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 – V
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				
2425501	**BEC**	**Industrial Engineering &Management** (ELX, ELX (R), ME, ME (Auto))	02	01	-	02	05	04
2425502	**PCC**	**Industrial Automation and Mechatronics**	03	-	04	02	09	06
2425503	**PCC**	**Hybrid Automobile Engineering**	03	-	04	02	09	06
2400504	**OEC**	**Open Electives* / COE** (Basic -Any One)	03	-	04	02	09	06
2400505	**NRC**	**Entrepreneurship Development & Start-ups** (Common for All Programmes)	-	-	04	02	06	03
2425506	**PSI**	**Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes)	-	-	02	04	06	03
2425507	**PSI**	**Minor Project** (Common for all programmes)	-	-	02	02	04	02
Total			**11**	**1**	**20**	**16**	**48**	**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)

*: 3D Printing & Design/ Art. Intelligence (AI)/ Drone Technology / Electric Vehicle / Ind. Automation / Robotics/ IOT/Transformer Manufacturing & 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 - V
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 Assessme	
2425501	**BEC**	**Industrial Engineering &Management** (ELX, ELX (R), ME, ME (Auto))	30	70	20	30	-	-	150
2425502	**PCC**	**Industrial Automation and Mechatronics**	30	70	20	30	20	30	200
2425503	**PCC**	**Hybrid Automobile Engg.**	30	70	20	30	20	30	200
2400504	**OEC**	**Open Electives* / COE** (Basic -Any One)	30	70	20	30	20	30	200
2400505	**NRC**	**Entrepreneurship Development & Start-ups** (Common for All Programmes)	-	-	20	30	20	30	100
2425506	**PSI**	**Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes)	-	-	20	30	20	30	100
2425507	**PSI**	**Minor Project** (Common for all programmes)	-	-	10	15	10	15	50
Total			**120**	**280**	**130**	**195**	**110**	**165**	**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.
3D Printing & Design/ Art. Intelligence (AI)/ Drone Technology / Electric Vehicle / Ind. Automation / Robotics/ IOT/Transformer Manufacturing & 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 activiti.

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

J) Theory Session Outcomes (TSOs) and Units: T2425501

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain industrial functions related to the given situation. *TSO 1b.* Identify different types of plant layouts. *TSO 1c.* Select site for the given situation. *TSO 1d.* Explain acts and taxes relevant to the given industrial situation. *TSO 1e.* Describe different types of Industrial disputes. *TSO 1f.* Identify relevant acts applicable for the given corporate situation. *TSO 1g.* Identify relevant taxes applicable for the given business situation.	**Unit-1.0 Industrial Engineering** 1.1 Need, role and benefits of Industrial Engineering 1.2 Principles of Industrial Engineering and its Historical developments 1.3 Industrial Functions-Design, Procurement, production, operation, installation, inspection, maintenance, marketing, etc. 1.4 Types of Industries/Business units 1.5 Plant layout and its types, Site selection 1.6 Industrial Acts & Taxes: Salient features of various acts pertaining to industry- The Factories Act 1948. Industrial Disputes Act 1947. The Workmen's Compensation Act 1923/1956.	**CO1**
TSO 2a. Apply methods of improving productivity for the given situation. *TSO 2b.* Conduct method study to eliminate unnecessary operations in the given production situation. *TSO 2c.* Use different flow charts and flow diagrams to study a process for improvement. *TSO 2d.* Apply time study procedure required for work measurement in the given situation. *TSO 2e.* Explain different allowances related to employees. *TSO 2f.* Solve simple numerical problems related to Standard Time calculation. *TSO 2g.* Explain basic concepts of Production study *TSO 2h.* Apply work measurement techniques in the given organization to eliminate ineffective time	**Unit-2.0 Work and Method Study** 2.1 Productivity; Standard of living; Method of improving Productivity: Objectives 2.2 Method Study: Definition; Objectives; Selection of a job for Method study; Basic procedure and tools to conduct Method study 2.3 Operation process chart; Flow process chart; Two handed process chart; Man Machine chart 2.4 String diagram and flow diagram. 2.5 Work Measurement: Definition: Basic procedure in making a time study 2.6 Calculation of standard time; Basic concept of Production study; Techniques of Work Measurement	**CO2**
TSO 3a. Explain major functions of production planning and control required in a production plant *TSO 3b.* Use suitable methods of forecasting to estimate future demands in the given situation. *TSO 3c.* Use routing and scheduling techniques to allocate resources effectively *TSO 3d.* Apply dispatching and controlling of jobs to improve production efficiency *TSO 3e.* Solve simple numerical problems on CPM and PERT technique in project completion	**Unit-3.0 Production Planning and Control** 3.1 Introduction; Major functions of Production Planning and Control 3.2 Forecasting and Methods of forecasting: Qualitative Methods and Quantitative Methods-moving average and exponential smoothing only (Related simple numerical); 3.3 Routing and Scheduling; Dispatching and Controlling 3.4 Concept of Critical Path Method (CPM) and PERT; Simple related numericals 3.5 Types of Production: Mass Production, Batch Production and Job Order Production: Characteristics	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3f. Select the appropriate type of production system catering to the given market demand and operational requirements. *TSO 3g.* Apply the principles of product planning and process planning required in producing the given product. *TSO 3h.* Identify the importance of quality control in production. *TSO 3i.* Use different inspection techniques to control quality of the given product and process(es). *TSO 3j.* Identify advantages and disadvantages of statistical quality control. *TSO 3k.* Apply the concepts of ISO 9001:2008 in quality management system. *TSO 3l.* Outline the procedures for obtaining ISO certification. *TSO 3m.* Enlist benefits of ISO to the organization.	3.6 Principles of Product Planning and Process Planning; 3.7 Quality Control: Definition; Objectives; Types of Inspection: First piece, Floor and Centralized Inspection; Advantages and Disadvantages; Statistical Quality Control; Concept of ISO 9001:2008, Quality Management System, Registration/Certification procedure; Benefits of ISO to the organization	
TSO 4a. Describe the functions of Management. *TSO 4b.* Compare the salient features of different types of organization. *TSO 4c.* Implement F.W. Taylor's and Henry Fayol's in Management. *TSO 4d.* Describe the roles and functions of a manager in an organization. *TSO 4e.* Identify the type of leadership style required for the given situation. *TSO 4f.* Explain the concept of motivation with the examples of positive and negative motivations in an organization. *TSO 4g.* Apply the concepts of modern management techniques for improving the quality of the production process. *TSO 4h.* Identify the responsibility of human resource management official. *TSO 4i.* Identify different components of wages and salary. *TSO 4j.* Calculate depreciated values of the given machine. *TSO 4k.* List reasons to replace the given machine/machine component.	**Unit-4.0 Industrial Management** 4.1 Concept of Management and its functions, Organization and Organizational Structure (organization chart of Govt. deptt., Industrial undertakings, private industries, etc.) 4.2 F.W. Taylor's and Henry Fayol's Principles of Management; Functions of Supervisor/Manager 4.3 Team Working and Leadership: Styles of Leadership; Qualities of a good leader; Motivation; Positive and Negative Motivation 4.4 Modern Management Techniques; Just in Time; Total Quality Management (TQM); Quality circle; Zero defect concept; 5S Concept 4.5 Human Resource Management (HRM): Objectives and Responsibility of HRMS; Selection Procedure; Training of Workers- Apprentice Training; On the Job training; 4.6 Wages and Salary; Component of Wages, Types of wages, Payment of Wages 4.7 Depreciation: Meaning of depreciation, Methods of calculating depreciation charges, obsolescence – definition and reasons. 4.8 Replacement economy: Reasons for replacement, installation and removal costs.	**CO4**
TSO 5a. Describe the importance of material management. *TSO 5b.* Identify different types of costs involved in production. *TSO 5c.* Calculate break even quantity of in the given production situation. *TSO 5d.* Use purchase procedure for the procurement of the specified materials.	**Unit-5.0 Material Management and Industrial Safety** **Material Management** 1. Introduction: Purpose. Functions of material Management, Cost Accounting- Introduction & necessity, elements of cost – direct and indirect, variable and fixed, prime cost, overhead cost, total cost, marginal costing, break-even analysis.	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5e. Calculate EOQ of the given production situation. *TSO 5f.* Describe various techniques of inventory management. *TSO 5g.* Identify different material handling equipment. *TSO 5h.* List elements of industrial hygiene in the given situation. *TSO 5i.* Identify the importance of plant safety. *TSO 5j.* Identify the causes of accident and estimate the cost of accident. *TSO 5k.* Identify the ways to control and manage industrial waste.	2. Purchase -Purchase Procedures, reordering cycle system, base stock and lead-time, inventory valuation, Economic order quantity (EOQ) 3. Store Management -stores procedures, layouts, safety provisions, inventory control techniques- ABC, VED, FIFO, and LIFO systems. Introduction to Material handling and material handling equipment **Industrial Hygiene & Safety** 4. Industrial Hygiene: Methods of achieving industrial hygiene. 5. Industrial safety: - Safety awareness of employees, use of various safety devices, responsibilities of employees and employer towards safety. 6. Accident: Causes and Cost of an Accident, Accident Proneness, Prevention of Accidents 7. Industrial waste control: - Types of industrial waste, problem of disposal, waste control programme, recycling and power of waste.	

