength; Design of Bolted Joints subjected to eccentric loading; Design of Parallel and Transverse fillet welds; Axially loaded symmetrical section; Merits and demerits of screwed and welded joints. 5.2 Ergonomics & Aesthetic consideration in design: Ergonomics of Design: Man– Machine relationship; Design of Equipment for control, environment & safety; Aesthetic considerations regarding shape, size, color & surface finish.	CO5, CO6

Note: One major TSO may require more than one theory session/period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self Learning: S2425601 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

1. Perform designing of simple components under static single load situation through at least 5 numerical problems
2. Perform designing of simple components under simple static multi-load situation through at least 2 numerical problems
3. Prepare a list of tests and map them with corresponding mechanical properties.
4. Discuss the selection of materials for machine elements, taking into account properties like strength, stiffness, and wear resistance.
5. Perform designing of simple machine components like Cotter Joint; Knuckle Joint; Turnbuckle; Hand/Foot Lever & Bell Crank Lever; C- Clamp; Off-set links; Overhang Crank; Arm of Pulley.

- I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self-Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units: T2425602**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO 1a. Describe the role of government in industrial safety.</p> <p>TSO 1b. Explain educational training in safety</p> <p>TSO 1c. Use of various safety equipment's by workers in different industry.</p> <p>TSO 1d. Application of different Firefighting equipment for given industry.</p> <p>TSO 1e. Explain Industrial psychology in accident prevention and Safety trial.</p> <p>TSO 1f. Use of various PPE for given solar appliances in Solar industry.</p> <p>TSO 1g. Explain various solar appliances & its construction, working and function</p>	<p>Unit-1.0 Industrial Safety Equipment's</p> <p>1.1 Introduction to Industrial Safety and Management, safety principal safe working condition and practices, Safety and productivity,</p> <p>1.2 Role of management and role of Govt. in Industrial safety, motivation for safety.</p> <p>1.3 Education and training in safety, Survey the plant for locations, Part of body to be protected, cause of accident & prevention, Housekeeping, Accident Preventions, Protective Equipment's and the Acts</p> <p>1.4 Personal protective equipment (PPE) , PPE for solar industry-hard hats, safety glasses, respiration ,gloves , fall protection equipment , hearing protection</p> <p>1.5 Medical emergency, introduction to first aid, first aid box, incident management, CPR, bleeding, shock, burns & Scaldes</p> <p>1.6 Fire, classification of fire, Firefighting equipment-Fire Extinguishers, types of fire extinguishers-Powder foam, CO2, wet chemical, water, uses of different types of fire extinguishers, symbols of fire extinguisher, fire safety sign, fire triangle and tetrahedral, Smoke detectors, Fire Alarm system.</p> <p>1.7 Accident, Measures in industry, Accident reporting, Investigations, Industrial psychology in accident prevention, accident record keeping. Occupational safety and health assessment (OSHA)</p> <p>1.8 Introduction to solar appliances, construction, working & function- Solar Water Heater, Photovoltaic Cell, Solar Distillation, solar drying, solar cooker, solar lighting</p>	<p>CO1</p>
<p>TSO 2a. Explain the features of factory Act (Explosive Boiler Act, ESI Act Workman's compensation Act etc).</p> <p>TSO 2b. Explain Ergonomics.</p> <p>TSO 2c. Describe the methods of controlling chemical hazards for a give situation.</p> <p>TSO 2d. Explain Code and regulations for worker safety for solar penal.</p> <p>TSO 2e. Use of electricity act 2003 for</p>	<p>Unit-2.0 Industrial Safety Acts</p> <p>2.1 Features of Factory Act (1948), implementation of factory act(1948), Introduction of Explosive Act, Boiler Act(1923), Employee's state insurance Act(1948), Workman's compensation Act(1923),</p>	<p>CO2</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
installation of solar Panel.	2.2 Industrial hygiene, Diseases prevention, Ergonomics& health, Occupational diseases, stress, fatigue, health, safety and the physical environment, 2.3 Methods of controlling chemical hazards, safety and the physical environment, Control of industrial noise and protection against it 2.4 Code and regulation for solar panel installation-Building codes, fire codes and Electrical Codes, Code and regulations for worker safety. 2.5 Major solar policies in India.	
TSO 3a. Explain principle and merits of maintenance. TSO 3b. Define reliability& equipment life cycle. TSO 3c. Explain the need of maintenance TSO 3d. Classified different types of maintenance used in industries TSO 3e. Calculating the costs associated with given asset breakdowns and downtime. TSO 3f. Enlist preventive maintenance of components of given solar appliances TSO 3g. Prepare maintenance contracts for given equipment used in industry.	Unit-3.0 Principles and Practices of Maintenance 3.1 Basic Principles of maintenance – Objectives, Benefit of Maintenance systems – Reliability and machine availability, Equipment Life cycle 3.2 Need and type of Maintenance- Breakdown maintenance, Preventive Maintenance, Condition Based monitoring - on line -off line monitoring, visual, temperature, leakage & lubricant monitoring 3.3 Introduction of Condition based Maintenance (CBM), Benefits, Principle and its Application (Temperature Readings, Pressure States and Oil Viscosity). 3.4 Maintenance budget and its components 3.5 Solar panel Maintenance- Preventive maintenance on major components of a solar system (Battery, Solar Panels, Charge Controller, Inverter and Wiring and connections) 3.6 Maintenance contracts and agreements.	CO3
TSO 4a. Evaluate role of maintenance planning for a given optimizing operations. TSO 4b. Prepare a maintenance work order for a given equipment. TSO 4c. Prepare Scheduling and maintenance plan for given machine to minimize downtime. TSO 4d. Analyzed CMMS and its function. TSO 4e. Analyzed Implementation and utilization of CMMS for efficient maintenance management in industry TSO 4f. Describe solar system and solar panel TSO 4g. Define maintenance measures and its related terms. TSO 4h. Explain maintenance organization TSO 4i. Prepare the various types of maintenance charts use in industry. TSO 4j. Prepare fault tree analysis for given equipment failures.	Unit-4.0 Maintenance Planning and Management 4.1 Role of maintenance planning and scheduling, planning and scheduling techniques, gantt chart and bar chart, types of maintenance strategies, 4.2 Computerized maintenance Management Systems (CMMS)- Introduction to CMMS and its functions, Implementation and utilization of CMMS for efficient maintenance management, E-maintenance solution for industrial equipment, Introduction of Software maintenance (SM) (Software-Hippo CMMS, open MAINT), Need for SM, Type of SM, its Process& Advantages. 4.3 Measures for Maintenance Performance: Equipment’s breakdowns, Mean Time Between Failures and Repair, Factors of availability, Maintenance organization, 4.4 Repair cycle, Principles and methods of lubrication, Fault Tree Analysis and trouble shooting	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	4.5 Solar System Maintenance schedule, Solar Panel maintenance log sheet.	
TSO 5a. Analyze various solar appliances and its application TSO 5b. Explain Solar Panels TSO 5c. Explain preventive & predictive maintenance of equipment Solar appliances TSO 5d. Prepare a preventive maintenance chart for the given machine/ Engine. TSO 5e. Evaluating the effectiveness of the preventive and predictive maintenance chart for a given equipment. TSO 5f. Prepare service agreements document for given equipment. TSO 5g. Explain warranties and service agreement for given equipment's. TSO 5h. Explain the decision levels for given equipment maintenance. TSO 5i. Explain standards and requirements applicable to the measuring equipment. TSO 5j. Explain the need for calibration of measuring equipment. TSO 5k. Prepare a maintenance record keeping for a given equipment. TSO 5l. Enlist type of maintenance record keeping.	Unit-5.0 Application of Maintenance of Mechanical Equipment's & Solar Appliances 5.1 Maintenance checklist of Photovoltaic Cell, Solar Water Heater and Solar lighting. 5.2 Preventive maintenance chart of Lathe machine, drill, refrigerator and four stroke IC Engine. 5.3 Managing equipment warranties, guarantees and service agreements 5.4 Policy and objective for maintenance, Decision levels for equipment maintenance. 5.5 Calibration, need for calibration, standards and requirements, standard operating procedures for calibration. 5.6 Record keeping -need of record keeping, advantages of record keeping, types of record keeping- manual, automatic & computerized record keeping maintenance record format.	CO5

Note: One major TSO may require more than one theory session/period

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425602

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1. Use of personal protective equipment.	1.	Identify given personal protective equipment	CO1
	2.	Select PPE for the given job.	CO1
LSO 1.2. Use first aid for the given injuries	3.	Perform first aid process in bleeding, shock, burns & scalds	CO1
LSO 1.3. Use different types of fire extinguishers	4.	Identify different types of fire Extinguishers.	CO1
	5.	Operate the given fire extinguishers	CO1
LSO 1.4. Apply OSHA	6.	Apply OSHA for the given laboratory	CO1
LSO 1.5. Use Smoke detectors and Fire Alarm Systems	7.	Operate Smoke detectors and Fire Alarm Systems.	CO1
	8.	Test smoke detector and fire alarm system for its performance	CO1
	9.	Inspect test solar panel system and components for its performance	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
	10.	Identify the faults in the given solar panel	CO1
	11.	Test solar water heater	CO1
<i>LSO 2.1.</i> Identify hazards	12.	Identify potential hazards in the given laboratory and recommend control measures.	CO2
<i>LSO 2.2.</i> Use sound level meter	13.	Measure noise levels using sound level meters	CO2
<i>LSO 2.3.</i> Install solar systems	14.	Install solar system using codes and regulation	CO2
<i>LSO 2.4.</i> Boiler Act (1923)	15.	Identify the symbols and safety measures given on the boiler	CO2
<i>LSO 3.1</i> Equipment life cycle	16.	Calculate life of the given equipment	CO3
<i>LSO 3.2</i> Calculate total breakdown cost.	17.	Calculate direct and indirect breakdown costs of the given equipment	CO3
<i>LSO 3.3</i> Use maintenance schedule	18.	Perform maintenance of the given solar appliance as per the preventive maintenance schedule.	CO3
<i>LSO 4.1.</i> Calculate MTBF and MTTR for given equipment's	19.	Calculate MTBF and MTTR using provided data sets for the given equipment's	CO4
<i>LSO 4.2.</i> Troubleshoot the given system	20.	Troubleshoot the given solar system	CO4
<i>LSO 4.3.</i> Use CMMS	21.	Apply CMMS for the given equipment	CO4
<i>LSO 4.4.</i> Perform Fault Tree Analysis	22.	Conduct a Fault Tree Analysis for a given maintenance equipment problem	CO4
<i>LSO 4.5.</i> Apply relevant lubrication techniques	23.	Lubricate the given equipment	CO4
<i>LSO 4.6.</i> Use Solar panel maintenance log sheet template	24.	Prepare solar panel maintenance log sheet	CO4
<i>LSO 4.7.</i> Use maintenance software (Software-Hippo CMMS, open-MAINT	25.	Update the laboratory process by adding laboratory equipment to the software system, including details such as maintenance history and specifications.	CO4
	26.	Create work orders, update asset information, and generate maintenance reports of the given equipment.	CO4
<i>LSO 5.1.</i> Solar Panel Installation (mounting, wiring, and configuring the panels)	27.	Install solar panels on a mock roof or structure.	CO5
<i>LSO 5.2.</i>	28.	Inspect clean and repair solar water heaters, including checking pumps and controls.	CO5
<i>LSO 5.3.</i> Maintain solar lighting system	29.	Inspect a solar lighting system using preventive maintenance checklist including battery health, wiring, and light intensity.	CO5
<i>LSO 5.4.</i> Apply step-by-step calibration procedures for the given equipment's	30.	Identify tools and equipment required for calibration.	CO5
	31.	Calibrate the given micrometers and Vernier caliper	CO5
	32.	Calibrate the given pressure gauges	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
	33.	Calibrate the given screw driver and testers	CO5
	34.	Perform maintenance activities on the lath machine using preventive maintenance schedule	CO5

L) Suggested Term Work and Self Learning: S2425602 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

- i. Prepare a detailed report on different types of solar appliances used for household with specification and prepare a maintenance plan.
- ii. Prepare a detailed report of various type of protective equipment used in industry to prevent the accident.
- iii. Compare at least 04 types of maintenance software used in industries based on the given criteria's and select one software which can be applicable in the laboratory with justification.
- iv. Explain different codes and regulations used in manufacturing industry for worker safety.
- v. Prepare various maintenance chart for given mechanical and solar appliance.
- vi. Prepare a detail charts on different types of acts applied in industries and laboratories.
- vii. Develop preventive maintenance checklist for major components of a solar system
- viii. Prepare maintenance schedule for Solar Water Heater
- ix. Develop a preventive Maintenance schedule for a lathe machine, including lubrication, calibration, and tool inspections

b. Micro Projects:

- i. Troubleshoot 02 given equipment's can perform the maintenance of the given equipment in industries.
- ii. Calculate the life of the given 05 equipment.
- iii. Visit the industry and prepare detailed report on maintenance methods and activities adopted to maintain the machines and equipment for 02 industries.
- iv. Visit the industry and prepare the report for provision made for safety of man & machine and implementation of OSHA in the industries.
- v. Prepare E-maintenance solution for industrial equipment

c. Other Activities:

- i. Use demonstration, video/animation films field/industry visit for explaining complex/abstract concepts of Maintenance & Safety of Mechanical & Solar
- ii. Students may be asked the method to solve the Problem before accident during lecture periods.

J) Theory Session Outcomes (TSOs) and Units: T2425603A

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Differentiate among different mode of heat transfer.</p> <p><i>TSO 1b.</i> Draw graph between temperature and thermal conductivity for different metals.</p> <p><i>TSO 1c.</i> Determine the thermal conductivity of given material.</p> <p><i>TSO 1d.</i> Draw graph of temperature distribution in different materials of given shape.</p> <p><i>TSO 1e.</i> Explain the use of critical radius in cylindrical pipes.</p>	<p>Unit-1.0 Introduction to Heat Transfer</p> <p>1.1 Modes of heat transfer: conduction, convection and radiation</p> <p>1.2 Combined mode of heat transfer, Overall heat transfer coefficient, thermal conductivity of solid, liquid and gasses, effects of temperature on thermal conductivity of materials.</p> <p>1.3 Fourier law of heat conduction, Differential equation of heat conduction</p> <p>1.4 Steady state one dimensional Heat conduction – plane wall, sphere, cylinder, composite slab.</p> <p>1.5 Thermal contact resistance, Thermal diffusivity, critical radius of insulation.</p>	CO1
<p><i>TSO 2a.</i> Explain the need of fins.</p> <p><i>TSO 2b.</i> Calculate the effectiveness of the given fins.</p> <p><i>TSO 2c.</i> Compare different shape of fins.</p> <p><i>TSO 2d.</i> Find the time constant of the given lumped body.</p> <p><i>TSO 2e.</i> Test the efficiency and effectiveness of different types of fins.</p>	<p>Unit-2.0 Fins</p> <p>2.1 Types of fins, Heat flow through a rectangular fin, infinitely long fin, fin insulated at the tip and fin losing heat at tip.</p> <p>2.2 Effectiveness and efficiency of fin.</p> <p>2.3 Transient heat conduction, Lumped system analysis, Time constant, Unsteady state heat conduction in one dimension only, Biot number Heisler's chart</p>	CO2
<p><i>TSO 3a.</i> Draw the temperature profile and velocity profile of given type of convection.</p> <p><i>TSO 3b.</i> Determine convective heat transfer coefficient for a given convection process.</p> <p><i>TSO 3c.</i> Measure the fluid velocity and boundary layer for a given flow.</p> <p><i>TSO 3d.</i> Estimate the different dimensionless</p> <p><i>TSO 3e.</i> Number in given problem.</p> <p><i>TSO 3f.</i> Derive equation of flow</p>	<p>Unit-3.0 Convection</p> <p>3.1 Newton's law of cooling, Natural and forced convection</p> <p>3.2 Continuity, momentum and energy equation, Thermal and hydrodynamic boundary layer</p> <p>3.3 Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes.</p> <p>3.4 Heat transfer co-efficient and its interpretations</p> <p>3.5 Dimensional analysis applied to forced and natural convection</p> <p>3.6 Dimensionless number and their physical significance</p>	CO3
<p><i>TSO 4a.</i> Classify different types of heat exchanger.</p> <p><i>TSO 4b.</i> Determine LMTD for parallel and counter flow heat exchanger.</p> <p><i>TSO 4c.</i> Test the fouling factor of a given heat exchanger.</p> <p><i>TSO 4d.</i> Explain the use of NTU in heat exchanger.</p> <p><i>TSO 4e.</i> Describe the design parameter o design heat exchanger.</p> <p><i>TSO 4f.</i> Calculate mean temperature difference and outlet temperature of working fluid</p>	<p>Unit-4.0 Heat Exchanger</p> <p>4.1 Different Types of Heat exchangers, Parallel flow, counter flow, cross flow heat exchanger evaporator and condenser.</p> <p>4.2 Overall Heat transfer coefficient, Log mean temperature difference (LMTD), effectiveness of heat exchanger Number of transfer unit (NTU).</p> <p>4.3 fouling factor</p> <p>4.4 Design of heat-exchange equipment</p> <p>4.5 Mean temperature difference, calculating the outlet temperature of working fluids</p>	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 5a.</i> Determine the radiative heat transfer between two given surfaces.</p> <p><i>TSO 5b.</i> Calculate emissivity of the given plane body.</p> <p><i>TSO 5c.</i> Describe the irradiation and radiosity of a given solid.</p> <p><i>TSO 5d.</i> Explain the concept of shape factor.</p> <p><i>TSO 5e.</i> Interpretation of Fourier's law,</p> <p><i>TSO 5f.</i> Describe Electrical analogy of heat transfer</p> <p><i>TSO 5g.</i> Explain critical radius of insulation.</p>	<p>Unit-5.0 Thermal Radiation</p> <p>5.1 Basic radiation concepts, Black body radiation, Grey body, emissive power, emissivity, reflectivity, transmissivity</p> <p>5.2 Law of radiation-Plank's, Wein's displacement, Stefan Boltzmann, Kirchoff's.</p> <p>5.3 Irradiation, Radiosity, Concept of shape factor, Radiation shield.</p> <p>5.4 Electrical Analogy,</p> <p>5.5 Radiation through gases.</p>	CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425603A

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Apply Fourier's law of heat conduction. <i>LSO 1.2.</i> Determine Thermal conductivity of given material	1.	Determine Thermal conductivity of a metal rod.	CO1
	2.	Determine Thermal Conductivity of Liquid	CO1
	3.	determine the co-efficient of thermal conductivity of insulating powder	CO1
	4.	Determine of overall heat transfer coefficient of a given composite wall	CO1
<i>LSO 1.3.</i> Select insulating material	5.	Find critical radius of insulating material.	CO1
<i>LSO 2.1.</i> Determine heat transfer coefficient and efficiency of given fin	6.	Determine Effectiveness on a Metallic fin	CO2
	7.	Determine the heat transfer coefficient, fin efficiency and temperature distribution along the length of a pinfin in natural convection.	CO2
	8.	Determine the heat transfer coefficient, efficiency and temperature distribution of a pin fin in forced convection.	CO2
<i>LSO 3.1.</i> Heat transfer coefficient through natural and forced convection	9.	Determine the heat transfer co-efficient in natural convection for vertical tube	CO3
	10.	Determine the heat transfer co-efficient in forced convection for hot air flowing through horizontal tube	CO3
<i>LSO 4.1.</i> Use shell and tube type heat exchanger.	11.	Find coefficient of heat transfer from shell and tube heat exchanger.	CO4
<i>LSO 4.2.</i> Use counter and parallel flow heat exchanger	12.	compare temperature distribution, heat transfer rate, overall heat transfer coefficient in parallel flow and counter flow.	CO4
	13.	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.	CO4
<i>LSO 5.1.</i> Determine Stefan-Boltzman constant	14.	Determine the Stefan-Boltzman constant of radiation heat transfer.	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.2. Determine emissivity of the given surface	15.	Measure emissivity of a test plate surface	CO5
LSO 5.3. Determine critical heat flux across the given wire	16.	Determine critical heat flux values at different bulk temperatures and to observe the boiling phenomenon	CO5
LSO 5.4. Determine COP of the given system	17.	Determine the COP of vapour compression refrigeration system.	CO5

L) Suggested Term Work and Self Learning: 2425603A Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Derive a general 3 - dimensional conduction equation in Cartesian coordinates.
- Explain initial conditions and boundary conditions of I, II & III kind.
- Derive an expression for critical thickness of insulation for a cylinder.
- Derive an expression for temperature distribution and heat transfer from an extended rectangular surface of finite length with end insulation.
- Explain physical significance of Biot and Fourier numbers.
- Explain Heisler Charts and their significances in solving transient conduction problems

b. Micro Projects:

- Construct a working model of a shell and tube heat exchanger.
- Prepare a list of different types of heat exchanger used in thermal power plants.
- Prepare a list of conducting and insulating materials on the basis of thermal conductivity.
- Develop prototype model of different types of fins used in different machine and equipment's.

c. Other Activities:

1. Seminar Topics:

- Visual representation of heat exchanger in various parts of thermal power plants.
- Representation of heat transfer in Refrigerator and AC.
- Adverse effect of thermal radiation on human body.
- How to reduce fouling factor to increase heat transfer.
- Fundamental difference among all three modes of heat transfer.

2. Visits:

- Visit nearby thermal power plant to gain practical knowledge of different heat exchanger like economizer, Air preheater, Superheater Cooling tower and condenser.
 - Visit the industry which manufacture different types of heat exchanger.

3. Self-Learning Topics:

- Thermal conductivity in different medium.
- Necessity of fins in different machines.
- LMTD and NTU in Heat exchanger.
- Concepts of Black body in thermal radiation.
- Natural convection process.

J) Theory Session Outcomes (TSOs) and Units: T2425603B

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Identify the elements of coal thermal power plant.</p> <p><i>TSO 1b.</i> Explain the working of the given components of Coal thermal power plant like boiler, condenser, cooling tower and economizer etc.</p> <p><i>TSO 1c.</i> Compare the salient features of given type of high pressure boiler.</p> <p><i>TSO 1d.</i> List the salient features of Fluidized bed combustion boilers</p> <p><i>TSO 1e.</i> Explain the given control system of the steam power plant.</p> <p><i>TSO 1f.</i> Outline the maintenance procedure of a modern Coal thermal power plant.</p>	<p>Unit-1.0 Coal Thermal Power Plant</p> <p>1.1 General layout of modern coal thermal power plant and present scope of power generation in India.</p> <p>1.2 Working of Rankine cycle.</p> <p>1.3 Operation and Maintenance of Water treatment unit, Coal and ash handling unit and Natural Draught system.</p> <p>1.4 High Pressure Boilers – Classification; Construction and principle of working of Lamont boiler, Benson boiler, Loeffler boiler, Velox boiler, Schmidt Hartman boiler, Ramsin boiler;</p> <p>1.5 Fluidized bed combustion boilers (FBC): principle, need, types, various arrangement, control system and advantages over other boiler systems.</p> <p>1.6 Indian Boiler Regulation Act</p> <p>1.7 Maintenance procedure of major components of high pressure and FBC boilers.</p> <p>1.8 Operation and Maintenance of Steam turbine, Steam nozzle, Steam condenser, Cooling tower, Economizer, Heat exchanger.</p>	CO1
<p><i>TSO 2a.</i> Identify the given component(s) of gas turbine power plant.</p> <p><i>TSO 2b.</i> Explain the working of the given component (s) of Gas power plant.</p> <p><i>TSO 2c.</i> Explain the preventive maintenance of given major component of Gas power plant.</p> <p><i>TSO 2d.</i> Explain the predictive maintenance of given major component of gas power plant.</p>	<p>Unit-2.0 Gas Turbine Power Plant</p> <p>2.1 Classification, open and closed cycle gas turbine</p> <p>2.2 Gas turbine fuel</p> <p>2.3 Brayton cycle: Optimum pressure ratio for maximum efficiency, work ratio, airrate, specific fuel consumption rate</p> <p>2.4 Effect of operating variable on thermal efficiency and work.</p> <p>2.5 Operation and Maintenance of main components of Gas turbine power plant.</p>	CO2
<p><i>TSO 3a.</i> Sketch labeled arrangement of given nuclear power plant</p> <p><i>TSO 3b.</i> Explain the working of given reactor and other components of Nuclear power plant.</p> <p><i>TSO 3c.</i> Compare the calorific value of the given type of nuclear fuel.</p> <p><i>TSO 3d.</i> Interpret the regulation of nuclear power plant smoothly.</p> <p><i>TSO 3e.</i> Explain the methods of disposal of different Nuclear wastes.</p>	<p>Unit-3.0 Nuclear Power Plant</p> <p>3.1 Introduction to nuclear fission and fusion,</p> <p>3.2 Types of nuclear fuels, nuclear power plant fuels in India</p> <p>3.3 Components of nuclear reactor, pressurized water reactor and boiling water reactor</p> <p>3.4 Nuclear waste and its disposal</p>	CO3
<p><i>TSO 4a.</i> Identify the given component(s) of Hydro/Solar power plants.</p>	<p>Unit-4.0 Hydroelectric power plant and Solar power plant</p>	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 4b.</i> Explain the working of the given component (s) of Hydro/Solar power plants.</p> <p><i>TSO 4c.</i> Explain the maintenance procedure of given major component of Hydro/Solar power plants.</p>	<p>4.1 Introduction of Hydro power plant and Solar power plant, and its location in India.</p> <p>4.2 Operation and Maintenance of Micro and Pico Hydro power plant components.</p> <p>4.3 Operation and Maintenance of Solar power plant components.</p>	
<p><i>TSO 5a.</i> Estimate the cost of electricity in given situation using simple numerical problem situation.</p> <p><i>TSO 5b.</i> Calculate the performance parameter of the given power plant using simple numerical problem situation.</p> <p><i>TSO 5c.</i> Outline the common safety practices in a typical power plant.</p> <p><i>TSO 5d.</i> Estimate capital and operating costs in the given power plant.</p> <p><i>TSO 5e.</i> Explain pollution control techniques and waste disposal options in the given power plant</p>	<p>Unit-5.0 Safety, Maintenance cost, Economic and Environmental Aspects</p> <p>5.1 Safety (protective) Equipment, safety training</p> <p>5.2 Types, schedule, and cost of maintenance for different power plant</p> <p>5.3 Load distribution parameter, load curve, comparison of site selection criteria</p> <p>5.4 Capital and operating cost of different power plant</p> <p>5.5 Pollution control technique and waste disposal option of different power plant</p>	CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425603B

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Identify the given component(s) used in Coal thermal power plant.</p> <p><i>LSO 1.2.</i> Explain the operation of the given component(s) of Coal thermal power plant.</p>	1.	Identify and demonstrate working of various components used in Coal thermal power plant using models, charts, visits, simulated and real videos.	CO1
<p><i>LSO 2.1.</i> Maintain the condenser, economizer etc. components of Coal thermal power plant.</p>	2.	Demonstrate maintenance procedures of main components of Coal thermal power plant using models, charts, visits, simulated and real videos	CO1
<p><i>LSO 3.1.</i> Explain the construction details of the given nozzle.</p> <p><i>LSO 3.2.</i> Maintain the given nozzle of the steam power plant.</p>	3.	Study the different type of steam nozzles.	CO1
<p><i>LSO 4.1.</i> Identify the given component(s) of High Pressure Boiler.</p> <p><i>LSO 4.2.</i> Explain the operation of the given High Pressure Boiler.</p>	4.	Demonstrate working of any two types of High Pressure Boilers using models, charts, visits, simulated and real videos.	CO1
<p><i>LSO 5.1.</i> Identify component(s) of the given Fluidized Bed Combustion Boiler.</p> <p><i>LSO 5.2.</i> Explain the operation of the given Fluidized Bed Combustion Boiler.</p>	5.	Demonstrate Fluidized Bed Combustion Boilers using models, charts, visits, simulated and real videos.	CO1
<p><i>LSO 6.1.</i> Identify component(s) of the given Electro Static Precipitator.</p> <p><i>LSO 6.2.</i> Explain the operation of the given Electro Static Precipitator.</p>	6.	Demonstrate the working of Electro Static Precipitators using model, charts, visits, simulated and real videos.	CO1
<p><i>LSO 7.1.</i> Identify the component(s) of the given Temperature and Feed Water Control systems.</p>	7.	Demonstrate the working of Temperature and Feed Water Control systems using model, charts, visits, simulated and real videos.	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 7.2.</i> Explain the operation of the given Temperature and Feed Water Control systems.			
<i>LSO 8.1.</i> Identify the given Temperature and Coal and Ash handling system. <i>LSO 8.2.</i> Explain the operation of the given Coal and Ash handling system.	8.	Identify and demonstrate working of Coal and Ash handling system.	CO1
<i>LSO 9.1.</i> Prepare the model diagram of natural draught system of the steam power plant. <i>LSO 9.2.</i> Explain the operation of the given Natural Draught system.	9.	Study of Natural Draught system.	CO1, CO2
<i>LSO 10.1.</i> Prepare the model, chart of the given water treatment plant. <i>LSO 10.2.</i> Explain the operation of the given Water treatment plant.	10.	Develop the working model of Water treatment plant.	CO1, CO2
<i>LSO 11.1.</i> Identify the given component(s) of cooling tower. <i>LSO 11.2.</i> Explain the operation of the given Cooling tower.	11.	Develop the working model of Cooling tower.	CO1, CO2
<i>LSO 12.1.</i> Identify the given component(s) used in Gas thermal power plant. <i>LSO 12.2.</i> Explain the operation of the given component(s) of Gas thermal power plant.	12.	Identify and demonstrate working of various components used in Gas thermal power plant using models, charts, visits, simulated and real videos	CO2
<i>LSO 13.1.</i> Maintain the given component(s) of Gas thermal power plant.	13.	Demonstrate maintenance procedures of main components of Gas thermal power plant using models, charts, visits, simulated and real videos	CO2
<i>LSO 14.1.</i> Maintain Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant	14.	Maintain Fuel nozzles, Liners, Spark plugs, Flex hoses, Check valves etc. component of Gas turbine power plant	CO2
<i>LSO 15.1.</i> Identify the given component(s) used in Nuclear power plant. <i>LSO 15.2.</i> Explain the operation of the given component(s) of Nuclear power plant.	15.	Identify and demonstrate working various components used in Nuclear power plant using models, charts, visits, simulated and real videos.	CO3
<i>LSO 16.1.</i> Identify the given component(s) used in Micro/Pico Hydro power plant. <i>LSO 16.2.</i> Explain the operation of the given components of Micro/Pico Hydro power plant.	16.	Identify and demonstrate working of various components used in Micro/Pico Hydro power plant using models, charts, visits, simulated and real videos.	CO4
<i>LSO 17.1.</i> Maintain the given component of Micro/Pico Hydro power plant.	17.	Demonstrate maintenance procedures of main components of Micro/Pico Hydro power plant using models, charts, visits, simulated and real videos	CO4
<i>LSO 18.1.</i> Identify the given component(s) used in Solar power plant. <i>LSO 18.2.</i> Explain the operation of the given component(s) of Solar power plant.	18.	Identify and demonstrate working of various components used in Solar power plant using models, charts, visits, simulated and real videos.	CO4
<i>LSO 19.1.</i> Maintain the given component(s) of Solar power plant.	19.	Demonstrate maintenance procedures of main components of Solar power plant using	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		models, charts, visits, simulated and real videos	
<p>LSO 20.1. Identify the various energy consuming elements in the given setup.</p> <p>LSO 20.2. Estimate the cost of electricity consumption.</p>	20.	Calculate cost of electricity consumption of any one Laboratory.	CO5

L) **Suggested Term Work and Self Learning: S2425603B** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. **Micro Projects:**

- Prepare/Download the specifications of followings:
 - i. Coal Thermal Power plant equipment.
 - ii. Gas turbine power plant equipment and elements.
 - iii. Nuclear power plant equipment and elements.
 - iv. Hydro power plant equipment and elements.
 - v. Solar power plant equipment and elements.
- Prepare/Download control system components in the followings:
 - i. Coal Thermal Power plant
 - ii. Gas turbine power plant equipment
 - iii. Nuclear power plant equipment
 - iv. Hydro power plant equipment
 - v. Solar power plant equipment
- Prepare/Download the safety practices and pollution control approaches in the followings:
 - i. Coal Thermal Power plant
 - ii. Gas turbine power plant equipment
 - iii. Nuclear power plant equipment
 - iv. Hydro power plant equipment
 - v. Solar power plant equipment
- Download the maintenance procedure of the main equipment of the followings:
 - i. Coal Thermal Power plant
 - ii. Gas turbine power plant equipment
 - iii. Nuclear power plant equipment
 - iv. Hydro power plant equipment
 - v. Solar power plant equipment
- Collect information/videos of control systems of power plant.
- Collect information/videos about cogeneration plant.
- Perform comparative study of various parameters of performance evaluation of a power plant.
- Measure operating parameters of Boiler using appropriate instruments.
- Collect information regarding preventive, predictive and breakdown maintenance of various power plants.
- Develop maintenance procedure for preventive and predictive maintenance of a typical Hydro Power Plant and its components.