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: S2425501 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. Identify the different industries nearby your city on basis small, medium and large scale with justification.
ii. Identify industries nearby your area on basis of high and low production capacity with justification.
iii. Select the relevant plant layout for particular industrial application with justification.
iv. List factors considered in selecting a job for time study
v. Identify the objectives of work study for a given situation.
vi. Give examples of different types of recording techniques in method study.
vii. Identify the types of allowances given for any industrial work with reference to time study method.
viii. Solve problems related to calculation of Normal and Standard time for a given work study problem.
ix. Describe the function of PPC in a given organization.
x. Describe job, batch and Mass production with one example each.
xi. Draw flow process chart of a given industry.
xii. Describe differences between inspection and quality control.
xiii. Prepare list of control charts used for statistical quality control in any specific industry.
xiv. Prepare p chart and c chart for a given industry specific problem.
xv. Prepare process capability chart for a given case study of industry.
xvi. Interpret the given control charts in statistical quality controls.
xvii. Describe the functions of Management.
xviii. Identify the type of leadership style required for the given situation.
xix. Explain the concept of motivation with the examples of positive and negative motivations in an

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: T2425502

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Distinguish between automated and mechanized system. *TSO 1b.* Describe Industry 4.0 and its component *TSO 1c.* Select relevant automation strategies for the given manufacturing technique *TSO 1d.* To identify the different components required for production system automation *TSO 1e.* Analyze the working of industrial processes and products for automation. *TSO 1f.* Select criteria for factory automation and processes automation for a given industry	**Unit-1.0 Introduction to Industrial Automation** 1.1 Introduction to Industry 4.0 and its components, Issues and challenges in automation, Advantage & Disadvantage 1.2 Need of automation in industries, Principles and strategies of automation, factory automation, process automation 1.3 Basic elements of an automated system, Structure of Industrial Automation Advanced automation functions, Levels of automations 1.4 Industrial control Systems- Process and Discrete system 1.5 Types of automation system: Fixed, Programmable, Flexible Integrated Automation and its application 1.6 Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives. 1.7 Introduction to Internet of Things (IoT) and Industrial Internet of Things (IIOT) and its application in Automation. 1.8 Role of robots in automation and its components	**CO1**
TSO 2a. To differentiate between mechatronics and automation *TSO 2b.* To identify the different components of a mechatronic system. *TSO 2c.* Application of mechatronics in automotive industry.	**Unit-2.0 Introduction to Mechatronics Systems** 2.1 Definition and concepts of Mechatronics, Need and Role of Mechantronics in Design, manufacturing and Factory Automation. 2.2 Mechatronics Systems, classification and history of mechatronics system, Mechatronics system architecture and components 2.3 Basic system models -mechanical system building blocks -translational and rotational system, electrical system building blocks, electro mechanical systems - system components and functions 2.4 Introduction to real time mechatronics system-block diagram and functions, real time mechatronics system, Mechatronic Control in Automated Manufacturing, flexible manufacturing systems, Integrated Product Design 2.5 Application of Mechatronics	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3a Describe different types of Sensors giving their applications. TSO.3b Describe different types of actuators giving their applications. TSO.3c Select sensors for a given process with justification. TSO.3d Select relevant actuator for a given work process with justification. TSO.3e Develop hydraulic and pneumatic circuits for the given problem TSO.3f Explain the requirement of the motion conversion system within a system TSO.3g Explain the necessity of analog to digital and digital to analog conversion system. TSO.3h Identify the commonly used input field devices in PLC installations along with their symbols. TSO.3i Draw symbol of various switches used in PLC installations describing the function of each switch. TSO.3j Identify the various digital input devices used in a PLC installation.	**Unit-3.0 Hardware Components- Sensors, Actuators and Input Device** **Sensors and transducers** 3.1 Sensors concept, classification, Development in Transducer technology, General Characteristics of Sensor 3.2 Types: Principle/working, ratings/ specifications, cost, and applications of: - • Temperature- Thermistor, Thermocouple and Resistance temperature Detector (RTD), • Pressure sensors- Linear Variable Differential Transformer (LVDT), • Liquid level sensor -Capacitive and Ultrasonic • Force -Strain/Weight sensors • Flow sensors – turbine flow sensor • Acceleration sensor- Accelerometer • Angular and linear position sensor Proximity sensors- Inductive, Capacitive, Optical and ultrasonic • Smoke Sensors, IR, Opto- Electronics-Shaft encoders, CD Sensors, Vision System 3.3 Sensors for conditioning Monitoring, , Micro sensors in Mechatronics **Drives and Actuators** 3.1 Introduction to actuators, Actuator Concept, Relay as an actuator Classification of actuators 3.2 Mechanical actuators -Translational and rotational motion, kinematic chains, cams, gears, belt and chain drives, bearings 3.3 Hydraulic and Pneumatic actuators- linear and rotary actuators, single and double acting cylinder, directional, process and pressure control valves 3.4 Electrical actuators • Electromechanical actuators construction, working and application of Stepper motors, AC/DC Servo motors, BLDC Motor (Very brief) • Electrohydraulic actuators- Construction, working and application of Electro-hydrostatic actuator (EHA), ON/OFF Electro-hydraulic Rotary Actuator, Control Valve Rotary Actuator, Solenoid valve **Input device** 3.5 Analog input devices-Electromagnetic relays, Contactors, Motor starters, 3.6 Manually operated Switches 3.7 Toggle switch, pushbutton switch, knife switch and selector switches 3.8 Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols 3.9 Discrete/Digital Input device	**CO3**
TSO 4a. Describe various Continuous control system and their feasibility with different process. *TSO 4b.* Select relevant control system for	**Unit-4.0 Industrial Control System** 4.1 Block diagram of a basic control system 4.2 Types of control – On-off, Feed forward, Open loop and	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
the given situation *TSO 4c.* Describe the basic process control system with the help of a block diagram *TSO 4d.* Explain the types of control available in a process control *TSO 4e.* Describe the different types of controllers in a closed loop system with the help of a block diagram *TSO 4f.* Describe the different types of Industrial control systems.	closed loop control and Transfer function 4.3 Types of Industrial Control Systems- • Industrial automation and controls (IACS) • Distributed control systems (DCS) • Data collection system (DCS) • Human machine interface (HMI) • Intelligent electronic devices (IED) • Programmable automation systems (PAS) • Programmable automation controllers (PAC) • Programmable logic controllers (PLC) • Remote terminal units (RTU) • Supervisory control and data acquisition (SCADA) 4.5 Control Requirements. 4.6 PLC Working Principle with Block Diagram 4.7 SCADA Working Principle with Block Diagram 4.8 Different types of inputs-step and ramp 4.9 Controllers in closed loop control • Proportional Controller (P Controller) • Integral Controller (I Controller) • Derivative controller (D- Controller) • P-I Controller • P-D Controller • PID Controller	
TSO 5a. Develop PLC programme for the given problem *TSO 5b.* Develop programme to interface memory, I/Os with processor *TSO 5c.* Identify the characteristics of real time systems *TSO 5d.* Explain the building blocks of the PLC *TSO 5e.* Describe communication system in PLC. *TSO 5f.* Differentiate between parallel and series communication *TSO 5g.* Describe the data transfer mechanism for the given communication protocols. *TSO 5h.* Describe the given communication protocol used in PLC communication. *TSO 5i.* Summarize PLC to PLC communication procedure	**Unit-5.0 PLC and Communication System** 5.1 Introduction to PLC, evolution of PLC, Types of PLC – Fixed, Modular and their types 5.2 Building blocks of PLC - CPU, Memory organization, Input-Output modules (Discrete and Analog) Specialty I/O Modules, Power supply 5.3 PLC programming languages with simple examples: • Functional Block Diagram (FBD), • Instruction List. • Structured text, • Sequential Function Chart (SFC), • Ladder Programming 5.4 PLC I/O addressing in ladder logic 5.5 Simple programming example using ladder logic- Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature control, Conveyor system control **Industrial communication System** 5.6 Analog and Digital Communications on Plant Floors 5.7 Industrial Networking 5.8 RS232-422-485 standards for data communication 5.9 Industrial Ethernet, Concept of Fieldbus, MODBUS protocol 5.10 Highway Addressable Remote Transducer (HART)Protocol	**CO5**

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

K) Suggested Laboratory (Practical) and Session Outcomes (LSOs): P2425502

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify major automation components in a given system	1.	Identify various building blocks and major automation components in a given robotic system or any other system	CO1
	2.	Analyze given traditional machine in the laboratory and plan the steps and components required to automate it.	CO1
LSO 2.1. Identify and List various component's used in mechatronics system	3.	Identify the components in the given mechatronics systems	CO2
	4.	Identify the communication circuits between each component in the given mechatronics system	CO2
	5.	Replace one or two components in the given mechatronics systems and analyze the output	CO2
LSO 3.1 Design and test pneumatic and hydraulic circuits for the given situation	6.	Control the Speed of the Cylinder by Meter-In and Meter-Out Valve Circuit.	CO3
	7.	Operate Impulse pilot by single acting cylinder.	CO3
	8.	Operate lift and control the speed	CO3
	9.	Open and close the security gate and control the speed.	CO3
	10.	Design a circuit for speed control of hydraulic motor meter out/meter in circuit by using 4/3 DC valve.	CO3
LSO 3.2 Design and Test Electro-Pneumatic and Electro Hydraulic circuits	11.	Operate single and double acting cylinder using single solenoid valve	CO3
	12.	Control the single acting and double acting cylinder using pilot valves.	CO3
	13.	Control the speed of stepper motor and servo motors	CO3
LSO 3.3 Operate stepper motor	14.	Operate stepper motor and control the motor by changing number of steps, the direction of rotation and speed	CO3
LSO 3.4 Direct acting of hydraulic motor	15.	Operate hydraulic motor	CO3
LSO 3.5 Use digital inductive proximity sensor	16.	Test the response of digital inductive proximity sensor used to detect different types of materials	CO3
LSO 3.6 Use digital capacitive proximity sensor	17.	Test the response of digital capacitive proximity sensors used to detect o different materials	CO3
LSO 3.7 Use digital optical proximity sensor	18.	Test the response of digital optical proximity sensor to detect different materials	CO3
LSO 3.8 Use ultrasonic proximity sensors	19.	Test the response of digital ultrasonic proximity sensors to detect different materials	CO3
LSO 3.9 Use thermistor	20.	measure temperature of a given material using thermistor	CO3
LSO 3.10 Use thermocouple	21.	measure the temperature of a given liquid using Thermocouple and plot the output voltage versus temperature	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.11 Use RTD	22.	Control the temperature of an oven using RTD	CO3
LSO 3.12 Use flow sensor	23.	measure the flow of a given liquid or gas with flow sensors	CO3
LSO 3.13 Use pressure sensors	24.	Use pressure sensors to measure the pressure of a liquid or gas	CO3
LSO 3.14 Use load cell	25.	Use load cell for measurement of mechanical force/weight.	CO3
LSO 4.1 Analyze the given system to study open loop, closed loop and feed forward path.	26.	Test the output response of open loop closed loop and feed forward path	CO4
LSO 4.2 Analyze the given first order system and its transfer function and output response	27.	Build and test the output response of a first order system for a step input using a CRO	CO4
LSO 4.3 Analyze the given second order system and its transfer function and output response	28.	Build and test the response of a second order system for a step input using CRO.	CO4
LSO 4.4 Analyze the given water level control system with on-off, Proportional control.	29.	Test the Output response of an on-off and Proportional control-based level control system.	CO4
LSO 4.5 Analyze the given water level control system with P+I+D control.	30.	Test the Output response of a given water level control system with P+I+D based level control system.	CO4
LSO 5.1 Identify the parts of PLC	31.	Identify the various parts and front panel status indicators of the given PLC	CO5
LSO 5.2 Identify analog and digital input and output lines of the PLC	32.	Test the analog and digital input and output lines of the given PLC	CO5
LSO 5.3 Develop PLC prgramme for the given situation	33.	Develop Ladder logic program for different arithmetic operations	CO5
	34.	Develop Ladder logic program for different logical operations	CO5
	35.	Develop and execute PLC programme to control the devices like Lamp, Alarm, motor using push button switches	CO5
LSO 5.4 Establish communication between PLC, PC and sensors	36.	Transfer the control data from PLC to PC and vice versa	CO5
	37.	Transfer the control data from PLC to PLC	CO5
	38.	Transfer the sensor data from sensor to PLC to PLC and PC	CO5