J) Theory Session Outcomes (TSOs) and Units: T2425603C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the use of press tools and accessories.</p> <p><i>TSO 1b.</i> Select different types of press tool for the given situation with justification.</p> <p><i>TSO 1c.</i> Select suitable press tool in different operations for the given situation.</p> <p><i>TSO 1d.</i> Select relevant method for mounting punches and dies.</p>	<p>Unit-1.0 Press Tools</p> <p>1.1 Introduction to press tools.</p> <p>1.2 Recent development in press tools.</p> <p>1.3 press tools and accessories</p> <p>1.4 Types of presses and Specifications</p> <p>1.5 Cutting tools, bending tools, drawing tools, punching tools, blanking tools, notching tools, lancing tools, Embossing and Coining tools.</p> <p>1.6 Effect of clearances and Stages of cutting operation.</p> <p>1.7 Methods of mounting punches and dies.</p>	CO1
<p><i>TSO 2a.</i> Select suitable press working operation for given situation with justification.</p> <p><i>TSO 2b.</i> Explain clearances and its effect in punch and die operations.</p> <p><i>TSO 2c.</i> Calculate press tonnage for the given press tool component.</p> <p><i>TSO 2d.</i> Calculate blank size for the given simple part.</p> <p><i>TSO 2e.</i> Select the type of die for the given part with justification.</p> <p><i>TSO 2f.</i> Estimate the cost for developing a simple component by each operation</p> <p><i>TSO 2g.</i> Compare post processing operations on developed component</p>	<p>Unit-2.0 Press Working</p> <p>2.1 Press working operations - Cutting, bending drawing, punching, blanking, notching, lancing, Embossing and Coining.</p> <p>2.2 Punch and die clearances for blanking and piercing, effect of clearance.</p> <p>2.3 blanking and piercing tools, load variation during blanking-Calculation of press tonnage for blanking and piercing.</p> <p>2.4 Bending allowances, bending methods. Bending pressure-calculation of blank size and press tonnage for drawing metal flow during drawing operations.</p> <p>2.5 Die set components- punch and die shoe, guide pin, bolster plate, stripper, stock guide, feed stock, pilot.</p> <p>2.6 Types of dies, simple, compound, combination and progressive dies.</p>	CO2
<p><i>TSO 3a.</i> Differentiate between given jig and fixture.</p> <p><i>TSO 3b.</i> Select the suitable jigs for the given component with justification.</p> <p><i>TSO 3c.</i> Select the suitable fixtures for the given component with justification.</p> <p><i>TSO 3d.</i> Explain the principles of location and clamping with reference to the given work piece.</p> <p><i>TSO 3e.</i> Select different types of locators for the given situation.</p> <p><i>TSO 3f.</i> Select different types of clamping devices for the given situation.</p>	<p>Unit-3.0 Jigs and fixtures:</p> <p>3.1 Necessity for jigs and fixtures.</p> <p>3.2 Definitions and concept of Jig and fixture.</p> <p>3.3 Advantages of jigs and fixtures.</p> <p>3.4 Elements of jigs and fixtures</p> <p>3.5 Types of jigs: leaf jig, box & handle jig template jig, plate jig, indexing jig universal jig, vice jig- constructional details, working and application of above jigs.</p> <p>3.6 Types of fixtures: vice fixtures, milling fixtures, boring fixtures, grinding fixtures- constructional details, working and application of above fixtures.</p> <p>3.7 Basic principles of location: locating methods and devices,</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	3.8 Types of locators – pins and studs, V block, cup and cone location points, adjustable locating points, special adjustable stops, location from finished holes in the work, Diamond pin locator, Cam operated 'V' locator, Quick action 'V' locator, Six point location of a three legged object, Location of a cylinder on a v-block 3.9 Basic principles of the clamping: types of clamps-lever clamp, hinged clamp, two-way clamp, swinging clamp, wedge clamp, eccentric clamping arrangement, quick action clamp, Cam operated clamp, strap clamps quarter turn screw, Toggle clamp, Pneumatic and hydraulic clamps, Washers - 'C' washer, spherical and flat washer	
<i>TSO 4a.</i> Explain jig boring. <i>TSO 4b.</i> Select the type of jig boring for the given situation. <i>TSO 4c.</i> Explain construction and working of jig boring. <i>TSO 4d.</i> Explain system of location of holes.	Unit-4.0 Jig Boring: 4.1 Introduction to jig boring. 4.2 Jig boring on vertical milling machine 4.3 Types jig boring machines: Open front machine, Cross rail type machine - constructional details & their working. 4.4 System of location of holes.	CO3, CO4
<i>TSO 5a.</i> Explain the design procedure for the given Die and punch. <i>TSO 5b.</i> Explain the design procedure for given jig. <i>TSO 5c.</i> Explain the design procedure for given fixture	Unit-5.0 Design of Press tool, jigs and fixtures. 5.1 Design considerations and procedure for Die and punch. 5.2 Design of simple, compound and progressive dies. 5.3 Design considerations and procedure for following jigs- Template jig, plate jig, universal jig, leaf jig. 5.4 Design considerations and procedure for following fixtures-turning fixture, milling fixture, grinding fixture, boring fixture, welding fixture.	CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425603C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Use press tools. <i>LSO 1.2.</i> Prepare a list of parameters for comparison among qualities.	1.	Analyze the effect of different press tools process parameters on the different materials such as material required, power required, time, surface finish, etc.	CO1
<i>LSO 1.3.</i> Use the methods of mounting of die and punch. <i>LSO 1.4.</i> Select components for mounting die and punch.	2.	Remount different types of die and punch set already available in your workshop.	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.5.</i> Dismantle and assemble different press tools- Blanking die, piercing die and progressive die, compound die, V bending die, and drawing die	3.	Dismantle the components of the given press tools as per assembly drawing.	CO1
	4.	Assemble the components of the given press tools as per assembly drawing.	CO1
<i>LSO 2.1.</i> Perform suitable press tool operation relevant to job development.	5.	Develop following job using suitable press tool operation. <ul style="list-style-type: none"> • washer • ring. 	CO2
<i>LSO 2.2.</i> Surf web for downloading readymade list of products develop by die punch operation. <i>LSO 2.3.</i> Perform suitable die punch operation.	6.	Download three models of job available on web and then develop them by using suitable die and punch operation.	CO2
<i>LSO 2.4.</i> Choose the requirements of tools related to bending operation. <i>LSO 2.5.</i> Perform bending operation on the selected material w.r.t different parameters.	7.	Perform bending operation on two different material sheets and compare power requirement, time, surface finish etc.	CO2
<i>LSO 3.1.</i> Test the given fixtures	8.	Carry out load test on the given jigs & Fixtures.	CO3
	9.	Conduct the trial tests of fixture to ensure conformance to the standards	CO3
<i>LSO 3.2.</i> Measure the dimensions as per assembly drawing	10.	Measure the dimension of jigs and Fixture using measuring instrument like CMM or laser tracker	CO3
<i>LSO 3.3.</i> Analyze each and every jig and fixture in the workshop in context of function location and clamping facility	11.	Identify different jigs and fixtures available in workshop.	CO3
<i>LSO 3.4.</i> Use of available 3D scanner. <i>LSO 3.5.</i> Develop 3D digital model using scanning approach. <i>LSO 3.6.</i> Develop job using embossing process.	12.	Perform embossing operation on a suitable size of material available in your workshop.	CO3
<i>LSO 3.7.</i> Prepare list of press tool operation available workshop. <i>LSO 3.8.</i> Compare post processing operations on developed component	13.	Prepare a list of different press tools operations available in your workshop and estimate the cost for developing a simple component by each operation.	CO3
<i>LSO 3.9.</i> Identify the components of hydraulic press, surface and cylindrical grinder etc. available in work shop	14.	Identify and list different components of the given types of press and machines.	CO3
<i>LSO 4.1.</i> Identify and list different components of jig boring machines available in the work shop	15.	Identify and list different components of jig boring machines.	CO4
<i>LSO 4.2.</i> Identify tools & equipment's for the given job.	16.	Identify tools & equipment's as per desired specifications for drilling and tapping.	CO4
	17.	Set the job in four jaws chuck, truing.	CO4
<i>LSO 4.3.</i> Set the job and cutting tool and analyze its effect on metal cutting.	18.	Set the cutting tool on tool post, at centre height.	CO4
	19.	Compare the surface finishing of a job during following operations one using jigs and fixtures and other any clamping device Welding , Milling, Grinding, boring.	CO4
<i>LSO 4.4.</i> Select suitable jigs and fixtures for welding parameters.			

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 4.5. Measure the cutting force of the given machine tool	20.	Measure cutting force of lathe	CO4
	21.	Measure cutting force of milling	CO4
LSO 5.1. Design and develop (model) different types of Jigs and fixtures in the workshop	22.	Design and develop simple plate type drill jig as per the given design	CO5
	23.	Design and develop milling fixtures as per the given design	CO5
	24.	Design and develop model of Blanking (simple) die set components as per the given design	CO5
	25.	Design and develop of Piercing (simple) die set components as per the given design	CO5
	26.	Design and develop model of Progressive (simple) die set components as per the given design	CO5
	27.	Design and develop model of compound dies components as per the given design	CO5
	28.	Design and develop model of simple 'V' bending die components as per the given design	CO5
	29.	Develop model of Drawing die set components as per the given design	
LSO 5.2. Choose suitable material for punch die operation LSO 5.3. Choose suitable size to create a product. LSO 5.4. Produce washers in flexible sizes.	30.	Design a set of punch and die for the development of different sizes of washers.	CO5
LSO 5.5. Design and develop different types of Jigs as per the given specifications	31.	Design and develop a channel jig for the given mild steel components to drill the hole of 18mm. running fit	CO5
	32.	Design and develop leaf jig for drilling two holes of 10 mm diameter on the given work piece.	CO5
	33.	Design and develop indexing jig for the flange coupling to drill 4 holes of diameter 10mm on its pitch circle diameter	CO5

L) **Suggested Term Work and Self Learning: S2425603C** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Prepare a chart on safety precautions to be followed during working on press machine
- Describe fly and power press on the basis of -its parts, function of each part, operating procedure of presses, mounting procedure of die set on press machine, alignment technique between punch and die assembly.

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units: T2425603D**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Describe various laws governing fluid flow.</p> <p><i>TSO 1b.</i> Differentiate between aerostatic, hydrostatic, and hydrodynamic support</p> <p><i>TSO 1c.</i> Describe the cause of pressure drop and its effect</p> <p><i>TSO 1d.</i> Explain the properties of the given hydraulic oil.</p> <p><i>TSO 1e.</i> Select the hydraulic fluid for the given application based on the given criteria</p> <p><i>TSO 1f.</i> Describe the factors affecting hydraulic oil contamination</p> <p><i>TSO 1g.</i> Draw ISO symbols for the given hydraulic and pneumatic components</p> <p><i>TSO 1h.</i> Explain the safety procedure for the given industrial hydraulics and pneumatics systems.</p> <p><i>TSO 1i.</i> Identify the Hazards in using given hydraulic and pneumatic systems</p> <p><i>TSO 1j.</i> Describe the guiding rules for designing the given hydraulic and pneumatic system.</p> <p><i>TSO 1k.</i> Calculate the parameters of pneumatic and hydraulic systems</p>	<p>Unit-1.0 Introduction to Hydraulic and Pneumatic Systems</p> <p>1.1 Fluid power- history, concept and Definition, Fluid transport systems, Fluid power systems, merits and limitations</p> <p>1.2 Classification of Fluid Power Systems- Based on the control system and its type</p> <p>1.3 Concept of Hydrostatic and hydrodynamic</p> <p>1.4 Laws governing fluid flow- Pascal's law, Continuity equation, Bernoulli's theorem</p> <p>1.5 Flow through pipes-types, pressure drop in pipes.</p> <p>1.6 Hydraulic fluid - types ISO and SAE grades of oil and designations, properties, oil contamination and their advantages and limitations.</p> <p>1.7 General layout and ISO Symbols of hydraulic and pneumatic systems</p> <p>1.8 Hazard and safety in industrial hydraulics and pneumatics.</p>	<p>CO1</p>
<p><i>TSO 2a.</i> Compare given two types of pumps on the basis of the given criteria.</p> <p><i>TSO 2b.</i> Select relevant pump for the given application with justification.</p> <p><i>TSO 2c.</i> Compare the given actuators with respect to identified criteria.</p> <p><i>TSO 2d.</i> Assess the different factors that impact on actuator choice for a given application</p> <p><i>TSO 2e.</i> Describe with sketches the construction and working of the given actuators.</p> <p><i>TSO 2f.</i> Select the relevant actuators for the given application with justification.</p> <p><i>TSO 2g.</i> Identify the faults in the given pump and suggest the remedies</p> <p><i>TSO 2h.</i> Explain routine maintenance procedure of the pump and actuator</p> <p><i>TSO 2i.</i> Troubleshoot the given hydraulic system</p> <p><i>TSO 2j.</i> Calculate pump efficiency and Brake Horse Power (BHP) of the pump</p>	<p>Unit-2.0 Pumps and Actuators</p> <p>2.1 Classification of pumps.</p> <p>2.2 Construction and working of gear, vane, screw, lobe and piston pumps (axial and radial)</p> <p>2.3 Performance characteristics, specifications and selection criteria of pumps.</p> <p>2.4 Classification of hydraulic and pneumatic actuators.</p> <p>2.5 Construction and working of linear actuators – single acting and double acting cylinders, Cylinder –cushioning, stop tube</p> <p>2.6 Construction and working of rotary actuators (rotary Motors)-. Gear motors, Vane motors, Axial - in-line - swash plate piston motors</p> <p>2.7 Specifications and selection criteria of actuators</p> <p>2.8 Maintenance procedure for pumps and actuators</p>	<p>CO2</p>
<p><i>TSO.3a</i> Classify the given types of control valves with respect to identified criteria.</p>	<p>Unit-3.0 Control Valves and Sensors</p>	<p>CO3</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO.3b</i> Describe with sketches the construction and working of the given valves.</p> <p><i>TSO.3c</i> Describe the actuation method of the given valves for the given application.</p> <p><i>TSO.3d</i> Select relevant control valve for the given application with the justification.</p>	<p>3.1 Classification of control valves</p> <p>3.2 Construction and working of</p> <ol style="list-style-type: none"> i. pressure control valves-relief, unloading, sequence, counter balance, pressure reducing valves. ii. Direction control valves- check valves, 2/2, 3/2, 4/2, 4/3, 5/2, 5/3 D.C. Valves used in hydraulics and pneumatics. iii. Servo valves and Flow control valves – Non-compensated, Pressure and temperature compensated. <p>3.3 Standard centre positions, methods of actuation, Types of valve element</p> <p>3.4 Hydraulic and pneumatic sensors - Introduction, Unique features</p> <p>3.5 Types-Pressure and temperature monitoring sensors, hydraulic flow rate sensor, level sensor, Pneumatic Proximity Sensors, Back Pressure Sensor (Pilot tube), Reflex Sensor (Screen Nozzle) Air Barrier Sensor,</p>	
<p><i>TSO 4a.</i> Describe the function and working of the given compressor</p> <p><i>TSO 4b.</i> Select the relevant compressor for the given application with justification.</p> <p><i>TSO 4c.</i> Select the relevant accessories for the given type of hydraulic /pneumatic system with justification.</p> <p><i>TSO 4d.</i> Select appropriate hydraulic and pneumatic pipe for given application</p> <p><i>TSO 4e.</i> Use and maintain FRL unit in pneumatics</p> <p><i>TSO 4f.</i> Select hydraulic and pneumatic accessories with its location on hydraulic and pneumatic system.</p> <p><i>TSO 4g.</i> Calculate mechanical efficiency, volumetric efficiency and isothermal efficiency of the compressor.</p>	<p>Unit-4.0 Compressor, Components and Accessories</p> <p>4.1 Pneumatic Control System-Introduction, Air Preparation-Primary and Secondary Air Treatment</p> <p>4.2 Pneumatic Power Source- Compressor, Classification, Air Receiver and Control Methods</p> <p>4.3 Compressors-Types, construction, working principle of Reciprocating Type Air Compressor-Single and Multi-stage Piston Pump, Rotary compressors, PV Diagram and Work Done</p> <p>4.4 Construction, working principle of FRL unit, Dual (twin) pressure valve, shuttle valve, Quick exhaust valve, Time delay valve.</p> <p>4.5 Accessories: Oil reservoir, pipes, hoses, fittings, oil filters, air filters, seals and gaskets, intensifiers, accumulators, heat exchanger, muffler, Air Dryer</p> <p>4.6 Hydraulic pipes and pneumatics pipes -Types, standards, designation methods and specifications, pressure ratings, applications and selection criteria</p>	CO4
<p><i>TSO 5a.</i> Interpret given hydraulic and pneumatic circuit drawings.</p> <p><i>TSO 5b.</i> Explain with sketches the working of the given hydraulic and pneumatic circuit.</p> <p><i>TSO 5c.</i> Select the relevant components required to develop the given hydraulic and pneumatic circuit with justification.</p> <p><i>TSO 5d.</i> Analyze the given hydraulic and pneumatic circuits</p> <p><i>TSO 5e.</i> Select relevant components for the given hydraulic and pneumatic application</p> <p><i>TSO 5f.</i> Design hydraulic and pneumatic circuits</p> <p><i>TSO 5g.</i> for the given application</p>	<p>Unit-5.0 Hydraulic and Pneumatic Circuits</p> <p>5.1 Working and applications of basic Hydraulic Circuits, types - intensifier, regenerative, synchronizing, sequencing, speed components</p> <p>5.2 Design hydraulic circuits -single and double acting hydraulic cylinders, motors, circuit for speed control Meter-in, Meter-out, Bleed Off circuit</p> <p>5.3 Design hydraulic circuit for Regenerative, synchronizing counterbalance, Sequencing circuits, two pumps unloading</p>	CO5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 5h.</i> Describe the procedure for maintaining basic hydraulic circuit pneumatic circuits based on given system requirements.</p> <p><i>TSO 5i.</i> Identify the faults in the given hydraulic system and pneumatic system and remedial measures</p> <p><i>TSO 5j.</i> Troubleshoot the given hydraulic and pneumatic system</p> <p><i>TSO 5k.</i> Use hydraulic software and pneumatic software to develop circuits</p> <p><i>TSO 5l.</i> Simulate different components hydraulic and pneumatic systems</p>	<p>5.4 Design hydraulic circuits for Milling, Grinding and Shaper machine</p> <p>Pneumatic circuits</p> <p>5.5 Circuit diagram, components, working and applications. Analysis of Multiple Actuators</p> <p>5.6 Design pneumatic circuit by classic, cascade, step counter, karnaugh and combinational circuit design</p> <p>5.7 Design pneumatic circuits for- direct /indirect control of single and double acting air cylinders, motors, two step feed control, automatic cylinder reciprocation, time delay, sequencing circuits, Logic AND/OR circuits</p> <p>5.8 Design pneumatic circuits for Speed control of cylinders and motors.</p> <p>5.9 Analysis of Hydraulic and Pneumatic Circuits</p> <p>5.10 Use of simulation software for hydraulic and pneumatic circuits</p> <p>5.11 Selection of relevant components, fault detection, Remedies and Maintenance of hydraulic and pneumatic systems.</p>	
<p><i>TSO 6a.</i> Differentiate between Pneumatic servo system, Hydro-Pneumatics, Electro-Pneumatics, Electro-hydraulic systems</p> <p><i>TSO 6b.</i> Interpret given, Electro-hydraulic and Electro pneumatic circuit drawings.</p> <p><i>TSO 6c.</i> Describe the given Electro- pneumatic controls</p> <p><i>TSO 6d.</i> Select the relevant components required to develop the given Electro -hydraulic and electro-pneumatic circuit with justification.</p> <p><i>TSO 6e.</i> Analyze the given Electro-hydraulic and Electro pneumatic circuit</p> <p><i>TSO 6f.</i> Select relevant components for the given Electro-hydraulic and Electro pneumatic application</p> <p><i>TSO 6g.</i> Design Electro-hydraulic and Electro pneumatic circuit for the given application</p> <p><i>TSO 6h.</i> Use electro-hydraulic and electro-pneumatic software to simulate different Electro-hydraulic and Electro pneumatic systems</p>	<p>Unit-6.0 Electro Pneumatic System and Electro Hydraulic Systems</p> <p>6.1 Introduction to Pneumatic servo system, Hydro-Pneumatics, Electro-Pneumatics, Electro-hydraulic</p> <p>6.2 Applications, Advantages and Disadvantages of above systems.</p> <p>6.3 Electro -pneumatic controls, operation of electric actuated valves, Pneumatic electrical transducers, Electric converters, signal processors. Relays and protection relays. Connections of direct and indirect management.</p> <p>6.4 Logic circuits- Time Tracking Control, Checking workflows, Proportional pneumatics, Proportional switching</p> <p>6.5 Electrohydraulic control, electro Hydraulic cylinders, Control of pneumatic and hydraulic processes using a PLC controller</p> <p>6.6 Design of basic electro-pneumatic and electrohydraulic circuits.</p> <p>6.7 Application of hydraulic and Electro Hydraulic System - working principle, major elements of - Automotive hydraulic brake and power steering, Industrial Fork lift, Hydraulic jack, Hydraulic press, Rotary machining station</p> <p>6.8 Application of pneumatic and Electro pneumatic System- working principle, major elements of -Allocating device, sorting device, edge folding device, Foil welding, Feed rail separator, Input station for laser cutter, Drilling machine</p>	<p>CO6</p>

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425603D

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify components and draw ISO symbols of the components used in hydraulic and Pneumatics system	1.	Identify the components in the given hydraulic and pneumatic systems.	CO1
	2.	Identify and draw ISO symbols used in given hydraulic and Pneumatics components	CO1
LSO 1.2. Use Hydrostatics and properties of fluids apparatus	3.	Determine the effect of temperature and pressure on hydraulic oil performance	CO1
	4.	Determine the properties of the given hydraulic fluid	CO1
LSO 1.3. Use Bernoulli test rig	5.	Investigate the validity of the Bernoulli equation when it is applied to a steady flow of water through a tapered duct.	CO1
LSO 1.4. Use Flow losses in pipe apparatus	6.	Determine the Co-efficient of friction of flow through pipes of various sizes	CO1
	7.	Determine minor losses in flow through pipes	CO1
LSO 2.1. Use hydraulic bench / Centrifugal pump test rig	8.	Determine the various efficiencies of the given pump	CO2
	9.	Determine the efficiency of a given centrifugal pump and plot the following graphs. (i) I/P vs Discharge (ii) Total head vs Discharge (iii) Efficiency vs Discharge.	
	10.	Determine the operational characteristics of two centrifugal pumps when they are configured as a single pump, two pumps in series, and two pumps in parallel.	CO2
	11.	Determine the various performance of the single stage centrifugal pump for constant & variable speed.	CO2
	12.	Determine the various performance of the multi stage centrifugal pump for constant & variable speed.	CO2
	13.	Determine the various performance of the reciprocating pump for (1) Variable speed and constant head (2) Constant speed and variable head	CO2
	14.	Determine the efficiency of a given gear pump and plot the following graphs i) Percentage efficiency vs head ii) Percentage slip vs head iii) Discharge vs head iv) Output vs head	CO2
LSO 2.2. Use DC servo motor	15.	Determine speed-torque characteristic of D.C servomotor.	CO2
LSO 2.3. Use AC servo motor	16.	Determine speed torque characteristics of AC servo motor.	CO2
LSO 2.4. Use stepper motor	17.	Program the motor to operate in CCW and CW direction with user control speed	CO2
	18.	Identify of stepper motor terminals and control in wave step mode	CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.5. Use hydraulic and pneumatic trainer	19.	Design circuit to actuate double acting cylinder using pneumatic direction control valve	CO2
	20.	Control the direction and speed of cylinders.	CO2
LSO 3.1. Use Control Valve Characteristics Trainer	21.	Determine the flow coefficient Cv of the linear control valve	CO3
	22.	Determine the flow coefficient Cv of the quick open control valve	CO3
	23.	Calculate rangeability of linear control valve	CO3
	24.	Calculate rangeability of quick open control valve.	CO3
LSO 3.2. Use hydraulic and pneumatic trainer	25.	Design a circuit using direction control valve and pressure control valve for clamping device for jigs and fixture	CO3
LSO 3.3. Use Pressure Process Control Training System	26.	Determine the performance of ON-OFF/P/PI/PD/PID controllers on pressure process.	CO3
LSO 3.4. Use Level Control Trainer.	27.	Determine the performance of ON – OFF/P/PI/PD/PID controllers on level process	CO3
LSO 3.5. Use Flow Control Trainer	28.	Determine the performance of ON – OFF/P/PI/PD/PID controllers on flow process	CO3
LSO 3.6. Use temperature Control Trainer.	29.	Determine the performance of ON-OFF/P/PI/PD/PID controllers on temperature process.	CO3
LSO 4.1. Use compressor test rig	30.	Determine Performance of a two stage Reciprocating Air Compressor	CO4
	31.	Determine performance of a two-stage single acting reciprocating air compressor.	CO4
	32.	Determine volumetric efficiency and isothermal efficiency of two stage single acting reciprocating air compressor	CO4
	33.	Determine various performance of the given compressor	CO4
LSO 4.2. Use hydraulic ram test rig	34.	Determine the working characteristics of hydraulic ram at constant valve lift and constant supply head and plot the following curves. <ul style="list-style-type: none"> • Pumped water v/s Delivery head • waste water v/s Delivery head • D' aubussion efficiency v/s Delivery head • Rankines's efficiency v/s Delivery head • Number of heats/sec v/s Delivery head 	CO4
LSO 5.1. Use hydraulic trainer with simulation software	35.	Design, assemble and operate hydraulic circuit to actuate and control SAC and DAC	CO5
	36.	Design, assemble and operate Meter-in, Meter out hydraulic circuit.	CO5
	37.	Design, assemble and operate any suitable sequencing hydraulic circuit	CO5
	38.	Design the hydraulic system circuit based on given input and parameters using hydraulic simulation software.	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
	39.	Design, assemble and operate Regenerative Circuit	CO5
	40.	Design, assemble and operate hydraulic circuit using accumulator	CO5
	41.	Develop Automatic cylinder reciprocation circuit using hydraulic trainer.	CO5
LSO 5.2. Use pneumatic trainer with simulation software	42.	Design, assemble and operate Pneumatic circuits to actuate and control SAC, DAC, Air motor	CO5
	43.	Design, assemble and operate Pneumatic circuits for controlling speed	CO5
	44.	Design, assemble and operate indirect/pilot control Pneumatic circuit	CO5
	45.	Develop any suitable sequencing Pneumatic circuit.	CO5
	46.	Design, assemble and operate Pneumatic circuits for Logic functions (AND/OR/Time delay)	CO5
	47.	Develop Automatic cylinder reciprocation circuit using pneumatic trainer	CO5
LSO 6.1. Use electro pneumatic trainer	48.	Design, assemble and operate Electro Pneumatic circuits to actuate and control SAC, DAC, Air motor	CO6
	49.	Design, assemble and operate Electro Pneumatic circuits for the given application	CO6
LSO 6.2. Use electro hydraulic trainer	50.	Design, assemble and operate Electro Hydraulic circuits to actuate and control SAC, DAC, Air motor	CO6
	51.	Design, assemble and operate Electro Hydraulic circuits for the given application	CO6

L) **Suggested Term Work and Self Learning: S2425603D** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Produce a presentation analyzing fluid viscosity using Stokes' Law and validate how this relates to Navier–Stokes equations
- Stating any assumptions, compare the applications of practical hydraulic and pneumatic systems
- Prepare report of agriculture equipment's working on hydraulics and pneumatics.
- Prepare report on working of hydraulic jack and its system.
- Analyze the methods in fluid power principles and working of hydraulic pumps

b. **Micro Projects:**

- Prepare working model of hydraulic crane using waste injections used by doctors.
- Develop working model of automation of bench vice used in carpentry/fitting shop.
- Market survey of oil used in hydraulic system (Manufacturers, specification, trade names, cost, packing size)
- Design of hydraulic / pneumatic system and related components for any industrial application

Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2425603E

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain renewable and non-renewable energy sources.</p> <p><i>TSO 1b.</i> Compare renewable and non-renewable energy sources</p> <p><i>TSO 1c.</i> Explain primary and secondary energy sources.</p> <p><i>TSO 1d.</i> Explain Hybrid energy systems, Distributed energy systems and dispersed generation (DG)</p> <p><i>TSO 1e.</i> Identify different issues, prospects and need of renewable and alternate energy sources.</p>	<p>Unit-1.0 Introduction to Energy Sources</p> <p>1.1 Major sources of energy: Renewable and Non-renewable and comparison.</p> <p>1.2 Primary and secondary energy sources.</p> <p>1.3 Energy Scenario: - Prospects and Need of renewable and alternate energy sources.</p> <p>1.4 Hybrid energy systems, Distributed energy systems and dispersed generation (DG).</p> <p>1.5 Prospects and Achievements of renewable energy sources in India in general and Bihar state in particular.</p> <p>1.6 Issues related to power generation through renewable energy sources.</p>	<p>CO1</p>
<p><i>TSO 2a.</i> Explain Beam and diffuse radiation.</p> <p><i>TSO 2b.</i> Explain the given earth sun angle(s).</p> <p><i>TSO 2c.</i> Enumerate the uses of the given Solar energy collector.</p> <p><i>TSO 2d.</i> Describe the construction and working of the given Solar energy device(s).</p> <p><i>TSO 2e.</i> Explain the utility of low cost solar cooker as alternative cooking appliances in villages.</p> <p><i>TSO 2f.</i> Select photo-voltaic cells for domestic lightning in houses.</p>	<p>Unit-2.0 Solar Energy</p> <p>2.1 Solar radiation: Beam and diffuse radiation, Solar constant, Solar Radiations at earth's surface Solar Radiation Geometry: Declination, hour angle, altitude angle, incident angle, zenith angle, solar azimuth angle attenuation and measurement of Solar radiation, local Solar time, derived Solar angles.</p> <p>2.2 Flat plate collectors, concentrating collectors, elements and working</p> <p>2.3 Solar air heaters-types, Solar driers, elements and working.</p> <p>2.4 Storage of Solar energy-thermal storage, Electrical storage, Chemical storage.</p> <p>2.5 Solar water heaters, Solar distillation, Solar still, Solar cooker, elements and working.</p> <p>2.6 Photovoltaic - Solar cells & its applications, Solar panels, Solar PV pump, Solar Home lighting systems, Solar street lights, elements and working. (no derivations and numerical)</p>	<p>CO2</p>
<p><i>TSO 3a.</i> Describe the principle of conversion of wind energy.</p> <p><i>TSO 3b.</i> State advantages and limitations of wind energy.</p> <p><i>TSO 3c.</i> Determine wind power, power coefficient and maximum power.</p> <p><i>TSO 3d.</i> Select sites for the given wind mill.</p> <p><i>TSO 3e.</i> Explain construction and working of the given horizontal and vertical axis wind mills</p> <p><i>TSO 3f.</i> Compare horizontal and vertical wind mills.</p>	<p>Unit-3.0 Wind Energy</p> <p>3.1 Basic Principle of wind energy conversion.</p> <p>3.2 Power in wind, Available wind power formulation, Power coefficient, Maximum power</p> <p>3.3 Main considerations in selecting a site for wind mills.</p> <p>3.4 Advantages and limitations of wind energy conversion.</p> <p>3.5 Classification of wind mills</p> <p>3.6 Construction and working of horizontal and vertical axis wind mills, their comparison</p>	<p>CO3</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3g. Use wind energy for power generation and pumping in the given situation.	3.7 Main applications of wind energy for power generation and pumping.	
<p>TSO 4a. Identify common species recommended for biomass.</p> <p>TSO 4b. Describe the methods for obtaining energy from the given biomass.</p> <p>TSO 4c. Classify biomass- gasified, fixed bed and fluidized.</p> <p>TSO 4d. Explain the constructional details of Bio gas conversion plant.</p> <p>TSO 4e. Explain the application of Gasifier.</p> <p>TSO 4f. Explain the production and application of biodiesel.</p> <p>TSO 4g. Use agricultural waste as a biomass.</p> <p>TSO 4h. Explain biomass digester.</p> <p>TSO 4i. Compare biomass with conventional fuels.</p> <p>TSO 4j. Describe the maintenance procedure of Biogas plants and components.</p> <p>TSO 4k. Explain procedure to extract energy/fuel/gases from various waste like Tire, Rubber, Plastic, Mixed Solid Municipal waste.</p> <p>TSO 4l. Explore other alternate energy sources like flowing drain water, mass mobility of human and vehicles at Railway stations, Malls, Highways by modifying speed breakers, steps, stairs etc.</p>	<p>Unit-4.0 Energy from Biomass</p> <p>Energy from Biomass</p> <p>4.1 Common species recommended for biomass.</p> <p>4.2 Methods for obtaining energy from biomass</p> <p>4.3 Thermal classification of biomass a) Gasified, b) Fixed bed and fluidized</p> <p>4.4 Comparison of Biomass with conventional fuels</p> <p>4.5 Constructional details, site selection, filling a digester for starting, maintaining Biogas production, Fuel properties of Bio gas, and applications of Biogas.</p> <p>4.6 Maintenance of Biogas plants.</p> <p>4.7 Application of gasifier</p> <p>4.8 Biodiesel production and application</p> <p>4.9 Agriculture waste as a biomass</p> <p>4.10 Biomass digester</p> <p>Energy from wastes:</p> <p>4.11 Recycling of plastic and Tire/Rubber waste to produce fuel.</p> <p>4.12 Recycling of Mixed Solid Municipal waste to produce energy/Synthetic gases.</p> <p>4.13 Recycling of used Vegetable oil.</p> <p>4.14 Energy from flowing drain water, Energy from mass mobility of human and vehicles at Railway stations, Malls, Highways by modifying speed breakers, steps, stairs etc.</p>	CO4
<p>TSO 5a. Identify environmental implications of geothermal energy</p> <p>TSO 5b. Describe working of Geothermal plant.</p> <p>TSO 5c. Describe the given Ocean Thermal Electric Conversion (OTEC) systems</p> <p>TSO 5d. Explain construction and working of a tidal energy plant.</p>	<p>Unit-5.0 Geothermal Energy, Energy from Oceans</p> <p>5.1 Introduction, geothermal sources, classification, compressed resources, exploration, environmental implications, applications, advantages and disadvantages.</p> <p>5.2 Geothermal plant.</p> <p>5.3 Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle.</p> <p>5.4 Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation.</p>	CO5
<p>TSO 6a. Classify the types of fuel cells.</p> <p>TSO 6b. List applications of fuel cells.</p> <p>TSO 6c. State advantages and limitations of fuel cells.</p> <p>TSO 6d. Explain the working principle of the given Fuel cell.</p> <p>TSO 6e. Explain production, storage and transportation of hydrogen energy.</p> <p>TSO 6f. Explain the safety measures in hydrogen energy utilization.</p> <p>TSO 6g. Compare hydrogen energy with other automobile fuels.</p> <p>TSO 6h. Describe the utility of hydrogen powered vehicle.</p>	<p>Unit-6.0 Fuel Cells and Hydrogen Energy</p> <p>6.1 Fuel Cells- Introduction, Classification :-proton exchange membrane fuel cells (PEMFCs), solid oxide fuel cells (SOFCs), and alkaline fuel cells, Principles, performance, application, advantages and limitations.</p> <p>6.2 Hydrogen Energy - Introduction, production, storage, transportation, safety, utilization of hydrogen gas, comparison with other automobile fuels.</p>	CO6