Note: A suggestive list of practical experiment is given in the above table. More such practical experiment can be added to attain the COs and competency. A judicial mix of minimum 20 or more practical need to be performed, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

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: T2425503

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Differentiate between hybrid vehicle and conventional vehicle based on the given criteria *TSO 1b.* Analyze the drive train vehicle motion *TSO 1c.* Asses the economic and environment impact of hybrid vehicles *TSO 1d.* Describe the procedure for disposal of battery, cells and hazardous materials *TSO 1e.* Describe basic operating principals of Hybrid Electric Vehicles and their impact on the energy conversion process	**Unit-1.0 Introduction to Hybrid Vehicle & Electric Vehicle** 1.1 A brief history of Electric and Hybrid vehicles 1.2 Basic architecture of hybrid drive train and analysis of series drive train vehicle motion and the dynamic equations for the vehicle 1.3 Types of Electric vehicle and hybrid vehicle, advantages over conventional vehicles 1.4 limitations of Electric vehicle and hybrid vehicle 1.5 Economic and environmental impact of Electric vehicle and hybrid vehicle 1.6 Disposal of battery, cell and hazardous material and their impact on environment. 1.7 Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.	**CO1**
TSO 2a. Describe the procedure of sizing the given motor *TSO 2b.* Select relevant motor as pert the requirement *TSO 2c.* Calculate RPM and Torque of the given motor *TSO 2d.* Draw mechanical and electrical connection/wiring of the given motor *TSO 2e.* Determine the performance characteristics of the given motor	**Unit-2.0 DC and AC Machines & Drives in EV & HV** 2.1 Types of Motors, selection and sizing of Motor 2.2 RPM and Torque calculation of motor 2.3 Motor Controllers and Component sizing, Physical locations 2.4 Mechanical and electrical connection of motor 2.5 Induction motor drives and control characteristics 2.6 Permanent magnet motor drives and characteristics 2.7 Brushed & Brushless DC motor drive and characteristics 2.8 Switched reluctance motors and Characteristics 2.9 IPM motor drives and characteristics	**CO2**
TSO 3a. Identify the components of the given hybrid vehicle	**Unit-3.0 Hybrid Vehicle Architecture Design and Control unit**	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3b. Describe the system requirement and electrical protection for the given hybrid vehicle *TSO 3c.* Explain the architecture and working of the given hybrid vehicle *TSO 3d.* Compare fuel vs Electric and solar power *TSO 3e.* Describe control unit development process and data management system *TSO 3f.* Compare performance of EV and IC engine vehicles *TSO 3g.* Draw layouts and Identify nomenclature of auto electrical systems, chassis and Monocoque body, Steering Systems, Suspension system, Brakes, wheels & tyres.	3.1 Types of Electric Vehicle and components 3.2 Electrical protection and system requirement 3.3 Photovoltaic solar based EV design 3.4 Battery Electric vehicle (BEV) 3.5 Hybrid electric vehicle (HEV) 3.6 Plug-in hybrid vehicle (PHEV 3.7 Fuel cell electric vehicle (FCEV) 3.8 Electrification Level of EV 3.9 Comparison of fuel vs Electric and solar power 3.10 Solar Power operated Electric vehicles 3.11 Control unit -Function of CU, Development Process, Software, Hardware, Data Management	
TSO.4a Explain Grid to vehicle and vehicle to grid charging. TSO.4b Describe vehicle to vehicle and vehicle to personal communication systems for the given vehicle. TSO.4c Describe the procedure for installation and commissioning of battery charging station TSO.4d Estimate station capacity TSO.4e Explain the technical issues associated with given charging station TSO.4f Apply BEE standards for EV and HV.	**Unit-4.0 Grid Interconnection and Charging Station** 4.1 Introduction to smart charging: Grid to vehicle and vehicle to grid 4.2 Smart metering and ancillary services, vehicle to vehicle and vehicle to personal communication systems 4.3 Introduction to battery charging stations and its installation and commissioning, 4.4 Type of charging station, components of charging station 4.5 Selection and Sizing of charging station 4.6 Estimation on station capacity and associated technical issues, 4.7 Different connectors, policy regulations and standards for EV and HV, BEE standards, Indian and Global scenario, case studies	**CO4**
TSO 5a. Apply power and energy management strategies for the given situation *TSO 5b.* Select relevant energy storage device and technology as per the requirement *TSO 5c.* Prepare battery layout design *TSO 5d.* develop battery pack configuration and construction *TSO 5e.* apply Rule based control and optimization-based control battery management system *TSO 5f.* Energy conversion processes and energy flow through a hybrid electric vehicle	**Unit-5.0 Energy Storage and Battery Management System (BMS)** 5.1 Power and Energy management strategies and its general architecture of EV and HV 5.2 Cell Types (Lead Acid/Li/NiMH) 5.3 Battery charging and discharging calculation 5.4 Cell Selection and sizing, Battery lay outing design 5.5 Battery Pack configuration and construction 5.6 Need of BMS, Rule based control and optimization-based control 5.7 Software-based high-level supervisory control 5.8 Mode of power, behaviour of motor, advance Features 5.9 Hybridization of various energy storage devices, Selection of the energy storage technology.	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425503

Practical/Lab Session Outcomes (LSOs)	S. No	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify Electric vehicle components and Performance comparison of EV and IC engine vehicles.	1.	Identify and interpret different types of vehicles and their specifications.	CO1
	2.	Identify and become familiar with the components EV and how they are in comparison to IC engine-based vehicle	CO1
	3.	Identify various gauges/instrument on dashboard of an electric vehicle and identify differences in instrumentation panel with IC engine vehicle	CO1
	4.	Calculate motor effort	CO1
	5.	Test amplifier, output torque, and efficiency at different condition	CO1
	6.	Determine performance of electric vehicles, in comparison to IC engine vehicles	CO1
	7.	Determine fuel economy	CO1
LSO 2.1. Use induction motor test rig	8.	Determine the control characteristics of Induction motor used for electric motor vehicle	CO2
	9.	Determine speed control characteristics of Induction motor used for electric vehicle	CO2
LSO 2.2. Use BLDC motor test rig	10.	Determine the control characteristics of BLDC motor used for electric motor vehicle	CO2
	11.	Determine speed control characteristics of BLDC motor used for electric motor vehicle	CO2
LSO 2.3. Use Switch Reluctance motor test rig	12.	Determine the control characteristics of Switch Reluctance motor used for electric motor vehicle	CO2
LSO 2.4. Use IPMSM motor test rig	13.	Determine the control characteristics of IPMSM motor used for electric motor vehicle	CO2
	14.	Determine torque control characteristics of IPMSM motor used for electric motor vehicle	CO2
	15.	Determine field control of IPMSM motor used for electric vehicle	CO2
LSO 2.5. Identify electrical and mechanical wiring in the given vehicle	16.	Identify electrical wiring in the given hybrid vehicle	CO2
	17.	Identify mechanical wiring in the given hybrid vehicle.	CO2
LSO 2.6. Wiring of head light, trafficators, and electric horn	18.	check the wiring of head light, trafficators, electric horn and replacing if not wired properly	CO2
LSO 3.1. Identify transmission and driveline systems in a given HV vehicle	19.	Identify main systems and sub systems of Automobile (transmission and driveline systems).	CO3
LSO 3.2. Test all Electrical, Electronic components & circuits and assemble circuit and high voltage wiring	20.	Trace and Test all Electrical, Electronic components & circuits and assemble circuit to ensure functionality of system.	CO3

Practical/Lab Session Outcomes (LSOs)	S. No	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
	21.	Trace the high voltage wiring on the vehicle.	CO3
LSO 3.3. Carryout the diagnostic procedure for troubleshooting	22.	Diagnose the following troubles in the electrical accessories: - No horn, poor horn, continuous horn. -Wiper and washer no operation, continuous operation, intermittent operation. - Power window no operation. - Power Door lock no operation. - Immobilizer system and keyless entry no operation. -Trouble (Error indication) in Automatic seat belt system. – Trouble (Error indication) in Air bag system.	CO3
LSO 3.4. Determine efficiency & output of an engine and electric machine	23.	Characterize the efficiency & output of an engine and electric machine	CO3
LSO 3.5. Determine the effects of aerodynamics & rolling resistance	24.	Determine the effects of aerodynamics & rolling resistance through vehicle coast-down testing	CO3
LSO 3.6. Test the sensors	25.	Test the various sensors fitted on the vehicle.	CO3
LSO 4.1. Establish communication between vehicle to vehicle and vehicle to personal communication systems	26.	Send & receive messages on a CAN bus	CO4
LSO 4.2. Use simulation software	27.	Perform vehicle simulation	CO4
LSO 5.1. Identify the major components of EV and HV	28.	Identify the components for required for installing battery charging station. Install battery charging station	CO5
LSO 5.2. Test batteries & perform battery maintenance	29.	Conduct specific gravity test and open voltage test of the given battery used in automobile and find the state of charge.	CO5
	30.	Characterize the performance of a battery pac	CO5
	31.	Develop battery pack components	CO5
	32.	Monitor and check performance of high voltage rechargeable energy storage system and Battery Management System.	CO5
	33.	Identify different cell chemistries and geometries	CO5
	34.	Identify various sensors installed - Battery Temperature Mapping.	CO5
	35.	Perform Verification of cell performance against supplier data sheet	CO5
	36.	Perform Interfacing of BMS with Battery Pack configuration of BMS with software application.	CO5
	37.	Measure voltage, current and temperature with BMS.	CO5
	38.	Perform battery testing, charging and cycling operations	CO5

Note: A suggestive list of practical experiment is given in the above table. More such practical experiment can be added to attain the COs and competency. A judicial mix of minimum 20 or more practical need to be performed, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

H) 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.

I) Theory Session Outcomes (TSOs) and Units: T2400504B

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Elaborate the use of ArtificialIntelligence TSO 1b. Explain various technological Driversof Modern AI TSO 1c. Describe Knowledge representation TSO 1d. Classify Intelligent agents TSO 1e. List the characteristics of agents TSO 1f. Apply various search strategies for problem solving	**Unit-1.0. Artificial Intelligence** **Artificial Intelligence:** What is AI?, Types of AI, History of AI, Turing Test, Symbol Systems and the scope of Symbolic AI, Structure of AI, Goals of AI, Importance ofAI, Techniques used in AI, Perception, Understanding and Action**,** Technological drivers of modern AI **Knowledge**: Definition, Knowledge Representation, objectives andrequirements, practical aspects of representation, Components **Intelligent Agents**: Agents and Environments, Properties of environments,characteristics of agents, classification of agents **Problem Solving:** Problem Formulation,Goal Formulation, State Space Search,Search Problem, Basic search algorithm,Search Tree, Search strategies–Uninformed and informed search, Breadth FirstSearch, Depth FirstSearch, Best FirstSearch, Constraint Satisfaction Problem (CSP), Back tracking Search.Problem Definitions: N Queen Problem, 8Puzzle Problem, Tic-tac-Toe.	**CO-1**
TSO 2a. Explain Python tokens and variables TSO 2b. Use the concept of l-value and r -value TSO 2c. Write python program using various data types TSO 2d. Write Program using variousoperators in Python TSO 2e. Write program using conditional statements TSO 2f. Use various string functions for problem solving in python program TSO 2g. Write programmes using various operations on list TSO 2h. Write programmes by using various operations on Tuples and Dictionary TSO 2i. Create user defined functions TSO 2j. Write python programmes using built-in functions TSO 2k. Describe the procedure to import	**Unit-2.0 Python Programming** Python character set, Python tokens, variables, concept of l-value and r-value,use of comments. Data types: number (integer, floating point, complex), boolean, sequence (string,list, tuple), none, mapping (dictionary), mutable and immutable data types Operators: arithmetic operators, relationaloperators, logical operators, assignmentoperator, augmented assignmentoperators. Expressions, statement, typeconversion & input/output: precedence ofoperators, expression, evaluation ofexpression. **Conditional and Iterative statements:** if, if-else, if-elif-else, for loop, range function, while loop, break and continue statements, nested loops **String, List, Tuples and Dictionary:** String: indexing, string operations (concatenation, repetition, membership & slicing), traversing a	**CO-2**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
module in the Python TSO 2l. Describe procedure to Import Libraryand functions in the Python TSO 2m. Write program using Iterativestatements.	string using loops, built-in functions. Lists: introduction, indexing, list operations (concatenation, repetition, membership & slicing), traversing a list using loops, built- in functions, linear search on list of numbers and counting the frequency of elements in a list Dictionary: accessing items in a dictionary using keys, mutability of dictionary (adding a new item, modifying an existing item), traversing a dictionary, built-in functions **Python Functions:** types of function (built- in functions, functions defined in module, user defined functions), creating user defined function, arguments and parameters, default parameters, positionalparameters, function returning value(s), flow of execution, scope of a variable (global scope, local scope) **Modules and Packages:** Importing module using 'import' Regular Expressions,Exception Handling, PyPI Python PackageIndex, Pip Python package manager, Importing Libraries and Functions	
TSO 3a. Explain Data Analytics and its elements TSO 3b. Differentiate Data Analysis and Data Analytics TSO 3c. Explain the use of open source data TSO 3d. Differentiate Qualitative and Quantitative data analysis TSO 3e. Explain procedure to Install NumPyLibrary TSO 3f. Use NumPy library to perform various operations and functions on array TSO 3g. Write Programs using NumPy for array manipulations	**Unit-3.0 Data Analytics and Computing with NumPy** **Data Analytics**: Data, Types of Data, Importance of Data, Data Analysis Vs Data Analytics, Types of Data Analytics, Elements of Analytics, Data Analysis Process, Qualitative and Quantitative analyses, Open Source Data. **NumPy Library**: Introduction, Installation, **Ndarray**: creating an array, intrinsic creation of an array, Data types, basic operations, aggregate functions, Indexing, slicing, Iterating, Conditions and Booleanarrays, Array **manipulation:** Joining, splitting, shape changing, sorting, Structured arrays, Reading and Writing array data on a File.	**CO-3**
TSO 4a. Apply Pandas data structure for data analysis TSO 4b. Write Programs using Pandas to perform various operations and functions on series. TSO 4c. Perform various operation in a Data Frame columns and rows TSO 4d. Write Programme to read and write on CSV, XLS and Text data files TSO 4e. Apply various data cleaning operations and prepare data.	**Unit-4.0 Data Analysis with Pandas** **Pandas data structures**: Series, Declaration, selecting elements, assigning values, Filtering values, operations, mathematical functions, evaluating values, handling missing data, creating series from dictionaries, adding two series. **Data Frame:** Defining, selecting elements, assigning values, membership, deleting a column, filtering. Index Objects: Indexing, Re-indexing, Dropping, sorting and ranking, Descriptive Statistics **Data Loading**: Reading and Writing csv, xls, text data files, Data Cleaning and Preparation: Handling missing data, removing duplicates, replacing values,Vectorized String Methods, HierarchicalIndexing, Merging and Combining, Data aggregation and Grouping.	**CO-4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 5a. Illustrate the use of Matplotlib and PyPlot package for showing plots and images TSO 5b. Customize plots with Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids TSO 5c. Differentiate various charts based on their applications	**Unit-5.0 Data Visualization with Matplotlib** Data Visualization: Introduction to Matplotlib ,PyPlot package, Figures andSubplots, showing plots and images Customizing Plots: Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids ,Annotating with text, Matplotlib Configuration Chart types: Line, Bar, stacked bar, Box plots, pie chart , Histogram and Densityplots, Scatter plot, Saving Plots to a file, Close and clear plots.	**CO-5**

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

J) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504B

Practical/ Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1 Use various data types and operators to solve given problem LSO 1.2 Use conditional and iterative statements for solving given problem	1	**Conditional and Iterative statements** 1a. Write a program to generate randomnumbers between 5 and 10. 1b. Write a program to find the square root of a number. 1c. Write a python program to check if a numberis positive, negative or 0. 1d. Write Python program to print all primenumbers between 0-50.	CO-2
LSO 2.1 Use string functions for performing various string operations	2	**String Handling** 2a. Write a Programme that asks the user for astring with only single space between words, and return number of words in thestring. 2b. Write a Program that inputs a line of textand print the count of Vowels in it. 2c. Write a Program that inputs a line of text andprint the biggest word in it. 2d. Write a Program that inputs a line of textand print a new line of text where each word of input line is reversed.	CO-2
LSO 3.1 Use list operations for concatenation, repetition & slicing LSO 3.2 Perform various operation in the Tuples LSO 3.3 Perform various operation in the dictionary	3	**List, Tuples and Dictionary** 3a. Write a python program to convert a stringto a list. 3b. Write a program to print the largest numberin a list. 3c. Given a tuple pairs = ((3,9), (8,4), (3,7), (24,18)), count the number of pairs (a, b)such that both a and b are odd. 3d. Write a program to input a list of numbers and swap elements at the even location withthe elements at the odd location. 3e. Write a program to merge two dictionaries.	CO-2
LSO 4.1 Use built-in functions to solve given problem LSO 4.2 Create user defined functions to	4	**Python Functions** 4a. Write a function to reverse a string. 4b. Write a function to calculate the factorial of a	CO-2