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425603E

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Identify the given component(s) used in Flat Plate Solar Collector.</p> <p><i>LSO 1.2.</i> Explain the operation of the given component(s) of Flat Plate Solar Collector.</p>	1.	Identify and demonstrate working of various components used in Flat Plate Solar Collector using test rig, models, charts, visits, simulated and real videos.	CO2
<p><i>LSO 2.1.</i> Identify the given component(s) used in Solar air heaters and Solar driers.</p> <p><i>LSO 2.2.</i> Explain the operation of the given component(s) of Solar air heaters and Solar driers.</p>	2.	Identify and demonstrate working of various components used in Solar air heaters and Solar driers using test rig, models, charts, visits, simulated and real videos.	CO2
<p><i>LSO 3.1.</i> Identify chemicals that have capability to store heat energy.</p> <p><i>LSO 3.2.</i> Explain the chemical storage method user for solar energy.</p>	3.	Prepare a desk top model for storing heat energy using chemical storage. Measure the quantity of heat stored and duration.	CO2
<p><i>LSO 4.1.</i> Correlate the effect of input parameters on the performance parameters of the given Flat Plate solar collector.</p> <p><i>LSO 4.2.</i> Estimate the conversion efficiency of the given Flat Plate solar collector.</p>	4.	Measure the heat radiations received and heat collected in the given Flat Plate solar collector.	CO2
<p><i>LSO 4.3.</i> Correlate the effect of input parameters on the performance parameters of the given Concentrating Parabolic trough solar collector.</p> <p><i>LSO 5.1.</i> Estimate the conversion efficiency of the given Concentrating Parabolic trough solar collector</p> <p><i>LSO 5.2.</i> Compare the performance of the given Concentrating Parabolic trough solar collector with the flat plate collector.</p>	5.	Measure the heat radiations received and heat collected using a Concentrating Parabolic trough solar collector with varying tracking angles. Compare its performance with the flat plate collector.	CO2
<p><i>LSO 6.1.</i> Identify the component(s) of the given Solar energy device.</p> <p><i>LSO 6.2.</i> Explain the operation of the given Solar energy device.</p> <p><i>LSO 6.3.</i> Correlate the effect of input parameters on the performance parameters of the given Solar energy device.</p>	6.	Estimate the performance parameters in any one: Solar water heaters/Solar distillation/Solar still/Solar cooker.	CO2
<p><i>LSO 6.4.</i> Identify the component(s) of the given Solar energy device.</p> <p><i>LSO 6.5.</i> Explain the operation of the given Solar-Electro energy device.</p> <p><i>LSO 6.6.</i> Correlate the effect of input parameters on the performance parameters of the given Solar-Electro energy device.</p>	7.	Estimate the performance parameters in any one: Photovoltaic Solar panels, Solar PV pump, Solar Home lighting systems, Solar street lights.	CO2
<p><i>LSO 8.1.</i> Identify the given component(s) of Solar appliances like drier, cooker, lantern etc.</p>	8.	Estimate the performance parameters in any one: Solar appliances like drier, cooker, lantern etc.	CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 8.2.</i> Explain the operation of the given Solar appliances like drier, cooker, lantern etc.</p> <p><i>LSO 8.3.</i> Correlate the effect of input parameters on the performance parameters of the given Solar appliances like drier, cooker, lantern etc.</p>			
<p><i>LSO 9.1.</i> Identify the components of a wind power generation system.</p> <p><i>LSO 9.2.</i> Explain the operation of the given wind power generation system.</p> <p><i>LSO 9.3.</i> Draw the characteristic curves of the given generator: Three-phase voltage depending on the speed of rotation.; Continuous voltage depending on the speed of rotation; Torque based on the generated current; Three-phase active power depending on the speed of rotation; Power in direct current as a function of the speed of rotation.</p> <p><i>LSO 9.4.</i> Calculate constant of torque / current and voltage / speed of rotation of the given generator.</p>	9.	Study the operation of portable wind power generation system. Draw the characteristic curves of the generator and calculate constant of torque / current and voltage / speed of rotation of the generator.	CO3
<p><i>LSO 10.1.</i> Identify the given component(s) of the rectifier.</p> <p><i>LSO 10.2.</i> Explain the operation of the given rectifier.</p> <p><i>LSO 10.3.</i> Correlate the effect of input parameters on the performance parameters of the rectifier.</p>	10.	Evaluate performance of the rectifier and determine optimum operating points against variable atmospheric conditions	CO3
<p><i>LSO 11.1.</i> Identify the given component(s) used in portable Biogas plant.</p> <p><i>LSO 11.2.</i> Explain the operation of the given component(s) of portable Biogas plant.</p> <p><i>LSO 11.3.</i> Correlate the effect of input parameters on the performance parameters.</p>	11.	Evaluate performance parameters of a portable Biogas plant with different mix of solid municipal waste.	CO4
<p><i>LSO 12.1.</i> Identify the given component(s) used in Geothermal plant.</p> <p><i>LSO 12.2.</i> Explain the operation of the given component(s) of Geothermal plant.</p>	12.	Identify and demonstrate working of various components used in Geothermal plant using models, charts, visits, simulated and real videos.	CO5
<p><i>LSO 13.1.</i> Identify the given component(s) used in Ocean Thermal Electric Conversion (OTEC) systems.</p> <p><i>LSO 13.2.</i> Explain the operation of the given component(s) of Ocean Thermal Electric Conversion (OTEC) systems.</p>	13.	Identify and demonstrate working of various components used in Ocean Thermal Electric Conversion (OTEC) systems using models, charts, visits, simulated and real videos.	CO5
<p><i>LSO 14.1.</i> Identify the given component(s) used in Single basin and Double basin tidal power plants.</p>	14.	Identify and demonstrate working of various components used in Single basin and Double basin tidal power plants using models, charts, visits, simulated and real videos.	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 14.2.</i> Explain the operation of the given component(s) of Single basin and Double basin tidal power plants.			
<i>LSO 15.1.</i> Identify the given component(s) used in Proton exchange membrane fuel cells (PEMFCs), Solid oxide fuel cells (SOFCs), and alkaline fuel cells. <i>LSO 15.2.</i> Explain the operation of the given component(s) of Proton exchange membrane fuel cells (PEMFCs), Solid oxide fuel cells (SOFCs), and alkaline fuel cells.	15.	Identify and demonstrate working of various components used in Proton exchange membrane fuel cells (PEMFCs), Solid oxide fuel cells (SOFCs), and alkaline fuel cells using models, charts, visits, simulated and real videos.	CO6

*A judicious mix of minimum 14 or more practical need to be performed, out of which, the practical marked as '**' are compulsory.

L) **Suggested Term Work and Self Learning: S2425603E** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- i. Quantify the harmful effects of pollutants from conventional energy sources.
- ii. Briefly introduce the importance of energy sources in our daily lives and their impact on the environment.
- iii. Create a table or chart comparing the energy sources you've discussed in terms of their environmental impact, efficiency, and availability.
- iv. Prepare a chart of cumulative achievements of renewable energy sources in India.
- v. Determine the collector efficiency of Solar flat plate collector.
- vi. Identify the basic components of Solar water heater.
- vii. Determine the collector efficiency of concentrating type flat plate collector.
- viii. Identify of basic components of photo voltaic cell.
- ix. Identify of basic components of Solar cooker.
- x. Prepare a demonstration model of Wind energy conversion system
- xi. Compare horizontal and vertical Wind mill.
- xii. Explore the potential sites for Wind mill installation in India.
- xiii. Identify the various components of Bio gas plant model.
- xiv. Identify the different Bio gas digesters.
- xv. List the Performance characteristics of Bio gas plant.
- xvi. Slurry treatment parameters for efficient utilization of Bio gas fuels.
- xvii. Identify the different parts of geothermal plant.
- xviii. Justify the use of geothermal plant as a renewable source of energy.
- xix. List the site selection criterion of geothermal plant.
- xx. Identify the different parts of fuel cell.
- xxi. Analyze the working of hydrogen powered vehicle.
- xxii. Describe the chemical reactions in H₂ – O₂ fuel cell.
- xxiii. Enlist the practical fields where hydrogen is used as a fuel.
- xxiv. Select one specific region or country and investigate its energy mix. Discuss the primary energy sources used, the reasons for their selection.
- xxv. Identify and describe at least three different types of fuel cells. Discuss how each type works and their specific applications.
- xxvi. Describe real-world applications of fuel cells in various sectors, such as transportation, stationary power generation, and portable devices.
- xxvii. Describe the practical applications of geothermal energy.
- xxviii. Create a table or chart comparing the geothermal energy sources in terms of their production country wise.

J) Theory Session Outcomes (TSOs) and Units: T2400604B

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
TSO 1a. Describe the basic terminology of Machine learning TSO 1b. Explain the concept of dataset and ways to handle them TSO 1c. illustrate the process of dataset division TSO 1d. Explain process involved in machine learning	Unit – 1.0: Introduction to machine learning Concept of Machine Learning, Define Learning, Learn the Network, Evaluate the Network, datasets and ways to handle them, Feature sets, Dataset division: test, train and validation sets, cross validation. Applications of Machine Learning, processes involved in Machine Learning	CO-1
TSO 2a. Identify the category or class of a particular dataset using KNN algorithm TSO 2b. Use Linear regression for predictive analysis TSO 2c. Predict the categorical dependent variable using Logistic Regression TSO 2d. Use SVM for classification problems in Machine Learning TSO 2e. determine the performance of the classification models TSO 2f. evaluate the performance of the classification model using ROC-curve TSO 2g Explain characteristics of Unsupervised learning. TSO 2h. Explain different clustering methods TSO 2i. Implement K-means clustering algorithm to group the unlabeled dataset	Unit 2.0: Supervised and unsupervised learning Supervised learning: Introduction to Supervised Learning, K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: confusion matrix, precision, precision and recall, ROC-Curve (Receiver Operating Characteristic curve) Unsupervised learning: Introduction to Unsupervised Learning, Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering. Expectation-Maximization (EM) Algorithm	CO-2
TSO 3a. Explain Structure and working of Biological Neural Network. TSO 3b. differentiate between Artificial Neural Network and Biological Neural Network TSO 3c. State key historical points in development of ANN TSO 3d. Explain the architecture of an artificial neural network	Unit 3.0: Introduction to neural networks Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.	CO-3
TSO 4a. Use neuron McCulloch – Pitts model in designing logical operations TSO 4b. Apply Rosenblatt's Perceptron to solve linear classification problems TSO 4c. Implement Adaptive Linear Neuron (Adaline) training algorithm in neural network TSO 4d. Use Backpropagation neural training algorithm TSO 4e. Use ART (Adaptive Resonance Theory) learning model TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network	Unit 4.0: Neural networks models and Learning Methods Models of neuron McCulloch – Pitts model, Rosenblatt's Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, Adaptive Resonance Theory (ART), Associative memories, BAM.	CO-4
TSO 5a. Illustrate the features of Tens or flow TSO 5b. Manipulate tensors TSO 5c. Explain features of Tens or Board	Unit-5.0 Tensor flow features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension	CO-5

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
visualization TSO 5d Explain the concept and features of Tens or flow playground	and two-dimension tensor, Tensor handling and manipulations, Tensor board visualization- symbols Tensors, Variables, Automatic differentiation, Graphs and tf.function, modules layers and models, training loops, features of Tens or flow playground- data ,the ration of train and test data, features, hidden layers, Epoch, learning rate, activation function, regularization, problem type	

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604B

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	CO-2
LSO 3.1 Perform clustering operations using k-means algorithm	3	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2
LSO 4.1 Perform clustering operations using EM algorithm	4	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1 Build artificial neural network LSO 5.2 Test artificial neural network	5	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4
LSO 6.1 Detect features or business intelligence in the input data using perceptron	6	Implement the perceptron algorithm from scratch in python.	CO-4
LSO 7.1 Use Tensors for given problems	7	Write a programme to implement two dimension and three-dimension Tensor.	CO5
LSO 8.1 Use basic features for tensor handling and manipulations	8	Write a programme to add and multiply two 4x4 matrix, you can Import "tens or flow" and "numpy".	CO5
LSO 9.1 Test artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries.	9	Solve a classification problem on the Tens or flow playground. Hint: refer https://www.educba.com/tensorflow-playground/	CO5
LSO 10.1 Implement artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries LSO 10.2 perform predictive analysis using linear regression	10	Implement algorithm for linear regression in tens or flow	CO5, CO2

L) **Suggested Term Work and Self Learning: S2400604B** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in linewith the targeted COs.

b. **Micro Projects:**

Use python programming for the solutions of Microproject problems

1. (a) Create a Bar plot to get the frequency of the three species of the Iris data.
(b) Create a Pie plot to get the frequency of the three species of the Iris data.
(c) Write a Python program to create a graph to find relationship between the sepal length and width.
2. (a) Write a Python program to split the iris dataset into its attributes (X) and labels (y). The X variable contains the first four columns (i.e. attributes) and y contains the labels of the dataset.
(b) Write a Python program using Scikit-learn to split the iris dataset into 70% train data and 30% test data. Out of total 150 records, the training set will contain 120 records and the test set contains 30 of those records. Print both datasets.
3. Conduct performance analysis of Classification Algorithms (any 2) on a specific dataset.

J) Theory Session Outcomes (TSOs) and Units: T2400604C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.1. a. Write the steps to install Python.</p> <p>TSO.1. b. Explain given types of variables in python.</p> <p>TSO.1. c. Explain use and importance of Tuple, Dictionary, operators in python</p> <p>TSO.1. d. Explain use of array in python.</p> <p>TSO.1. e. Explain use of 2-Dimensional Array in python</p> <p>TSO.1. f Explain uses of given type of Conditional statement in python.</p>	<p>Unit-1.0 Python Basics: - Installation of Python Variables, Print () function, Escape character sequence and run python Program Python Tuple, Dictionary, operators Python arrays, create, reverse and append data into it. Python 2 Dimensional arrays. Python Conditional statement.</p>	CO-1 and CO-5
<p>TSO.2. a. Explain uses of given type of do & while loops in python</p> <p>TSO.2. b. Explain working of break, continue and pass statement in python</p> <p>TSO.2. c. Write the benefits of using OOP methodology in python.</p> <p>TSO.2. d. Explain given type of string operation related to python.</p> <p>TSO.2. e. Explain given function in python</p> <p>TSO.2. f Explain use of Lambda function in python.</p>	<p>Unit 2.0 Python Advance: - 2.1 Python Do & while loops 2.2 Python break, continue, pass statements 2.3 Python OOPs Class, Object, Inheritance and Constructor 2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length 2.5 Python Functions, Built-in functions and user defined functions 2.6 Lambda function and uses</p>	CO-1 and CO5
<p>TSO.3. a. Differentiate between Cloud and IoT cloud.</p> <p>TSO.3. b. Explain features of Cloud in IoT environment</p> <p>TSO.3. c. List features of various types of Cloud</p> <p>TSO.3. d. List features of cloud services like SaaS, PaaS and IaaS</p> <p>TSO.3. f List advantages of cloud data storage.</p> <p>TSO.3. g Explain Arduino architecture and its applications.</p> <p>TSO.3.h Explain Raspberry pi architecture and its applications.</p>	<p>Unit-3.0 Cloud Features: - Cloud computing and IoT cloud Benefits of cloud in IoT Types of Cloud public, private and hybrid Cloud services like SaaS, PaaS and IaaS Cloud connectivity and Data storage on Cloud. Arduino: Architecture, Programming, and Applications Raspberry Pi Architecture, Programming, and Application basic level for IoT applications</p>	CO-1, CO-2 and CO-5
<p>TSO.4. a. Explain wired network</p> <p>TSO.4. b. Explain short range wireless network</p> <p>TSO.4. c. Explain M2M communication</p> <p>TSO.4. d. Explain various generation of wireless network</p> <p>TSO.4. e. Explain the importance of LWPAN in IoT</p> <p>TSO.4. f Differentiate between SigFox & LoRaWAN</p> <p>TSO.4. g Explain use of NB-IOT (Narrow Band IOT)</p> <p>TSO.4.h Create heterogenous network using RFID.</p>	<p>Unit.4.0 IoT Networking and Application: - 4.1 Wired and short-range wireless network 4.2 M2M – 2G, 3G, 4G & 5G networks 4.3 LPWAN – Low Power Wide Area Networks 4.4 SigFox & LoRaWAN. 4.5 NB-IOT (Narrow Band IOT) 4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors- Cables- Readers- encoder/ printers for smart labels- Controllers software 4.7 RFID advantages over Bar codes.</p>	CO-1 and CO-4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5. a. Identify suitable framework for IoT app development TSO.5. b. Identify various stages of selected app TSO.5. c. Develop the app. TSO.5. d. Implement and deploy the app TSO.5. e. Maintain and improve the app based on the feedback	Unit. 5.0 IoT App Development: - Framework selection for IoT app development Identify stages of app to be developed. Develop, Implement, and Deploy the App Testing and Integration Maintain and improve	CO-4 and CO-5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Python installation LSO 1.2 Prepare and run python program on given problem LSO 1.3 Prepare python program on Dictionary, Tuple and operators. LSO 1.4 Prepare program on arrays LSO 1.5 Prepare a program on 2-dimensional array LSO 1.6 Create program on conditional statement	1.	Install given version of Python on the computer system. Prepare a python program using print() function and run it. Access given value from the tuple Print the given value of key from the dict. Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array. Write a python program to check whether person is eligible for voting or not. (accept age from the user) Write a python program to check whether the entered number is even or odd. Write a python program to check whether entered number is divisible by another entered number. Write a python program to display "Yes" is entered number is divisible by 5 otherwise display "No"	CO-1
LSO 2.1 Prepare python program on Do & while loops LSO 2.2 Prepare python program on break and continue statement. LSO 2.3 Prepare Python program using break and continue statements LSO 2.4 prepare python program using OOP LSO 2.5 Prepare Python program using functions	2.	Prepare a python program which can print first 10 even and odd numbers using while statement Write a python program which can print first 10 integers and its square using while/for loop. Write a python program which can print sum of first 10 natural numbers using while/for loop. Write a python program which can identify the prime number between the range given using while/for loop. Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		<p>Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use.</p> <p>Create a Class with instance attributes</p> <p>Create a Vehicle class without any variables and methods</p> <p>Write a Python function to find the Max of three numbers.</p> <p>Write a Python program to reverse a string.</p>	
<p>Signup for free cloud storage</p> <p>Store data into cloud and retrieve it.</p>	3.	<p>Create a free cloud account</p> <p>Store data on cloud and retrieve it</p>	CO-3
<p>LSO 4.1 Design various types of network cables</p> <p>LSO 4.2 Connect computer in LAN.</p> <p>LSO 4.3 Connect devices using wireless network</p> <p>LSO 4.4 Connect machine with machine</p> <p>LSO 4.5 Connect devices using IEEE 802</p> <p>LSO 4.6 Connect devices using LPWAN</p> <p>LSO 4.7 Connect devices using RFID</p>	4	<p>4.1 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.</p> <p>4.2 Connect the computers in Local Area Network</p> <p>4.3 Connect 2 or more devices using Bluetooth</p> <p>4.4 Connect 2 or more devices using infrared</p> <p>4.5 Connect 2 more machine using m2m</p> <p>4.6 Connect 2 or more different devices using access point</p> <p>4.7 Connect 2 devices using LPWAN (Smart Meter)</p> <p>4.8 Connect 2 or more devices using RFID</p>	CO-4
<p>LSO 5.1 Develop a IoT app</p> <p>LSO 5.2 Develop IoT applications using smartphones.</p>	5.	<p>5.1 Identify a problem and develop an app</p> <p>5.2 Building a temperature monitoring system using sensors and Smartphone</p>	CO-5