Practical/ Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
solve given problem		number.	
LSO 5.1 use basic data structure using NumPy LSO 5.2 Convert the list and tuple as NumPy array	5.	**Basic data structures in NumPy** 5a. Create a List, set, tuple and dictionary whichstores the details of a student (roll no, name, dept, branch, percentage of mark) inPython and print the values. 5b. Convert the list and tuple as NumPy array.	CO-3
LSO 6.1 Create Arrays in Numpy using different intrinsic methods LSO 6.2 Perform arithmetic operations and mathematical operations using arrange and ones intrinsic method.	6	**Arrays in NumPy** 6a. Create arrays using different intrinsic methods (ones, zeros, arange, linspace,indice) and print their values. 6b. Check the results of arithmetic operations like add(), subtract(), multiply() and divide()with arrays created using arrange and ones intrinsic method. 6c. Check the results of mathematical operations like exp(), sqrt(), sin(), cos(), log(), dot() on an array created using arrange intrinsic method.	CO-3
LSO 7.1 Apply aggregate functions on data by using Built-in function s in Numpy	7	**Built-in functions in NumPy.** 7a. Load your class Mark list data from a csv (comma separated value) file into an array. Perform the following operations to inspect yourarray. Len(), ndim, size, dtype, shape, info() 7b. Apply the aggregate functions on this data and print the results. (Functions like min(), max(), cumsum(), mean(), median(), corrcoef(), std())	CO-3
LSO 8.1 Handle multiple arrays by applying various operations on arrays	8	**Handling Multiple Arrays** 8a. Create two python NumPy arrays (boys, girls) each with the age of nstudents in the class. 8b. Get the common items between twopython NumPy arrays. 8c. Get the positions where elements of twoarrays match. 8d. Remove from one array those items thatexist in another. 8e. Extract all numbers between a given rangefrom a NumPy array.	CO-3
LSO 9.1 Apply indexing on the given set of data	9	**Indexing in NumPy** 9a. Load your class Mark list data from a csv fileinto an array. 9b. Access the mark of a student in a particularsubject using indexing techniques. 9c. Select a subset of 2D array using fancyindexing (indexing using integer arrays	CO-3
LSO 10.1 Create series using list and dictionary in pandas LSO 10.2 Print different values from series.	10	**Working with a Series using Pandas** 10a. Create a series using list and dictionary. 10b. Create a series using NumPy functions in Pandas. 10c. Print the index and values of series. 10d. Print the first and last few rows from the series.	CO-4
LSO 11.1 Perform various operation in a Data Frame rows	11	**Working with Data Frame Rows** 11a. Slicing Data Frame using loc and iloc. 11b. Filter multiple rows using isin. 11c. Select first n rows and last n rows 11d. Select rows randomly n rows and fractionsof	CO-4

Practical/ Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
		rows (use df. sample method) 11e. Count the number of rows with eachunique value of variables 11f. Select nlargest and nsmallest values.11g. Order/sort the rows	
LSO 12.1 Apply different techniques to merge and combine data	12	**Merge and combine data** 12a. Perform the append, concat and combinefirst operations on Data Frames. 12b. Apply different types of merge on data. 12c. Use a query method to filter Data Frame with multiple conditions.	CO-4
LSO 13.1 Create Linear Plot to identify various relation in the data using Matplotlib LSO 13.2 Create Scatter Plot to identify various relation in the data using Matplotlib	13	**Consider the Salary dataset, which contains 30 observations consisting of years of working experience and the annual wage. Download thedata set from** https://www.kaggle.com/rohankayan/years-of- experience-and-salary-dataset 13a. Create a linear plot to identify the relationship between years of working experience and the annual wages with suitable title, legend and labels. 13b. Create a scatter plot to identify the relationship between years of working experience and the annual wages with title, legend and labels. 13c. Also distinguish between observations that have more than 5 years of working experience and observations that have lessthan 5 years of working experience by using different colors in one single plot.	CO-5
LSO 14.1 Plot Bar graph by Changing the color of each bar, Change the Edge color, Linewidth and Line style.	14	**Consider the Iris dataset, where observations belong to either one of three iris flower classes. Download the data set from** https://www.kaggle.com/arshid/iris-flower- dataset 14a. Visualize the average value for each feature of the Set osa iris class using a bar chart. 14b. Format the obtained bar graph by Changingthe color of each bar, Change the Edge color, Line width and Line style.	**CO-5**

K) Suggested Term Work and Self Learning: **S2400504B** 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. **Handing Two-dimensional array in NumPy**
   Download the data set from
   https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.datahttps://www.kaggle.com/arshid/iris-flower-dataset

   a. Import iris dataset with numbers and texts keeping the text intact into python NumPy.
   b. Convert the 1D iris to 2D array (iris2d) by omitting the species text field.
   c. Find the number and position of missing values in iris2d's sepal_length
   d. Insert np.nan values at 20 random positions in iris 2d dataset
   e. Filter the rows of iris2d that has petal_length> 1.5 and sepal_length< 5.0

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: T2400504C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a. Describe the concept of IoT. TSO.1. b. Explain the functions of each block of the Basic IoT system. TSO.1. c. Compare features of various IoT platforms TSO.1. d. List IoT Real time Applications. TSO.1. e. Describe the functioning of given real-time applications	**Unit-1.0 Introduction to IoT** 1.1 Basics of IoT, concepts of IoT, History of IoT 1.2 Basic IoT System and its building blocks 1.3 Various platforms for IoT (e.g. AWS, AZURE, GCP) 1.4 Introduction to Python programming and IoT software 1.5 Applications of IoT	**CO-1 and CO-5**
TSO.2. a. Explain various communication protocols. TSO.2. b. Explain working and application of blue tooth TSO.2. c. Explain working and application of ZigBee TSO.2. d. Explain working and application of LoRa TSO.2. e. Explain working and application of Wi-fi	**Unit 2.0 IoT Communication Protocols** 2.1 Basics of given communication protocol alongwith its applications 2.2 Explain Communication Protocols MQTT 2.3 Bluetooth Low Energy ZigBee LoRa Wi-fi	**CO-1 and C02**
TSO.3. a. Differentiate between sensor and Actuator. TSO.3. b. Classify IoT sensors on the basis of their application. TSO.3. c. Describe the function of each block of Node MCU. TSO.3. d. Explain the procedure to connect sensors with Node MCU.	**Unit-3.0 Sensors and Hardware for IoT** 3.1 Sensors and Actuators, Transducers, Classifications of sensors, IoT Sensors 3.2 Development Boards, classifications, and basics of wireless networks, WiFi libraries 3.3 Introduction to node MCU, block diagram, functions, interfacing with sensors and publishing data on webserver 3.4 Device integration with node MCU 3.5 Interfacing of sensors with boards	**CO-1, CO-3 and CO-5**
TSO.4. a. Define APIs and its uses TSO.4. b. Explain working and application of REST. TSO.4. c. Explain working and application of SOAP TSO.4. d. Explain working and application of json TSO.4. e. Explain the integration of API in IoT application development.	**Unit.4.0 IoT APIs and its Integration** 4.1 Explain APIs and its use 4.2 Explanation of given IoT APIs along with its applications 4.3 MQTT, Broker, subscriber, publisher **4.4 REST** **SOAP** **4.5 JSON** **4.6 Programming API using Python**	**CO-1 and CO-4**
TSO.5. a. Differentiate between industrial IoT and IoT. TSO.5. b. Describe the applications of IoT in the medical field.	**Unit. 5.0 IoT Applications**: - 5.1 Industrial IoT and Internet of everything 5.2 IoT for consumer electronics products	**CO-1 andCO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5. c. Describe the medical applications of IoT in the agriculture field. TSO.5. d. Describe the innovative IoT applications.	5.3 IoT for Medical applications 5.4 IoT for Agriculture 5.5 IoT for security and Law enforcement	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant CosNumber (s)
LSO 1.1 List various IoT platforms. LSO 1.2 List Down broad features of given platforms. LSO 1.3 List IoT based features in python language.	1.	Prepare a list of platforms used for IoT. Prepare a list of features of above IoT platforms. Prepare a list of features provided by python language for IoT applications.	CO-1
LSO 2.1 Arduino connection with Arduino IDE. Connect Bluetooth with Arduino. verification of data communication withBluetooth.	2.	Establish connectivity between various components of IoT. Establish connection between Arduino and Bluetooth module. Establish connection using WiFi	CO-2
LSO 3.1 Measure the temperature of the givensensor. LSO 3.2 Measure the humidity of the given sensor. LSO 3.3 Measure the pressure of the given sensor.	3.	Publish data on the IoT platform. Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system. Measure the humidity of a remotely located humidity sensor Using IOT based humidity data-monitoring system. Measure the pressure of a remotely located pressure sensor Using IOT based pressure data-monitoring system.	CO-3
LSO 4.1 Working with APIs. LSO 4.2 Implementation of APIs using POSTMANApplication.	4	Download and Configure POSTMAN Application Verify REST APIs through POSTMAN. Verify JSON APIs through POSTMAN. Verify SOAP APIs through POSTMAN.	CO-4
LSO 5.1 Identification of components for variousapplications. LSO 5.2 Estimate the cost for components.	5.	Identify components for given project Estimate the cost to make Project working.	CO-5

L) Suggested Term Work and Self Learning: S2400504C 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 (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: T2400504D

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Describe the various historicalevolutionary steps of drone technology TSO 1b. Explain Drone motion based on principle of aerodynamics. TSO 1c. Classify different types of drones and make chart of its application, advantages and disadvantages TSO 1d. Develop attitude to follow proper rules and regulations of drones flying in India. TSO 1e. Explore future prospects of drones inIndia.	**Unit-1.0Introduction to Drone Technology** Introduction to Drones and UAV • Definition • History • Drone in Indian aspect Introduction to Flight Dynamics Various types of Drones and their respective Applications • Multirotor drones • Fixed wing structure Drone flights using an understanding of FAA • DGCA • Digital sky platform • RPTO Drone regulations-No drone zones	**CO-1**
TSO 2a. Explain the use and function of different types of Drone components. TSO 2b. Select suitable drone frame and propellers for given application. TSO 2c. Explain working principle and function of different sensors used in drone technology. TSO 2d. Write use of Gyro sensor and Accelerometer in drone. TSO 2e. Describe different types and capacity of Battery used in various drone applications. TSO 2f. State the selection criteria of motor for given drone application. TSO 2g. Write advantage of BLDC motors in making of Drones.	**Unit-2.0 Drone and its components** Drones components • Drone frame • Propellers Sensors • Gyro sensor and Accelerometer • Speed and Distance Sensor • Temp sensor • Barometer • TOF Sensor Battery • Types and Capacity Motors • Motor types • Motor capabilities • Application of BLDC motors in drones	**CO-2**
TSO 3a. Explain four types of motion used indrone's operation.	**Unit-3.0 Drone controller and motion** Propulsion and Vertical Motion Controller and Flying Instructions	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3b. Describe the working and applicationsof Electronic speed controller. TSO 3c. Explain the working principle of Flight controller unit used in drone. TSO 3d. Explain Radio communication unit used in drone. TSO 3e. Explain the communication of Flight controller board with motor, ESC andsensors with suitable diagram	Electronic speed Controller (ESC) Flight Controller Board (FCB) Radio Communication Transmitter and Receiver for radio signal	
TSO 4a.Describe utility of different communication port used in drone. TSO 4b. Identify different types of connectors and write their specifications TSO 4c. Explain the use of drone simulatorsoftware and hardware.	**Unit-4.0Connections and Interfaces of Devicesin Drone and Drone Simulator** Communication Port • PWM • RS232, RS422, RS485 • UART • CAN • I2C Different types of connectors and its specification Drone Simulator software Drone simulator Hardware	**CO-4**
TSO 5a.Write basic code in Python. TSO 5b. Explain structure and components of a Python program. TSO 5c. write syntax of loops and decision statements in Python. TSO 5d. Explain steps to create functions and pass arguments in Python.	**Unit-5.0 Introduction to Python for Drone** Python programing refreshers for IoT, AI andDrone Integration of devices with cloud services Microsoft Azure, AWS	**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: P2400504D

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1 Choose suitable materials for making drone frame.	1.	Determine the strength of materials used in drones frame.	CO-2
LSO 2 Select suitable materials for making drone propellers.	2.	Determine the strength of materials used in drones Propellers.	CO-2
LSO 3 Use appropriate battery as per need of flight time for specific drone application.	3.	Test different parameters of batteries used in drones	CO-2
LSO 4 Identify suitable motors as per payload of specific drone application.	4.	Test motors suitable for specific Drone application.	CO-2
LSO 5 Operate Gyro sensor and Accelerometer.	5.	Test and measure Gyro sensor and Accelerometer and their characteristics.	CO-2
LSO 6.1 Identify different sensors based on their characteristics. LSO 6.2 Interface different types of sensor in drone.	6.	Test different sensors and their characteristics with Microcontroller based Flight controller board.	CO-2, CO-3
LSO 7 Demonstrate four type of drone motion.	7.	Determine thrust/torque of motor by changing different drone motion	CO-2, CO-3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 8.1 Configure Flight control board (FCB) LSO 8.2 Demonstrate use of Flight control board (FCB	8.	Test and troubleshoot Flight control board (FCB).	CO-3
LSO 9.1 Measure various parameters of sensor LSO 9.2 Interface sensor with flight controller board.	9.	Test and perform communication of Flight control board (FCB) with sensor	CO-3, CO-2
LSO 10 Use motor with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with motor.	CO-3, CO-2
LSO 11 Interface ESC with flight controller board.	11.	Test and perform communication of Flight control board with ESC.	CO-3
LSO 12 Configure radio communication device to control drones	12.	Test and perform communication of Flight control board with RF transceiver.	CO-3
LSO 13.1 Identify different types of ports and connectors of drone. LSO 13.2 Assemble drone component.	13.	Test Hardware assembly for drone.	CO-4 CO-3
LSO 14.1 Identify different motions in drone simulator. LSO 14.2 Operate drone in simulator for specific task	14.	Perform different motion in drone simulator.	CO-4
LSO 15.1 Write code of loop and decision statement in python. LSO 15.2 Interpret loop and decision statement LSO 15.3 Debug code of loop and decision statement	15.	Build and run loops and decision statements for specific application in Python.	CO-5
LSO 16.1 Make function in python. LSO 16.2 Interpret given function statement LSO 16.3 Debug code of function in python	16.	Build and Run functions for specific application and pass arguments in Python.	CO-5
LSO 17.1 Identify python programming steps to interface drone components. LSO 17.2 Identify error in python program LSO 17.3 Debug the given python program	17.	Write basic programming in python to interface different component of Drones	CO-5, CO-3

L) Suggested Term Work and Self Learning: S2400504D 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:

1.Design drone for simple application.
2.Test different sensors, their characteristics and make chart which are used in different drones' applications.
3.Download 5 videos on drone design with different components. Watch them and write report on it.
4.Write report on Drone application for precision agriculture.
5.Survey nearby electronics shop and Prepare report of list of drone component and its specification.
6.Visit nearby tool room, small industry, Drone training institute facilities. Prepare report of visit with special comments of drone technology used, material used, cost of printed component.

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: T2400504E

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain CAD-CAM and related terminologies. *TSO 1b.* Convert the given CAD file format into others. *TSO 1c.* Transfer the given CAD data to CAM facilities. *TSO 1d.* Classify 3D Printing processes. *TSO 1e.* List the advantages of additive manufacturing processes over conventional manufacturing processes. *TSO 1f.* List typical steps involved in 3D printing of an object from digital model. *TSO 1g.* Explain reverse engineering steps for 3D Printing.	**Unit-1.0 Additive Manufacturing Introduction and CAD** 1.1 CAD-CAM and its integration. 1.2 CAD- Part and Surface modeling. 1.3 CAD file formats. 1.4 Additive v/s Conventional Manufacturing processes. 1.5 Process chain for 3D Printing. 1.6 Classification of 3D Printing Processes. 1.7 Product design and prototyping. 1.8 Reverse Engineering for 3D Printing.	**CO1**
TSO 2a. Explain the given STL interface terminology. *TSO 2b.* Use the given alternative 3D printing interface. *TSO 2c.* Generate STL file for the given CAD file. *TSO 2d.* Repair the given STL file. *TSO 2e.* Apply part orientation and support techniques for the given situation. *TSO 2f.* Perform slicing of the given CAD model using the given slicing software. *TSO 2g.* Generate tool path using simulation software for the given situation.	**Unit-2.0 Data Preparation for 3D Printing** 2.1 STL interface Specification, STL data generation, STL data Manipulation. 2.2 Advantages and limitations of STL file format, Open files, Repair of STL files, 2.3 Alternative 3D Printing interfaces. 2.4 Part orientation and support generation, Factors affecting part orientation, Various models for part orientation determination. 2.5 The function of part supports, Support structure design, Automatic support structure generation. 2.6 Model Slicing and Contour Data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination. 2.7 Tool path generation.	**CO1, CO2**
TSO 3a. Explain the given 3D Printing process. *TSO 3b.* Select FDM 3D Printing materials for the given application. *TSO 3c.* Select FDM based 3D Printing processes parameters for given application with justification.	**Unit-3.0 Additive Manufacturing Techniques** 3.1 Fused Deposition Modeling (FDM), Stereo lithography (SLA), Selective Laser Sintering (SLS), Binder Jetting, Material Jetting, Direct Energy Deposition and Laminate Object Manufacturing. 3.2 FDM based 3D printing process details. 3.3 3D Printing materials and selection for FDM. 3.4 FDM Process parameter for various applications.	**CO3, CO4**
TSO 4a. Identify various Aerospace, Electronics, Health care, Automotive, Construction, Food processing, Machine tool components that can be 3D Printed.	**Unit-4.0 Application of 3D Printing** 4.1 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools	**CO3, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4b. Estimate the cost and time of FDM based 3D printing of the given component.		
TSO 5a. Select suitable 3D Printer (FDM) and software for the given application with justification. *TSO 5b.* Analyze the effect of given FDM based 3D printing process parameters using 3D printer software simulation. *TSO 5c.* List steps to perform 3D scanning of the given object. *TSO 5d.* Repair 3D scanned digital model. *TSO 5e.* Set different FDM 3D printing process parameters to get a sound plastic component.	**Unit-5.0 3D Printers and Software and Scanners** 5.1 Construction details and working of established FDM based 3D printers for plastics parts. 5.2 Accuracy, Precision and Tolerance in 3D printing. 5.3 3D Printer software- Fusion 360, Solidworks, Onshape, Tinkercad, Ultimaker Cura, MeshLab, Simplyfy 3D, Repetier host, Slic3r, etc. – use and operation of anyone. 5.4 3D Scanners and working. 5.5 Producing a part using FDM based 3D Printer.	**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: P2400504E

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Use CAD software. *LSO 1.2.* Prepare digital models of simple 3D entities.	1.	Develop digital models of following simple components using any CAD software: • Nut • Bolt • Network cable Jack • Coat button • Spoon	CO1
LSO 2.1. Prepare digital models of complex 3D entities and assemblies.	2.	Develop digital models of following assemblies using any CAD software: • Connecting Rod • Piston • Electric switch • Bathroom Tap • Mouse	CO1
LSO 3.1. Surf web for downloading readymade free CAD models. *LSO 3.2.* Convert one CAD file format into another.	3.	Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format.	CO1
LSO 4.1. Use the given Slicing software for 3D Printing. *LSO 4.2.* Perform slicing operation on the given digital model.	4.	Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3.	CO2
LSO 5.1. Use the available 3D printing software. *LSO 5.2.* Selection of 3D printing process and performance parameters.	5.	Analyse the effect of different process parameters, materials on printing time, material required, surface finish, etc. through simulation using 3D printing software on sliced models available from Pr. No. 4	CO3, CO4, CO5
LSO 6.1. Produce single plastic components using available 3D printer. *LSO 6.2.* Perform post processing operations on printed component.	6.	Print one single component on available FDM based 3D printer with PLA/ABS material	CO3, CO4, CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 7.1. Select appropriate layer thickness, tolerance, fit. *LSO 7.2.* Produce an assembly of plastic components using available 3D printer.	7.	Print one assembly on available FDM based 3D printer with PLA/ABS material	CO3, CO4, CO5
LSO 8.1. Choose suitable material for printing flexible structure (assembly of same small pieces to give flexible fabric effect). *LSO 8.2.* Choose suitable design/shape to create a flexible type structure. *LSO 8.3.* Produce flexible plastic structure using available 3D printer.	8.	Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect)	CO3, CO4, CO5
LSO 9.1. Selection of 3D printing process parameters.	9.	Change printing process parameters and repeat experiment number 6.	CO4, CO5
LSO 10.1. Use of available 3D scanner. *LSO 10.2.* Develop 3D digital model using scanning approach. *LSO 10.3.* Modeling of complex 3D objects using 3D scanning.	10.	Scan the given complex component using available 3D Sanner.	CO5
LSO 11.1. Produce a complex plastic structure using available 3D printer and scanner. *LSO 11.2.* Apply Reverse Engineering approach to exactly 3D print an existing real object.	11.	Print the 3D scanned digital model of Pr. No. 10 on available FDM based 3D printer with PLA/ABS material	CO5

L) Suggested Term Work and Self Learning: S2400504E 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. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.
2. Download 5 videos on 3D printing of different components, watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
3. Print two pieces of same components using ABS and PLA and compare their strength, surface roughness, weight, cost.
4. Download two 3D printing free software and try to check their compatibility with your lab printer.

c. Other Activities:

1. Seminar Topics:
   - Commercially available 3D printers and software.
   - Strength of 3D printed Plastic components as compared to Die cast Plastic components.
   - Properties of PLA and ABS 3D printing materials.
   - Reverse engineering application of 3D Printing.
2. Visits: Visit nearby tool room/industry with 3D Printing facilities. Prepare report of visit with special comments of 3D printing technique used, material used, single component/batch production/mass production and cost of printed component.