L) **Suggested Term Work and Self Learning: S2400604C** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

Micro Projects:

- Prepare a report on Python programming language.
- Develop a small software in python to solve a IoT data analysis.
- Create a id on free cloud storage and share data on it for others.
- Create a heterogenous network and connect different dives.
- Create a an IoT app for the identified problem

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units: T2400604D**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	Unit-1.0 Engineering mechanics for Drone Technology 1.1 Drone Mechanics <ul style="list-style-type: none"> Free body diagram of drone Method of finding resultant of force system Equilibrium of coplanar force system 1.2 Center of Gravity <ul style="list-style-type: none"> Centroid of plane figure Center of gravity of solid bodies 1.3 Force analysis in drone <ul style="list-style-type: none"> Force analysis in drone Forces of flight Principle axes and rotation of aerial systems 1.4 Dynamics of machine <ul style="list-style-type: none"> Static and dynamic force analysis Gyroscopic motions 	CO-1
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	Unit-2.0 Drone Frame and Components 2.1 Drone frame design <ul style="list-style-type: none"> Calculation principle for drone frame sizes Quadcopter frame design Smart materials for UAV frame Green material uses in drone 2.2 Advance Drones component <ul style="list-style-type: none"> GPS, Interfacing of GPS hardware Thermal and chemical sensor Tilt and LiDAR sensor 2.3 RF transmitter and receiver <ul style="list-style-type: none"> RF blocks RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	CO-2

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 3a. Identify features and specifications of FCB use in different application TSO 3b. Explain ports of any given advance flight controller board. TSO 3c. Write steps of software installation of flight controller board. TSO 3d. Describe installation and calibration steps of radio telemetry with FCB. TSO 3e. Write steps of calibration of accelerometer and ESC with FCB. TSO 3f. Describe interfacing of GPS with FCB.	Unit-3.0 Advance Flight Controller Board (FCB) 3.1 Specification and ports of FCB 3.2 Software for FCB <ul style="list-style-type: none"> • Software installation 3.3 Radio Communication with FCB <ul style="list-style-type: none"> • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC 3.7 GPS interface with FCB 3.8 Safety features of advance FCB	CO-3
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	Unit-4.0 Maintenance and assembling of Drone 4.1 Need and scope of drone maintenance 4.2 Types of maintenance 4.3 Routine drone maintenance and its checklist <ul style="list-style-type: none"> • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones <ul style="list-style-type: none"> • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling 	CO-4
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	Unit-5.0 Advance Drone Application 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in <ul style="list-style-type: none"> • Military • Precision Agriculture 	CO-5

Note: One major TSO may require more than one theory session/period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604D

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Use the force of gravity to compute the centre of gravity for a given drone structure.	1.	Determine Centre of gravity of different drone structure.	CO-1
LSO 2.1 Develop skills of observation and interpreting phenomenal changes on Drone model for stability and hovering.	2.	Demonstrate gyroscopic effect on a drone model	CO-1
LSO 3.1 Draw various frame to be required in designing drone structure. LSO 3.2 Use Measuring instrument in designing drone frame. LSO 3.3 Choose suitable materials for making drone frame	3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	CO-2, CO-4
LSO 4.1 Identify and measure the condition of sensors. LSO 4.2 Interface Tilt and LiDAR sensors in drone.	4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2
LSO 5.1 Identify different component of GPS module LSO 5.2 Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	CO-2
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identify different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	CO-3
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator. LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.	12.	Measure various electric parameters in drone hardware	CO-4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 13.1 Inspect drone as per the given checklist LSO 13.2 Diagnose drone problems after flying of 50 and 100hrs	13.	Perform preventive maintenance of drone components	CO-4
LSO 14.1 Perform dismantle process of drone. LSO 14.2 perform services need for operation LSO 14.3 Check and Install different parts of the drone system. LSO 14.4 Assemble drone component.	14.	Dismantle and service of different parts of drone system	CO-4

L) **Suggested Term Work and Self Learning: S2400604D** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Prepare maintenance report for small UAV.
2. Survey nearby electronics shop and Prepare report on types of drone frames and drone sensors available and its specification.
3. Prepare report of surveying & mapping of our institute using drone with HD and thermal image camera.
4. Prepare report on land and crops quality of nearby agriculture field using drone.
5. Prepare report on Identify and select different application drones like agriculture, Surveillance, Inspections and gathering Information for disaster management.
6. Download 5 videos on advance FCB of drone design. Watch them and write report on it.
7. Market survey on different types of FCB, its specification and specific application and prepare report.
8. Develop mission completion drone with the help of GPS based Advance FCB.

c. Other Activities:

1. Seminar Topics-Drone stability using gyroscopic motion, Quadcopter frame, Green material use in drone design, GPS based drones, types of HD and thermal Image camera, Safety features in advance drone, Drone Assembling, Military drone.
2. Visits: Visit nearby small industry, Drone institute facilities. Prepare report of visit with special comments of advance drone technology used, material used, cost of printed component.
3. Surveys: Survey nearby electronics shop and Prepare report of list of advance drone components and its specification.
4. Product Development
5. Software Development

d. Self-Learning Topics:

1. Different types Drones frame
2. Overview of GPS technology
3. Different types of HD and thermal Image camera
4. Safety features in Drone
5. Advance drone application

J) Theory Session Outcomes (TSOs) and Units: T2400604E

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain various forms of 3D printing raw material.</p> <p><i>TSO 1b.</i> Select material for the given popular 3D printing processes with justification.</p> <p><i>TSO 1c.</i> Select various Polymer based 3D printing raw materials with justification.</p> <p><i>TSO 1d.</i> Explain procedure of Powder preparation for the given 3D printing material.</p> <p><i>TSO 1e.</i> Explain properties of the given Metal/Ceramics 3D printing material.</p> <p><i>TSO 1f.</i> Choose suitable 3D printing material on the basis of Performance Requirements and Material Properties.</p>	<p>Unit-1.0 3D Printing Materials</p> <p>1.1 Various forms of 3D printing raw material- Liquid, Solid, Wire, Powder.</p> <p>1.2 Popular FDM, SLA, SLS, Binder Jetting, Material Jetting and Direct Energy deposition 3D printing materials.</p> <p>1.3 Polymers, Metals, Non-Metals, Ceramics.</p> <p>1.4 Polymers and their properties.</p> <p>1.5 Powder Preparation and their desired properties.</p> <p>1.6 Choosing the Right 3D Printing Material on the basis of Performance Requirements and Material Properties.</p>	CO1
<p><i>TSO 2a.</i> Explain working of a typical FDM based 3D Printer.</p> <p><i>TSO 2b.</i> Justify use of FDM based 3D printing process and material for the given component.</p> <p><i>TSO 2c.</i> Explain the Laminated Object Manufacturing process.</p> <p><i>TSO 2d.</i> Estimate the cost and time of the given FDM based 3D printed component.</p>	<p>Unit-2.0 Solid based 3D Printing Processes</p> <p>2.1 Basic principle and working of fused deposition modeling (FDM) process.</p> <p>2.2 Liquefaction, solidification and bonding.</p> <p>2.3 Laminated Object Manufacturing process.</p> <p>2.4 Cost estimation of FDM 3D printed component.</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the phenomenon of Photo Polymerization.</p> <p><i>TSO 3b.</i> Explain the working of a typical Stereo Lithography based 3D Printer.</p> <p><i>TSO 3c.</i> Explain procedure of 3D Scanning of the given component.</p> <p><i>TSO 3d.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 3e.</i> Estimate the cost and time of the given SLA based 3D printed component.</p> <p><i>TSO 3f.</i> Apply Curing process to SLA based 3D printed component.</p>	<p>Unit-3.0 Liquid based 3D Printing Processes</p> <p>3.1 Photo polymerization.</p> <p>3.2 Principle and working of stereo lithography apparatus.</p> <p>3.3 SLA based 3D printing processes.</p> <p>3.4 SLA based 3D printing process materials.</p> <p>3.5 Scanning techniques.</p> <p>3.6 Curing processes.</p> <p>3.7 Cost estimation of SLA 3D printed component.</p>	CO1, CO3
<p><i>TSO 4a.</i> Explain powder fusion mechanism.</p> <p><i>TSO 4b.</i> Explain working of a typical SLA based 3D Printer.</p> <p><i>TSO 4c.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 4d.</i> Explain Net shape process.</p> <p><i>TSO 4e.</i> Explain Binder Jet 3D printing process.</p> <p><i>TSO 4f.</i> Justify use of Binder Jet 3D printing process and material for the given component.</p> <p><i>TSO 4g.</i> Estimate the cost and time of the given SLS based 3D printed component.</p>	<p>Unit-4.0 Powder based 3D Printing Processes</p> <p>4.1 Powder fusion mechanism.</p> <p>4.2 Principle and working of Selective Laser Sintering (SLS) process.</p> <p>4.3 SLS based 3D printers.</p> <p>4.4 Laser Engineering Net Shaping process.</p> <p>4.5 Electron Beam Melting.</p> <p>4.6 Binder Jet 3D Printing.</p> <p>4.7 Materials and Process parameters for SLS based 3D printing processes.</p>	CO1, CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	4.8 Cost estimation of SLS based 3D printed component.	
<p><i>TSO 5a.</i> Justify the need of post processing in the given 3D printed component.</p> <p><i>TSO 5b.</i> List the various post processing techniques.</p> <p><i>TSO 5c.</i> List the steps to perform post processing.</p> <p><i>TSO 5d.</i> Explain the given Cleaning related post processing approach for 3D printed component.</p> <p><i>TSO 5e.</i> Explain the given Surface finishing related post processing approach for 3D printed component.</p> <p><i>TSO 5f.</i> Apply simple inspection and testing techniques on the given 3D printed component.</p> <p><i>TSO 5g.</i> Identify the type of defect(s) in the given 3D printed component.</p>	<p>Unit-5.0 Post Processing and Quality</p> <p>5.1 Need of post processing: Functional and Aesthetic reasons.</p> <p>5.2 Steps of Post Processing: Cleaning/Support removal, Fixing, Curing or hardening, Surface finishing, Colouring.</p> <p>5.3 Cleaning: Support Removal (FDM and Material Jetting); Powder Removal (SLS and Powder Bed Fusion); Washing (SLA and Photo polymerisation).</p> <p>5.4 Fixing: Filling, Gluing, Welding.</p> <p>5.5 Surface finishing: Sanding, Polishing, Tumbling, Hydro dipping, Epoxy coating, Electro Plating, Vapour smoothing-Acetone treatment.</p> <p>5.6 Colouring, Coating, Priming and Painting.</p> <p>5.7 Inspection and testing: Digital, Visual, Physical.</p> <p>5.8 Defects and their causes.</p>	CO1, CO2, CO3, CO4, CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604E

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Use the available 3D printing software.</p> <p><i>LSO 1.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 1.3.</i> Set printing process parameters.</p> <p><i>LSO 1.4.</i> Produce a complex component using available FDM Printer.</p>	1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	CO1, CO2
<p><i>LSO 2.1.</i> Use the available 3D printing software.</p> <p><i>LSO 2.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 2.3.</i> Set printing process parameters.</p> <p><i>LSO 2.4.</i> Produce a complex component using available SLA Printer.</p> <p><i>LSO 2.5.</i> Perform curing of the SLA based 3D printed component.</p>	2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	CO1, CO3
<p><i>LSO 3.1.</i> Use the available 3D printing software.</p> <p><i>LSO 3.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 3.3.</i> Set printing process parameters.</p> <p><i>LSO 3.4.</i> Produce a complex component using available SLS Printer.</p>	3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	CO1, CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 4.1.</i> Use the available 3D printing software.</p> <p><i>LSO 4.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 4.3.</i> Set printing process parameters.</p> <p><i>LSO 4.4.</i> Produce a complex component using available FDM, SLA and SLS Printer.</p> <p><i>LSO 4.5.</i> Perform Cost, Time, Surface finish and Strength estimations related to 3D printed components.</p>	4.	Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength.	CO1, CO2, CO3, CO4
<p><i>LSO 5.1.</i> Use the available 3D printing software.</p> <p><i>LSO 5.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 5.3.</i> Select appropriate tolerance, fit and printing process parameters.</p> <p><i>LSO 5.4.</i> Produce an assembly using available SLA/SLS Printer.</p>	5.	Print one digital assembly on SLA/SLS based 3D Printer.	CO2/CO3/CO4
<p><i>LSO 6.1.</i> Use of available 3D scanner.</p> <p><i>LSO 6.2.</i> Develop 3D digital model using scanning approach.</p> <p><i>LSO 6.3.</i> Use the available 3D printing software.</p> <p><i>LSO 6.4.</i> Produce a complex component using available SLA Printer.</p>	6.	Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.	CO2, CO3, CO4
<p><i>LSO 7.1.</i> Identify tools/devices/chemicals for post processing</p> <p><i>LSO 7.2.</i> Perform post processing operations on printed component.</p>	7.	Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.	CO5
<p><i>LSO 8.1.</i> Identify tools/devices/techniques for inspection and testing.</p> <p><i>LSO 8.2.</i> Identify the defects in 3D printed components</p> <p><i>LSO 8.3.</i> Apply remedial measures to bring soundness in the defective 3D printed component.</p>	8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	CO5

L) **Suggested Term Work and Self Learning: S2400604E** Some sample suggested assignments, micro project and other activities are mentioned here for reference

- a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units: T2400604F**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Describe how does a PLC communicate? TSO.1b Differentiate between parallel and series communication TSO.1c Describe the data transfer mechanism for the given communication protocols. TSO.1d Describe the given communication protocol used in PLC communication. TSO.1e Summarize PLC to PLC communication procedure TSO.1f Describe the common procedure to interface the PLC with other given hardware.	Unit-1.0 Industrial automation communication and Interfacing 1.1 Analog and Digital Communications on Plant Floors 1.2 Introduction to Industrial Networking 1.3 RS232-422-485 standards for data communication 1.4 Industrial Ethernet 1.5 Concept of Fieldbus 1.6 MODBUS protocol 1.7 Highway Addressable Remote Transducer (HART) Protocol 1.8 Interfacing of Programmable Logic Controller with other hardware	CO-1
TSO.2a Specify the proper I/O addressing format of the given PLC. TSO.2b Explain the use of different relay type instructions for the given operation. TSO.2c Describe how a program is executed with the help of Program Scan cycle TSO.2d Develop ladder logic program using arithmetic functions to perform the given operation. TSO.2e Develop ladder logic programs using logical and comparison instructions to perform the given operation TSO.2f Develop ladder logic programs using on delay, off delay and reset/retentive timer in a given PLC to create a delay in operation. TSO.2g Develop ladder logic programs using Up, Down and UP-down counter in a given PLC to count the number of products	Unit-2.0 PLC Programming 2.1 PLC I/O addressing in ladder logic 2.2 PLC programming instructions using ladder logic and relay type instructions 2.3 Program Scan cycle 2.4 PLC arithmetic functions - Addition, subtraction, multiplication, division instructions, increment decrement, trigonometric 2.5 PLC logical functions - AND, OR, XOR, NOT functions, PLC compare and convert functions. 2.6 Programming Timer –Addressing a timer block, status bits, On delay, Off Delay and reset/retentive timer 2.7 Programming Counter- Addressing a counter block, status bits, Up and Down counter, up-down counter, counter examples, register basics 2.8 Develop ladder logic for various simple applications	CO-2
TSO.3a Describe Requirements for PLC enclosure. TSO.3b Describe Proper grounding techniques. TSO.3c Describe noise reduction Techniques.	Unit-3.0 Installation and maintenance of PLC systems 3.1 PLC enclosure, grounding requirements, noise generating inductive devices, leaky inputs and outputs, techniques to reduce electrical noise and leakage.	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.3d Explain preventive maintenance procedure associated with PLC system to reduce environmental impact</p> <p>TSO.3e Identify faults in the given PLC system</p> <p>TSO.3f Explain the procedure for Troubleshooting PLC system</p> <p>TSO.3g Prepare preventive maintenance plan for the PLC system</p> <p>TSO.3h Use safety equipment's.</p> <p>TSO.3i Follow safe practices</p>	<p>3.2 Introduction to PLC Trouble shooting and maintenance, trouble shooting of hardware and software.</p> <p>3.3 Diagnostic LED Indicators in PLCs</p> <p>3.4 Common problems</p> <ul style="list-style-type: none"> • Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory • External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI), Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated Circuitry, Field Input and Output Devices, Communication Issues. • Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer <p>3.5 Troubleshooting of Specific Components of the PLC System</p> <ul style="list-style-type: none"> • Power Supply Troubleshooting • I/O Modules Troubleshooting • Troubleshooting PLC Program Errors • Troubleshooting the Working Environment of a PLC • Replacement of CPU <p>3.6 PLC trouble shooting flowchart</p> <p>3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system.</p> <p>3.8 Safety procedure and safety equipment's.</p>	
<p>TSO.4.a Describe the function of given element of a SCADA system.</p> <p>TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC).</p> <p>TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application.</p> <p>TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.</p>	<p>Unit-4.0 SCADA and DCS</p> <p>4.1 Introduction, need, benefits and typical applications of SCADA and DCS</p> <p>4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA</p> <p>4.3 Comparison of SCADA with DCS</p> <p>4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture</p> <p>4.5 Creating SCADA Screen HMI for simple object, Steps for linking SCADA object (defining Tags and items, creating trends etc.,) with PLC ladder program using OPC, configuring simple applications using SCADA: Traffic light control, water distribution, pipeline control, Power generation, transmission and distribution etc.</p> <p>4.6 Procedure to maintain the SCADA based PLC system.</p>	CO-3
<p>TSO.5a Identify different components used for automation in the given system</p> <p>TSO.5b Select automation components for a given situation</p> <p>TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible.</p>	<p>Unit-5.0 Applications of Industrial Automation</p> <p>5.1 Manufacturing- Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation.</p>	CO-5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5d Prepare plan for sustainable automation as per the requirement.	<p>5.2 Health Care- microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci</p> <p>5.3 Defense- guided rockets and missiles, counter measures, UAV drones, launcher, radar antenna, engagement control system</p> <p>5.4 Automobile –Break monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps, Intelligent Parking Assist System, Driverless/Autonomous Cars</p> <p>5.5 Agriculture- harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor</p> <p>5.6 Mining- Mine planning system, mine picture compilation, mine control system, seismic imagining, laser imaging, Rig control system, automated drilling, automated exploration, automated truck</p>	