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 thecompletion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

J) Theory Session Outcomes (TSOs) and Units: T2400504F

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a Describe Industry 4.0 and its component TSO.1. b Explain different types of automation systems TSO.1.c Identify the type of automation used in a given industry TSO.1.d Analyze the working of industrial processes and products for automation. TSO.1.e Select principles and strategies for automation for a given situation using 4R's and 1U TSO.1. f Select criteria for factory automation and processes automation for a given industry. TSO.1. g Describe briefly different systems used for industrial automation. TSO.1.h Describe IOT, IIOT and role of robots with respect to automation.	**Unit-1.0 Overview of Industrial Automation** Introduction to Industry 4.0 and its components, Issues and challenges in automation Need of automation in industries, Principles and strategies of automation, factory automation, process automation Basic elements of an automated system, Structure of Industrial Automation Advanced automation functions, Levels of automations Industrial control Systems- Process andDiscrete system Types of automation system: Fixed, Programmable, Flexible IntegratedAutomation and its application Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives. Introduction to Internet of Things (IoT) and Industrial Internet of Things (IIOT) and its application in Automation. Role of robots in automation and its components.	**CO1**
TSO.2. a Explain PLC and list its advantages over relay systems. TSO.2.b Distinguish between PLC and a PC, PLC and dedicated controllers. TSO.2.c List the types of PLCs and brands available in the market. TSO.2.d Describe the function of each block of a PLC with the help of a block diagram. TSO.2.e Describe the basic sequence of operation of a PLC with a simple example. TSO.2.f Explain different PLC programming languages withsimple examples. TSO.2.g Describe a simple PLC programming using ladder logic specifying I/O addressing TSO.2.h List the applications of PLC	**Unit-2.0 Fundamentals of PLC** Introduction to PLC, evolution of PLC • Comparison of PLC and Personal Computer(PC) • Comparison of PLC and dedicated controllers like PAC and CNC • Types of PLC – Fixed, Modular and their types • Different brands of PLCs available in the market Building blocks of PLC -CPU, Memory organization, Input-Output modules (Discrete and Analog) Specialty I/O Modules, Power supply PLC programming languages with simpleexamples: • Functional Block Diagram (FBD), • Instruction List. • Structured text, • Sequential Function Chart (SFC), • Ladder Programming PLC I/O addressing in ladder logic Simple programming example using ladderlogic Applications of PLC: Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature control, Conveyor system control	**CO2**
TSO.3.a Identify the commonly used input field devices in PLC installations along with	**Unit 3.0 – Sensors and Input Field Devices**	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
their symbols. TSO.3.b Draw symbol of various switches used in PLC installations describing the function of each switch. TSO.3.c Identify the various digital input devices used in a PLC installation. TSO.3.d Identify the commonly usedsensors as input field devices found in PLC installations. TSO.3.e Describe the working of different types of discrete sensors giving their applications. TSO.3.f Describe the working of different types of advanced sensors giving their applications. TSO.3.g Select Sensors as per the given requirement for ecofriendly automation	Analog input devices-Electromagnetic relays,Contactors, Motor starters, Manually operated Switches Toggle switch, pushbutton switch, knife switch and selector switches Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols Discrete/Digital Input device, Constructionand working of Sensors • Proximity sensors- Inductive, Capacitive, Optical and ultrasonic Advanced sensors- Construction and workingof • Temperature sensors- Thermistor, Thermocouple and Resistance temperature Detector (RTD) • Liquid level sensor -Capacitive and Ultrasonic • Force -Strain/Weight sensors • Flow sensors – turbine flow sensor • Pressure sensors- Linear Variable Differential Transformer (LVDT) • Inclination sensor -Inclinometer • Acceleration sensor- Accelerometer Angular and linear position sensor	
TSO.4.a Classify the actuators. TSO.4.b Describe the construction and working of a given actuator. TSO.4.c Explain the basic principle of operation of a given actuator. TSO.4.d Differentiate between hydraulic and pneumatic actuators TSO.4.e Explain the basic principle of operation of a given control valve. TSO.4.f Select actuators and valves as per the given requirement for ecofriendly automation. TSO.4.g Develop different hydraulic and pneumatic circuits for simple application. TSO.4.h Identify the commonly used output field devices in PLC installations TSO.4.i Draw the symbol of various output devices used in PLC installations describing the function of each. TSO.4.j Select output devices for a PLC installation as per the requirement.	**Unit 4.0- Actuators and Output Devices** Introduction to actuators, Classification ofactuators Mechanical actuators -Translational and rotation motion, kinematic chains, cams, gears, belt and chain drives, bearings Hydraulic and Pneumatic actuators- linear and rotary actuators, single and doubleacting cylinder, directional, process and pressure control valves Electrical actuators • Electromechanical actuators Construction, working and application of Stepper motors, AC/DC Servo motors,BLDC Motor (Very brief) • Electrohydraulic actuators-Construction, working and application of Electro- hydrostatic actuator (EHA), ON/OFF Electro-hydraulic Rotary Actuator (E2H90, Control Valve Rotary Actuator (E2HR), Solenoid valve Thermal actuators -Construction, workingand application of Hot-And-Cold-Arm Actuators, Chevron-Type Actuators 4.6 Magnetic actuators- Construction, working principle and application of Moving coil actuators, moving magnet actuator, Moving iron actuator Selection criteria of actuators Other Output devices- Indicators, Alarms Pilot Lights, Buzzers, Valves, Motor starters, Horns and alarms, Stack lights Control relays,Pumps and Fans.	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5.a Describe the basic process control system with the help of a block diagram TSO.5.b Explain the types of control available in a process control TSO.5.c Describe the different types of controllers in a closed loop systemwith the help of a block diagram TSO.5.d Describe the construction, working and application of a given control system components.	**Unit 5.0 – Control System** Block diagram of a basic control system Open and closed loop system, their transfer function First order and second order system and their output response and parameters Different types of inputs-step and ramp Types of control – On-off, Feed forward, Open loop and closed loop control and Transfer function Controllers in closed loop control • Proportional Controller (P Controller) • Integral Controller (I Controller) • Derivative controller (D- Controller) • P-I Controller • P-D Controller PID Controller	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504F

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify various building blocks and major automation components in a given robotic system LSO 1.2 Identify various building blocks and major automation components in a given electrical drives	1.	Identify major automation components in a given system	CO1
LSO 1.3 Analyze and plan the steps to automate the given system.	2.	Analyze given traditional machine in the laboratory for and identify thesteps and components required to automate it.	
LSO 1.4. Identify the building blocks of a given typical SCADA system LSO 1.5. Identify the symbol library of SCADA software	3.	Use Scada software for simple application	
LSO 2.1 Identify the various parts and front panel status indicators of the given PLC.	4.	Observe various parts and frontpanel indicators of a PLC	CO2
LSO 2.2 Identify different input and output devices that can be connected to a given PLC.	5.	Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC	
LSO 2.3 Test the analog input and output lines of the given PLC.	6.	Identify Analog input and output lines of a PLC	
LSO 2.4 Test the digital input and outlines of the given PLC.	7.	Identify digital input and output lines of a PLC	
LSO 2.5 Use PLC to control the devices like Lamp, Alarm, motor using push button switches	8.	Practice using PLC to control various digital and analog output devices	
LSO 3.1. Test the response of digital inductive proximity sense or used to detect different types of materials	9.	Identify different types of digital inductive proximity sensor and itsuse	CO3
LSO 3.2. Test the response of digital capacitive proximity sensors used to detect o different materials	10.	Identify different types of digital capacitive proximity sensor and itsuse	
LSO 3.3. Test the response of digital optical proximity sensor used to detect different materials	11.	Identify different types of digital optical proximity sensor and its use	

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.4. Test the response of digital ultrasonic proximity sensors used to detect different materials	12.	Identify different types of digital ultrasonic proximity sensor and itsuse	
LSO 3.5. Use thermistor to measure temperature of a given material	13.	Identify different types ofthermistor and its use	
LSO 3.6. Use Thermocouple to measure the temperature of a given liquid and plot the output voltage versus temperature	14.	Observe the conversion of temperature to electric parameter conversion of a Thermocouple	
LSO 3.7. Use RTD to control the temperature of an oven	15.	Observe different types of RTDs usedin industries for temperature measurement	
LSO 3.8. Use flow sensors to measure the flow of a given liquid or gas	16.	Observe different types of flow sensors used in industries for flow measurement	
LSO 3.9. Use pressure sensors to measure the pressure of a liquid or gas	17.	Observe different types of pressure sensors used in industries for pressure measurement	
LSO 3.10. Use load cell for measurement of mechanical force/weight.	18.	Observe the different types of loadcell used in industries for force/weight measurement	
LSO 4.1 Design and actuate pneumatic circuit for lift control LSO 4.2 Design a pneumatic system that rivets the pockets on jeans LSO 4.3 Design pneumatic circuit to open and close the security gate and control the speed. LSO 4.4 Design a circuit for speed control of hydraulic motor meter out circuit by using 4/3 DC valve. LSO 4.5 Design a circuit for speed control of double acting cylinder meter in by using 4/2 dc solenoid valve. LSO 4.6 Designing a circuit for speed control of double acting cylinder meter out by using 4/3 solenoid valve	19.	Design and actuate pneumatic/ hydraulic circuit for the given situation	CO4
LSO 4.7 Direct acting of hydraulic motor	20.	Operate hydraulic motor	
LSO 4.8 Operate stepper motor and control the motor by changing number of steps, the direction of rotation and speed.	21.	Operate stepper motor	
LSO 4.9 Identify the components of thermal and magnetic actuators available in the laboratory. LSO 4.10 Use thermal and magnetic actuators	22.	Thermal and magnetic actuators	
LSO 5.1 Test the output response of a open loop closed loop and feed forward path	23.	Analyze the given system to studyopen loop, closed loop and feed forward path.	CO5
LSO 5.2 Build and test the output response of a first order system for a step input using a CRO	24.	Analyze the given first order system and its transfer function and output response	
LSO 5.3 Build and test the response of a second order system for a step input using CRO. Also mark various parameters	25.	Analyze the given second order system and its transfer function andoutput response	
LSO 5.4 Test the Output response of an on-off and Proportional control-based level control system.	26.	Analyze the given water level control system with on-off, Proportional control.	