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604F

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Data communication from PLC to PC and vice versa	1.	Transfer the control data from PLC to PC and vice versa	CO1
LSO 1.2 Establish Communication channels between PLC s.	2.	Transfer the control data from PLC to PLC	CO1
LSO 1.3 Transfer data from sensors to PLC and from PLC to PC.	3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1
LSO 1.4 Interface the given PLC with a PC or a Laptop	4.	Interface the given PLC with a PC or a Laptop	CO1
LSO 2.1 Identify Different parts and front panel indicators of a PLC	5.	Identify the various parts and front panel status indicators of the given PLC.	CO2
LSO 2.2 Develop Ladder logic program for different arithmetic operations	6.	Develop/Execute ladder logic program for different arithmetic operations such as Addition, subtraction, multiplication, division increment, decrement, trigonometric in a given PLC	CO2
LSO 2.3 Develop Ladder logic program for different logical operations	7.	Develop/Execute ladder logic program for logical operations such as AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate along with truth table	CO2
LSO 2.4 Program Latch and Unlatch circuit in a PLC for motor operation	8.	Program the given PLC to start run and stop the given motor using latch circuit	CO2
LSO 2.5 Create delay in operation using on delay, off delay and retentive timer function in a given PLC.	9.	Test the functionality of on delay, off delay and retentive timer for its correct operation in a given PLC.	CO2
LSO 2.6 Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	10.	Test the functionality of Up, Down and Up-down counter for its correct operation in a given PLC.	CO2

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 2.7</i>	Program PLC using ladder logic to control a LED/Lamp	11.	Develop/Execute a ladder logic program to put LED/lamp in the blinking mode	CO2
<i>LSO 2.8</i>	Program PLC using ladder logic to control a simple traffic light system	12.	Develop/Execute a ladder logic program to control a simple traffic light control system using PLC	CO2
<i>LSO 3.1</i> <i>LSO 3.2</i> <i>LSO 3.3</i> <i>LSO 3.4</i> <i>LSO 3.5</i> <i>LSO 3.6</i> <i>LSO 3.7</i> <i>LSO 3.8</i> <i>LSO 3.9</i>	Use hygrometer to measure the humidity inside the panel Use thermometer to measure ambient temperature inside the panel Use tester to determine the voltage fluctuation at the power supply terminals is within specifications Test the ground connections of the given PLC. A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output Investigate the cause of Noise in the given PLC PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure. Troubleshoot the corrupted PLC memory. Replace CPU and power supply fuses in a given PLC system.	13.	Troubleshooting of PLC system	CO3
<i>LSO 4.1</i> <i>LSO 4.2</i> <i>LSO 4.3</i> i. ii. iii. iv. v. <i>LSO 4.4</i>	Download any open source SCADA software and install the same. Interpret the available components in symbol factory of SCADA software Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list) i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property. Create historical and real time trends for the given automation	14.	Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties	CO4
<i>LSO 5.1</i>	Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 5.2</i> Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application</p> <p><i>LSO 5.3</i> Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.</p> <p><i>LSO 5.4</i> Develop a Automation system to Open and close the door in the shop</p> <p><i>LSO 5.5</i> Develop a line following robot with RFID sensor for supplying materials and automating workflow.</p> <p><i>LSO 5.6</i> Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day.</p> <p><i>LSO 5.7</i> Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.</p>			

L) **Suggested Term Work and Self Learning: S2400604F** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- i. State three advantages of using programmed PLC timer over mechanical timing relay.
- ii. It is required to have a pilot light glow, meeting all of the circuit requirements given below:
 - All four circuit pressure Switches must be closed.
 - At least two out of three circuit limit Switches must be closed.
 - The reset Switch must not be closed.
- iii. Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem
- iv. Prepare a comparison chart of different types of PLC
- v. Prepare a maintenance plan for a given PLC system.

b. **Micro Projects:**

1. Troubleshoot the faulty equipment/kit available in automation laboratory
2. Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
3. Develop a working model of a given application using given actuators and valves.
4. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.
5. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application
6. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at the course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units: T2400604G**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the vehicle movement process TSO 1b. Derive various equations for the movement of Vehicles TSO 1c. Compute different resistances affecting Vehicle movement. TSO 1d. Explain the dynamics of the given type of EV system.	Unit-1.0 Vehicle Dynamics 1.1 Vehicle Movement 1.2 Rolling Resistance: Equation, Coefficient, factor affecting rolling resistance, typical values of rolling resistance 1.3 Grading resistance 1.4 Road resistance 1.5 Acceleration resistance 1.6 Total driving resistance 1.7 Aerodynamic drag: Equation, typical values of the drag coefficient. 1.8 Vehicle dynamics <ul style="list-style-type: none"> • Hybrid and Electric Vehicles • DC Motor Dynamics and Control • AC Motor Dynamics and Control 	CO1
TSO 2 a. Identify the given elements of Automobile Systems. TSO 2 b. Describe the functions of the given elements of Automobile Systems. TSO 2 c. Explain the dynamic characteristics of the Disc Braking System for the given braking steps. TSO 2 d. Describe the Procedure for testing the given AC/DC motors. TSO 2 e. Describe the Procedure of Installation and Testing of the given EV Charging Stations. TSO 2 f. Describe the Procedure for Commissioning EV Charging Stations. TSO 2 g. Explain the functions of the EV Control Unit.	Unit-2.0 Elements of Automobile 2.1 Suspension and Damping systems 2.2 Brake system: Half-step braking, Full step Braking 2.3 Transaxle 2.4 Elements of Noise Vibration and Harshness Control 2.5 Body balancing 2.6 Tyre Technology 2.7 AC/DC motor 2.8 Air-conditioning and Heating System 2.9 Lighting System 2.10 Automotive wiring system 2.11 Earthing and Insulation 2.12 Charging stations – Installation and Commissioning 2.13 Vehicle control unit	CO2
TSO 3a. Compare different power transmission systems in EVs. TSO 3b. List the main Components of the EV Power Train. TSO 3c. Explain the functions of the given EV Power Train component. TSO 3d. Describe the testing procedure of the given EV Power Train component.	Unit-3.0 EV Power Transmission System 3.1 Transmission System: Single and Multi-transmission system 3.2 EV Power Train 3.3 EV Power Train Components: Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger.	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3e. Explain the regenerative braking operation in the given EV motor. TSO 3f. Describe the speed control mechanism of the given motor. TSO 3g. Explain various parameters of the given battery. TSO 3h. Select the suitable battery for the given EV application. TSO 3i. Describe the assembling and dismantling procedure of the given battery. TSO 3j. Describe the Mechanism of Gear and Differential Assembly.	3.4 Battery Parameters: Voltage, Current, Charging rate, efficiency, energy density, power density, State of Charge (SoC), Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. 3.5 Battery Assembly and Dismantling. 3.6 Gear and Differential Assembly 3.7 Safe disposal of used battery	
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.	Unit- 4.0 Vehicle Control Unit (VCU) 4.1 Electronic Control Unit: Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	CO4
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.	Unit- 5.0 EV Charging Technologies 5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	CO5

Note: One major TSO may require more than one theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604G

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	<ul style="list-style-type: none"> Testing of Control Disc Braking system and Control Regenerative Braking system. 	CO2
LSO 2.3 Test the performance of different types of propulsion motors.	2.	<ul style="list-style-type: none"> Testing of Motors 	
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	<ul style="list-style-type: none"> Testing of the automotive wiring system. 	

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.1	Test the performance of a new set of batteries and aged batteries.	4.	<ul style="list-style-type: none"> Testing of Batteries used in EVs 	CO2, CO3
LSO 3.2	Compare the performance of the battery and find the Fuel Gauge after discharging the battery. <ol style="list-style-type: none"> 0% - 100% 30% - 100% 50% - 100% 			
LSO 3.3	Evaluate the following parameters of the given EV battery. <ol style="list-style-type: none"> Specific power Specific energy Life span and Cost parameters 			
LSO 3.4	Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.			
LSO 3.5	Test the dynamic performance of the given motor; <ol style="list-style-type: none"> Speed and torque spectrum. Speed and torque oscillation Friction torque friction spectrum. 	5.	<ul style="list-style-type: none"> Speed control of Electrical Motors 	
LSO 3.6	Test the following speed-controlled performance characteristics of the given motor; <ol style="list-style-type: none"> Motor voltage over time Motor current over time. Speed and torque over time. Torque over speed. Current over speed. Electrical input power and the mechanical input power over speed 			
LSO 4.1	Connect the components of the EC Units with EV subsystems.	6.	<ul style="list-style-type: none"> Connection of Electronic Control Unit components Troubleshooting of electronic control unit 	CO4
LSO 4.2	Troubleshoot basic faults in the electronic control unit of EV.			
LSO 5.1	Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	<ul style="list-style-type: none"> Impacts of G2V and V2G 	CO 5
LSO 5.2	Prepare a layout of a charging station	8.	<ul style="list-style-type: none"> Demonstration of Charging stations 	

L) **Suggested Term Work and Self-Learning: S2400604G** Some sample suggested assignments, micro projects and other activities are mentioned here for reference.

a. **Assignments:** Questions/ Problems/ Numerical/ Exercises to be provided by the course teacher in line with the targeted COs.

Legend:

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604H	Robotics (Advanced)	30	70	20	30	20	30	200

Legend:

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done internally (40%) as well as externally (60%). Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2400604H

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the need and scope of industrial robots. TSO 1b. Describe the concept of robot dynamics with regards to methods for orientation and location of objects. TSO 1c. Analyse robot direct kinematics for the given 2 DOF planar manipulator. TSO 1d. List types of robots	Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications 1.1 Definition need and scope of Industrial robots 1.2 Robot dynamics – Methods for orientation and location of objects 1.3 Planar Robot Kinematics – Direct and inverse kinematics for 2 Degrees of Freedom.	CO2, CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1e. List safety steps while handling the given robot.	1.4 Safety while operating and handling robot	
TSO 1f. Interface robots with the given welding machine.	1.5 Robot Industrial applications: <ul style="list-style-type: none"> Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing Spray painting Robots, assembly operation, cleaning. 	
TSO 1g. Interface robots with the given painting machine.		
TSO 1h. Interface robots with the given assembly machine.		
TSO 2a. Explain the techniques to control robot motion.	Unit– 2.0 Robot Drives, Control and Material Handling 2.1 Controlling the Robot motion. 2.2 Position and velocity sensing devices. 2.3 Drive systems – Hydraulic and Pneumatic drives 2.4 Linear and rotary actuators and control valves 2.5 Electro hydraulic servo valves, electric drives, motors 2.6 End effectors – Vacuum, magnetic and air operated grippers 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS) 2.8 Bar code technology 2.9 Radio frequency identification technology.	CO2, CO3
TSO 2b. Describe the given robot drive system.		
TSO 2c. Describe the types of grippers.		
TSO 2d. Design grippers for specific application.		
TSO 2e. Test the designed gripper for the application.		
TSO 2f. Use Bar code technology for robotic applications.		
TSO 2g. Integrate radio frequency identification technology in robotic applications.		
TSO 2h. Assemble an automated guided vehicle for the given situation using standard components.		
TSO 2i. Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components.		
TSO 3a. Differentiate between various work cell layouts.	Unit– 3.0 Robot Cell Design and Application 3.1 Robot work cell design, control and safety 3.2 Robot cell layouts 3.3 Multiple Robots and machine interference 3.4 Robot cycle time analysis 3.5 Industrial application of robotic cells	CO3
TSO 3b. Select work cell for specific robot with justification.		
TSO 3c. Analyse robot cycle time.		
TSO 3d. Explain industrial applications of robotic cell.		
TSO 3e. Follow safety procedures in robotic cell.		
TSO 4a. List different programming languages for the robots	Unit– 4.0 Robot Programming and Economics of Robotization 4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on investment method. 4.9 Testing methods and acceptance rules for industrial robots	CO1, CO4, CO5
TSO 4b. Describe artificial intelligence		
TSO 4c. Write a programme in the required language to operate a robot for the given task.		
TSO 4d. Optimise robot programming parameters.		
TSO 4e. Select a robot on the basis of cycle time analysis.		
TSO 4f. Conduct an economic analysis for use of robots.		
TSO 4g. Follow testing methods and acceptance rules for industrial robots.		

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5a. Describe applications of robots in healthcare and medicine. TSO 5b. Describe applications of robots in Construction industry. TSO 5c. Describe applications of robots in Underground coal mining. TSO 5d. Describe applications of robots in utilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	Unit-5.0 Applications in Non-manufacturing Environments 5.1 Applications of Robots in <ul style="list-style-type: none"> • Healthcare and medicine • Construction industry • Underground coal mines • Utilities, military & firefighting operations • Undersea • Space • Logistics, • Retail and Hospitality • Smart Cities • Farming and Agriculture 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604H

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify Wireless Sensor Network. LSO 1.2 Use wireless sensor Network for different robotic applications	1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3
LSO 2.1 Identify different Radio Frequency (RF) Controlled Wireless LSO 2.2 Use Radio Frequency (RF) Controlled Wireless for different robotic applications.	2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2
LSO 3.1 Identify the different Voice operated robot with speaker identification technology LSO 3.2 Use different Voice operated robot with speaker identification technology for different robotic applications.	3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3
LSO 4.1 Identify the components required for a computer-controlled pick and place robot (wireless). LSO 4.2 Integrate the components for the required application.	4.	Design a computer-controlled pick and place robot (wireless)	CO1
LSO 5.1 Identify the components required for a Zigbee controlled Boat with wireless video and voice transmission. LSO 5.2 Integrate the components for the required application.	5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3
LSO 6.1 Identify the components required for a PC controlled wireless Multipurpose robot for engineering applications. LSO 6.2 Integrate the components for the required application.	6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO2, CO4, CO5
LSO 7.1 Identify the components required for an unmanned arial photography LSO 7.2 Integrate the components for the required application.	7.	Design an unmanned arial photography system.	CO3, CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 8.1 Develop a program LSO 8.2 Simulate palletizing and depalletizing operations through robots.	8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5
LSO 9.1 Develop a program LSO 9.2 Simulate direction control and step control logic for robotization	9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5
LSO 10.1 Develop a program LSO 10.2 Simulate robotising an inspection and part assembly.	10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5
LSO 11.1 Develop a program. LSO 11.2 Simulate obstacle avoidance of robots.	11.	Develop obstacle avoidance robot Programming	CO1, CO5
LSO 12.1 PLC programming. LSO 12.2 Simulate robotising of welding operation.	12.	Program and simulate welding operation using robot simulation software.	CO1, CO5
LSO 13.1 Simulate robotising of drilling operation.	13.	TPP / Offline program for drilling operation.	CO1, CO5
LSO 14.1 Develop a program for an industrial application. LSO 14.2 Execute the robot programme.	14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5
LSO 15.1 Use robot simulation software for Direct Kinematic analysis upto 4-axis robots LSO 15.2 Correlate the simulated results with respective mathematical calculations.	15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2

L) Suggested Term Work and Self Learning: S2400604H Some sample suggested assignments, micro project and other activities are mentioned here for reference.

- a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
- b. **Micro Projects:** A suggestive list of micro-projects is given here. Similar micro-projects that match the COs could be added by the concerned course teacher. The student should strive to identify eco-friendly or recycled material prior to selection for robotic applications.
 1. Develop coin separating robot.
 2. Develop robot using radio frequency sensors for material handling.
 3. Develop robot for land mine detection.
 4. Develop a robot for car washing.
- c. **Other Activities:**
 1. Seminar Topics: Recent developments in the industrial applications of robotics
 2. Visits: Visit a robotic exhibition.
 3. Case Study: Identify a robotic application in automobiles and present a case study
 4. Download videos related to simple robotic applications in domestic and industrial purposes.
 5. Self-Learning Topics:
 - Robotic component manufacturers

J) Theory Session Outcomes (TSOs) and Units: T2400604I

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the use of different materials in transformers.</p> <p><i>TSO 1b.</i> List the various types of materials used in transformers.</p> <p><i>TSO 1c.</i> Explain the insulating materials.</p> <p><i>TSO 1d.</i> Explain the winding material.</p> <p><i>TSO 1e.</i> Explain the magnetic materials.</p>	<p>Unit-1.0 Transformer Materials</p> <p>1.1 Review of basic materials and their processing</p> <p>1.2 Insulating oil, insulating paper, pressboard, wood</p> <p>1.3 Insulated copper conductor for windings, crepe paper, sealing materials</p> <p>1.4 cold-rolled grain oriented electrical steel sheet, structural steel, future trends</p> <p>1.5 Magnetic Circuit Materials</p>	CO1
<p><i>TSO 2a.</i> Explain the basic concept of transformer design.</p> <p><i>TSO 2b.</i> List the various parameters to be considered during design.</p> <p><i>TSO 2c.</i> Choose the number of turns, the core diameter.</p> <p><i>TSO 2d.</i> Select the winding wires and strips.</p> <p><i>TSO 2e.</i> Choose the size of HV and LV conductors.</p>	<p>Unit-2.0 Transformer Design</p> <p>2.1 Basic Concept of Design.</p> <p>2.2 Selection of number of turns.</p> <p>2.3 Selection of core diameter.</p> <p>2.4 Selection of winding wires and strips.</p> <p>2.5 Size HV and LV conductors.</p> <p>2.6 Transposition</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the concept of computer aided design.</p> <p><i>TSO 3b.</i> Learn the programming skills,</p> <p><i>TSO 3c.</i> Modify the programming considering other aspects.</p> <p><i>TSO 3d.</i> Validate and print the design.</p> <p><i>TSO 3e.</i> Use software to design.</p>	<p>Unit-3.0 Transformer Design – Using CAD</p> <p>3.1 Computer aided design: Basic concept, specification needs.</p> <p>3.2 Computer programming, variable inputs, program convergence.</p> <p>3.3 Design output, design modification, other aspects of design.</p> <p>3.4 Design validation, design package, computer design printout.</p> <p>3.5 Software application for design.</p>	CO3, CO4
<p><i>TSO 4a.</i> Explain the testing of Transformer oil.</p> <p><i>TSO 4b.</i> Use of Transformer oil.</p> <p><i>TSO 4c.</i> List the causes of oil ageing.</p> <p><i>TSO 4d.</i> List the various tests to monitor the working conditions of a transformer.</p>	<p>Unit-4.0 Transformer Condition Monitoring</p> <p>4.1 Transformer oil testing and Interpretation</p> <p>4.2 Introduction, mineral insulating oil.</p> <p>4.3 Four functions of transformer oil.</p> <p>4.4 Causes of oil ageing.</p> <p>4.5 Various tests on transformer oil such as power factor, moisture, neutralization number, interfacial tension, relative density, color, visual examination, breakdown voltage, dissolved gas analysis.</p>	CO3, CO4
<p><i>TSO 5a.</i> Apply the concepts for practical use.</p> <p><i>TSO 5b.</i> Design a practical power transformer.</p>	<p>Unit-5.0 Transformer Design - Practical Applications</p> <p>5.1 Design of a 100 KVA transformer.</p> <p>5.2 Design of 630 KVA transformer.</p> <p>5.3 Design of 5 MVA, 33/11 KV transformer</p>	CO4, CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604I

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Knowledge of knowing the various components of a power transformer. <i>LSO 1.2.</i> Explain the use of those components in the power transformer.	1.	Dismantling a power transformer and understanding various components.	CO1
<i>LSO 2.1.</i> Design a transformer using computer programming considering various aspects.	2.	Designing a transformer using computer programming.	CO1
<i>LSO 3.1.</i> Use of a commercial software to design a transformer.	3.	Application of software for transformer design.	CO1
<i>LSO 4.1.</i> Understand the breakdown voltage (BDV) of transformer oil.	4.	Breakdown voltage test of transformer oil.	CO2
<i>LSO 5.1.</i> Explain the practical applications of power transformers. <i>LSO 5.2.</i> Knowledge of various transformers used in substations.	5.	Substation visit to see the application of power transformers.	CO3, CO4, CO5

L) Suggested Term Work and Self Learning: S2400604I Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Explore recent advancements in core material technology.
- Discuss the lifecycle, recycling, and disposal of transformer materials and their environmental footprint.
- Discuss the key parameters and design equations used in transformer design.
- Explore the steps involved in modeling the transformer core using CAD software.
- Use CAD software to simulate different winding configurations and their impact on performance.
- Discuss the advantages of real-time data collection and analysis for proactive maintenance.
- Investigate the different requirements for distribution transformers in urban versus rural settings.

b. **Micro Projects:**

- Compare the performance of different insulating materials used in transformers (e.g., paper, pressboard, Nomex).
- Study the magnetic properties of different core materials (e.g., silicon steel, amorphous steel).
- Evaluate the environmental impact of transformer materials and their disposal methods.
- Build a small-scale transformer to understand the basics of transformer construction and operation.
- Investigate the impact of different winding techniques on transformer efficiency and performance.
- Compare different core materials to determine their effect on transformer performance.
- Design various core shapes (e.g., E-core, toroidal, C-core) using CAD and analyze their magnetic properties.
- Design and optimize different winding layouts to improve efficiency and reduce losses.
- Design a system to monitor and log the temperature of transformer components.
- Monitor transformer vibrations to detect mechanical issues.
- Design a system to monitor the quality of transformer oil.
- Develop a lightweight, portable transformer for powering equipment at outdoor events.

Legend:

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604J	Optical Fiber and 5G Communication (Advance)	30	70	20	30	20	30	200

Legend:

- PTA: Progressive Theory Assessment in classroom (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- II) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2400604J

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1f.</i> Highlight the need for 5G communication system.</p> <p><i>TSO 1g.</i> Describe the radio spectrum and channel model with the help of suitable sketch and tables.</p> <p><i>TSO 1h.</i> Describe the working of the 5G physical layer with the help of a suitable sketch.</p> <p><i>TSO 1i.</i> Describe 5G network slicing with an example.</p> <p><i>TSO 1j.</i> Explain the mobility and hands-off management in 5G environment.</p>	<p>Unit-1.0 5G Radio Access Technology</p> <p>1.6 5G Radio Spectrum</p> <p>1.7 5G Channel Model</p> <p>1.8 Radio Interface Architecture</p> <p>1.9 5G Physical Layer</p> <p>1.10 5G Radio-Access Technologies</p> <p>1.11 Introduction To 5G Network Slicing</p> <p>1.12 Mobility and Handoff Management In 5G</p>	CO1
<p><i>TSO 2f.</i> Describe the architecture and key components of basic GSM (Global System for Mobile Communications) networks.</p> <p><i>TSO 2g.</i> List the components of the GSM(LTE) system.</p> <p><i>TSO 2h.</i> Describe the working of the various components and their functions of the given type of wireless communication network</p> <p><i>TSO 2i.</i> Analyze the functions of base station subsystems (BS)</p>	<p>Unit-2.0 Study of GSM Architecture</p> <p>2.7 GSM System Architecture (LTE)</p> <p>2.8 Explain the different components of Wireless Communication Network</p> <p>2.9 Operation of base station (BS) subsystems</p>	CO2
<p><i>TSO 3f.</i> Explain different principles and various factors affecting radio wave propagation in different environments.</p> <p><i>TSO 3g.</i> Apply the free space propagation model to estimate signal strength and coverage.</p> <p><i>TSO 3h.</i> Explain how reflection, scattering, and diffraction impact radio wave behaviour and signal quality.</p> <p><i>TSO 3i.</i> Use the given type of path loss models to predict signal degradation over distance.</p> <p><i>TSO 3j.</i> Differentiate between large-scale and small-scale fading and their effects on wireless communication.</p> <p><i>TSO 3k.</i> Analyze the characteristics and behaviour of wireless channels, including their impact on signal transmission.</p> <p><i>TSO 3l.</i> List the noise sources present in the wireless channel.</p> <p><i>TSO 3m.</i> Describe the effects of noise on signal propagation through wireless channels and its impact on signal quality.</p> <p><i>TSO 3n.</i> Calculate the capacity of channels with Additive White Gaussian Noise (AWGN).</p>	<p>Unit-3.0 Channel and channel behavior</p> <p>3.6 Analysis of radio wave propagation</p> <p>3.7 Free Space Propagation Model</p> <p>3.8 Reflection, Scattering, Diffraction of Radio Waves</p> <p>3.9 Path Loss Models</p> <p>3.10 Study of Fading (Large, small-scale fading)</p> <p>3.11 Analysis of Wireless Channel</p> <p>3.12 Analysis of Noise, types of noise</p> <p>3.13 Capacity of AWGN and Fading Channel (only formula and its variable parameters)</p>	CO3
<p><i>TSO 4e.</i> Describe various diversity techniques to improve signal reliability and performance in wireless communication.</p> <p><i>TSO 4f.</i> Describe receiver diversity methods and their impact on enhancing signal quality and reducing errors.</p> <p><i>TSO 4g.</i> Describe transmitter diversity techniques and their role in mitigating fading and improving communication robustness.</p> <p><i>TSO 4h.</i> Describe the principles and applications of Multiple Input Multiple Output (MIMO) technology.</p> <p><i>TSO 4i.</i> Suggest the techniques to correct distortions and mitigate inter-symbol interference in wireless communication systems.</p>	<p>Unit-4.0 Mitigation Techniques</p> <p>4.6 Diversity techniques</p> <p>4.7 Analysis of various receiver diversity techniques</p> <p>4.8 Analysis of various transmitter diversity techniques</p> <p>4.9 MIMO technology advantages in communication systems</p> <p>4.10 Equalization techniques and their importance in communication systems</p>	CO4
<p><i>TSO 5c.</i> Discuss the various types of dispersion in optical fibre design</p> <p><i>TSO 5d.</i> Explain the optimization technique of single mode fibre.</p> <p><i>TSO 5e.</i> Describe the working and characteristics of different optical networks.</p>	<p>Unit-5.0 Advanced Optical Fiber Communication and Emerging Technologies</p> <p>5.4 Advanced Optical Fiber: Dispersion issues, Dispersion shifted, Dispersion flattened, Dispersion Compensating fibre</p> <p>5.5 Design and optimization of single-mode fibers</p>	CO5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 5f.</i> Explain the nonlinear effect on network performance of optical fibre systems.</p> <p><i>TSO 5g.</i> Explain multicarrier modulation techniques to enhance data transmission and system performance.</p> <p><i>TSO 5h.</i> Describe the principles and advantages of Orthogonal Frequency Division Multiplexing (OFDM) in improving bandwidth efficiency and reducing interference.</p> <p><i>TSO 5i.</i> Analyze given emerging technologies.</p>	<p>5.6 Optical Networks- Basic Networks SONET, SDH-wavelength-routed networks</p> <p>5.7 Nonlinear effect on Network Performance, performance of various systems (WDM, DWDM + SOA)</p> <p>5.8 Multicarrier Modulation Technique</p> <p>5.9 Orthogonal Frequency Division Multiplexing (OFDM)</p> <p>5.10 Emerging Technology: Green Communication network, Vehicle 2 everything (V2X), Aerial Communication, Satellite Communication (LEO), Tactile Internet (TI), Free Space Optics (FSO), Near Field Communication, Quantum Communication, Molecular Communication</p>	

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604J

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.3.</i> Noise Modelling and its effect on Wireless Data Transmission	1.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	CO1
<i>LSO 2.2.</i> Effect of fading on wireless data transmission in terms of outage probability	2.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	CO2
<i>LSO 3.2.</i> Capacity of Wireless Channel (AWGN v/s Fading)	3.	Comparative Study of Channel Capacity: AWGN versus Fading Channels	CO3
<i>LSO 4.2.</i> Implementation of receiver diversity technique.	4.	Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication	CO4
<i>LSO 5.3.</i> Implementation of transmitter diversity technique.	5.	Practical Implementation and Performance Analysis of Transmitter Diversity Techniques	CO4
<i>LSO 6.1</i> Implement the (2X2) of MIMO system.	6.	Design and Implementation of MIMO Technology	CO4
<i>LSO 7.1</i> Implement of OFDM system and test the performance.	7.	Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems	CO5

L) **Suggested Term Work and Self Learning: S2400604J** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

d. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

e. **Micro Projects:**

Here are five micro projects that can be included in an optical fiber and 5G communication course to give students hands-on experience with practical applications of the concepts learned:

1. Design of solar cell enabled Base Station for Green Communication Network

Task: Conduct a feasibility study on integrating solar cells with base stations, design a prototype solar-powered base station, simulate its energy efficiency and environmental impact, evaluate its carbon footprint reduction, and document the design and performance outcomes.

2. Path loss models for Aerial Communication Network

Task: Research and adapt existing path loss models for aerial networks, develop tailored models for scenarios like drones, validate with field or simulation data, compare model performance, and document findings with recommendations for network design.

Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2400107

Major Theory Session Outcomes (TSOs)	Units	TSO 2j. Relevant COs Number(s)
<p><i>TSO 1a.</i> Define concepts-values and ethics and attitude, development of attitudes</p> <p><i>TSO 1b.</i> Identify situations depicting values such as humanity, honesty, punctuality, respect, peace, empathy</p> <p><i>TSO 1c.</i> Identify situations depicting ethics, healthy competition, integrity, truthfulness,</p>	<p>Unit-1.0 Values and Ethics in Day to Day Life</p> <p>1.1. Values- Definition and examples, Ethics- definition and examples, Concept of attitude and development of attitude</p> <p>1.2. Importance of values and ethics in day to day activities and at workplace- Ethical ways of communication, environmental considerations in engineering processes, Basic concept of Carbon footprint, ethics at workplace</p> <p>1.3. Examples of situations depicting values- based decisions and ethical behavior in day to Day life</p>	CO1
<p><i>TSO 2a.</i> Identify the relevance of profession to society and environment</p> <p><i>TSO 2b.</i> Identify the need of values and ethics in profession related activities</p> <p><i>TSO 2c.</i> Identify Ethical conflicts</p>	<p>Unit-2.0 Values and Ethics in Profession</p> <p>2.1 Relevance of profession to society</p> <p>2.2 ethical principles such as respecting others and ourselves, respecting the rights of others, keeping promises, avoiding unnecessary problems to others, avoiding cheating and dishonesty, showing gratitude towards others and encouraging them to work</p> <p>2.3 Identification of activities and related ethical and unethical behavior for professional activities in their area of work</p> <p>2.4 Examples of situations depicting values- based decisions and ethical behavior</p>	CO1, CO2

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Activities and Self-Learning: Reading books related to values and ethics/Epics/ Daily news and discussions in group

a. Assignments: Preparation for group discussion, panel discussion, role play, case study, seminar, skits

a. Micro Projects: Skits development and performance, poster making,

b. Activities: Role Play, Case studies, Debates, Group Discussion

c. Suggested Seminar/ Debates on Topics such as:

- i. charters of professions
- ii. Importance of Values and ethics in identified profession
- iii. Issues of ethical conflicts- Professional rivalry,
- iv. Identified issues from Chanakya Neeti
- v. Ethics in scriptures such as Kabir ke Dohe etc.
- vi. Lessons on ethics from religious scriptures
- vii. Issued based on Happenings reported in Daily news

J) Theory Session Outcomes (TSOs) and Units: T2400408

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Perform SWOT analysis and reflect.</p> <p><i>TSO 1b.</i> Develop skills in carrier planning & goal setting</p> <p><i>TSO 1c.</i> Build a Resume using Internet formats.</p> <p><i>TSO 1d.</i> Develop and Design portfolios.</p> <p><i>TSO 1e.</i> Maintain good grooming attire.</p> <p><i>TSO 1f.</i> Introduce oneself to others.</p> <p><i>TSO 1g.</i> Develop a personal website.</p>	<p>Unit-1.0 Goal Setting</p> <p>1.1 Career planning, SWOT</p> <p>1.2 Resume using Internet formats.</p> <p>1.3 Showcase portfolios.</p> <p>1.4 Personal grooming.</p> <p>1.5 Self-Introduction.</p> <p>1.6 Website Development.</p>	CO1
<p><i>TSO 2a.</i> Face interviews and E- Interviews confidently</p> <p><i>TSO 2b.</i> Participate in group discussions.</p> <p><i>TSO 2c.</i> Use Social media for personal enrichment & Netiquette</p> <p><i>TSO 2d.</i> Manage self for higher growth.</p> <p><i>TSO 2e.</i> Use body language for effective communication</p> <p><i>TSO 2f.</i> Manage Emotions for personal growth</p>	<p>Unit-2.0 Capacity Development</p> <p>2.1 Interview Skills</p> <p>2.2 Group Discussion – Do's & don'ts, leadership, Teamwork, how to interrupt, synthesis, and analysis of topics.</p> <p>2.3 Social Media for Personal Enrichment</p> <p>2.4 Body language</p> <p>2.5 Self-Management.</p> <p>2.6 Emotional Intelligence</p>	CO2
<p><i>TSO 3a</i> Develop & Maintain Social Contacts.</p> <p><i>TSO 3b</i> Engage in Social Service projects.</p> <p><i>TSO-3c</i> Collaborate for mutual advantage.</p> <p><i>TSO 3d</i> Apply QC-Tools in work situations.</p> <p><i>TSO 3e</i> Practice Lean Manufacturing Techniques for Production and Operations</p>	<p>Unit-3.0 Utilizing Potential</p> <p>3.1 Social Networking</p> <p>3.2 Social Engagements, Volunteering</p> <p>3.3 Collaboration & Team-work.</p> <p>3.4 QC-Tools – Check sheets, Fishbone Diagram, Histogram, Pareto chart, Control-chart, Scatter Diagram, Stratification,</p> <p>3.5 Lean Manufacturing, Kanban, Kaizen, Five S, Poka-yoke, Quality Circle</p>	CO3

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: - (Not Applicable)

L) Suggested Term Work and Self Learning: Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

- 1 Build a resume for Placement Activity.
- 2 Prepare letters for job applications.