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: T2400504G

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Identify the types of the vehicle based on the physical features, specification data and information. TSO 1b. State the advantages of EVs over Conventional IC Engine Vehicles. TSO 1c. Identify different components of Electric Vehicle systems TSO 1d. Explain the functions of different components of the EV	**Unit-1.0Introduction to Electric Vehicle** Review of Conventional Vehicle Engine System Electric Vehicle (EV) • The necessity of Electric Vehicle • Types of Electric Vehicles - Plug-in hybrid - Battery electric vehicle - Hybrid electric vehicle - Fuel Cell Electric Vehicle • Advantages of Electric Vehicles Electric Vehicle Components: Motor, Motor Controller, Battery, Battery Management System, and ChargingSystem.	**CO1**
TSO 2a. Explain the general characteristics of motorsused in EV TSO 2b. List different types of motors used in EV TSO 2c. Explain the working principles of motors used in EV applications TSO 2d. Interpret the nameplate ratings of the motorsfor EV applications. TSO 2e. Explain the motor selection criteria forparticular EV applications. TSO 2f. Describe the Mechanical and ElectricalConnections of Motors.	**Unit-2.0 Electric Motors used in EVs** Electric Motors for EV applications • General Characteristics of motors • Types of Motors: DC, Brushless DC, Induction, Permanent Magnet Synchronous Motors, SwitchedReluctance Motors Rating of Motors Selection Criteria Physical Location Connection of Motors: Mechanical Connections and Electrical Connections	**CO2**
TSO 3a. List the batteries used in EVs for energy storage TSO 3b. State various parameters related to batteries used in EV applications. TSO 3c. Explain the charging and discharging process ofthe given batteries. TSO 3d. Explain the salient features of Lithium Ionbatteries TSO 3e. Explain the Fuel Cell Storage System. TSO 3f. Identify various sensors installed for monitoringBattery condition. TSO 3g. Explain Battery Management System in EV usingBlock Diagram. TSO 3h. **Describe the procedure of battery Disposal andRecycling**	**Unit- 3.0 EV Batteries and Energy Storages** Types of Batteries: Lead Acid, Nickel Based, Lithium Based Battery Parameters Charging (AC) and Discharging (DC) Process Lithium Ion Batteries Fuel Cells, Fuel Cell Storage System Battery Condition Monitoring Battery Management System (BMS) • Need of BMS • Block Diagram of BMS **Battery Disposal and Recycling**	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 4a. Identify different types of diodes andtransistors. TSO 4b. Describe the testing procedure for the givenDiode and Transistor. TSO 4c. Explain the working principles of the givenpower electronic converter circuit. TSO 4d. Describe the types of Charging Systems TSO 4e. Describe different Components of the ChargingSystem TSO 4f. Explain the working of the Charging Systemusing a single-line diagram.	**Unit- 4.0 EV Charging Systems** Power electronics in EV • Power electronics components • Rectifiers • DC to DC Converter • DC to AC Converter Charging System • Types of charging Systems • Components of Charging Systems • Single line Diagram of Charging System	**CO4**
TSO 5a. Understand the Rules and Regulations set by theGovernment for selecting and manufacturing various components of an electric vehicle. TSO 5b. Understand the Policies for E-Vehicles. TSO 5c. Appreciate the importance of the reduction ofgreenhouse gases in the environment.	**Unit- 5.0 Regulatory Requirements andPolicies for EV Industry** Rules and Regulations set by the Indian government for the designer/manufacturer of EVs. Policies in India Global Policies for E- Vehicles. Carbon Footprint Issues	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504G

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1 Use the relevant digital meter for the given application. LSO 1.2 Use a measuring instrument for the given application. LSO 1.3 Use safety kits while working in the laboratory.	1.	• Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc. Practice using Screw Driver Kit, Vernier Caliper, Micrometer, Ampere Meter,Voltage Meter, and Techno-meter. Practice using safety kits.	CO1
LSO 2.1 Identify the motors used in EV applications LSO 2.2 Identify the given motor terminals	2.	• Identification of motors used in EVs	CO2
LSO 3.1 Identify the batteries available in the laboratory. LSO 3.2 Measure an open circuit voltage of the given battery. LSO 3.3 Determine the Ampere -Hour Capacity of the given battery with a given load. LSO 3.4 Test the performance of the given battery with different charging rates and at different ambient temperatures LSO 3.5 Demonstrate the effect on the state of health of the battery after several charge/ discharge cycles. LSO 3.6 Evaluate the temperature cut-off point for the given BMS.	3.	• Testing of Batteries used in EVs • Battery Management System	CO3
LSO 4.1 Identify the Electrical & Electronics components available in the laboratory using Digital Multimeters. LSO 4.2 Test the given power electronic	4.	• Power electronic circuits • Identification of Charging systems	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
components using digital meters LSO 4.3 Identify the given Power Electronic Circuits used in EVs LSO 4.4 Identify the components of the Charging System LSO 4.5 Recognize the types of Charging Systems available in the Laboratory			

L) **Suggested Term Work and Self-Learning: S2400504G** 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. Collect the information related to the performance of different types of electric vehicles and prepare acomparative report on economic and environmental analysis.
2. Collect specifications of different EVs available in the market.
3. Build and test a prototype circuit of converters used in an electric vehicle.
4. Visit a nearby Electric vehicle showroom or service centre & collect information on different types of motors usedin electric vehicles and prepare a comparative report on their performance,
5. Visit a nearby charging station and prepare a report describing the layout and components of the charging station.

c. Other Activities:

1. **Seminar Topics**:
   - Communication Systems, Sensors and batteries used in Evs.
   - Technological advances in Evs
   - Comparison of EVs manufactured by different companies.

2. **Surveys** – Survey the market and gather information on the electric vehicle manufacturers and submit the report.

3. **Product Development**- Develop an electric vehicle prototype using locally procured hardware components.

d. Self-Learning Topics:

- Global Manufacturers of EV
- Indian Manufacturers of EV
- Motors used in EV
- Batteries used in EV
- Cost comparison of EVs in market

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: T2400504H

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Explain the basic terms used in robotics TSO 1b. Identify components used in robots. TSO 1c. Explain various types of movements. TSO 1d. Distinguish various robots' configurations and their workspace. TSO 1e. Evaluate the degrees of freedom of the given robot. TSO 1f. Specify the methods of conversion of the given linear motion into rotary motion and vice-versa. TSO 1g. List the criteria for selecting robot for the given simple application with justification.	**Unit-1.0 Basics of Robotics Systems** 1.1 Definition, need, brief history of robotics 1.2 Basic Robot terminology, configuration and its working 1.3 Robot components overview - Manipulator, End effecters, Drive system, Controller, Sensors 1.4 Basic structure of a Robot and Classification – Cartesian, Cylindrical, Spherical, Horizontal articulated (SCARA), Parallel; Mechanic alarm, Degree of freedom, Links and joints, Wrist rotation, Mechanical transmission-pulleys, belts, gears, harmonic drive (gear box) 1.5 Linear and Rotary motion and its devices 1.6 Selection criteria for robots	**CO1, CO2**
TSO 2a. Explain the working of various types of End effecters used in robots with diagram. TSO 2b. Explain with sketches the function of the given sensing device used in a robot. TSO 2c. Describe working of the given sensor used in robot. TSO 2d. Explain the given robot configuration. TSO 2e. Select relevant robot sensors for a given application with justification. TSO 2f. Describe robot machine vision concepts along with block diagram of robot vision system. TSO 2g. Select vision equipment for a given robotic application.	**Unit– 2.0 Robot Components** 2.1 End effecters: types, sketches, working and applications 2.2 Sensing and Feedback devices: Optical sensors, Proximity sensors, LVDT, Thermocouple, RTD, Thermistor, Force sensing – strain gauge, Piezoelectric, Acoustic sensing Feedback devices; Potentiometers; Optical encoders; DC tachometers; 2.3 Robot machine vision: Block diagram of robot vision system, Vision equipment-camera, Imaging Components: Point, Line, Planar and Volume Sensors, Image processing, Part recognition and range detection	**CO3**
TSO 3a. Explain with sketches the function of the specified actuator used in a robot. TSO 3b. Differentiate between open loop and closed loop systems. TSO 3c. Explain various robotic controls. TSO 3d. Describe block diagrams of the given control system. TSO 3e. Specify drive system used for robotic control as per	**Unit– 3.0 Robotic Drive System and Controller** 3.1 Actuators; Hydraulic, Pneumatic and Electrical drives; linear actuator; Rotary drives 3.2 Control systems: Open loop and close loop with applications and its elements, Servo and non-servo control systems –	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
requirement. TSO 3f. Differentiate the various robot path controls. TSO 3g. Justify the selection of actuators, drives, control system, AC servo motor and path control for making of a robot.	Types, basic principles and block diagram Robot controller; Level of Controller 3.3 AC servo motor; DC servo motors and Stepper motors; 3.4 Robot path control: Point to point, Continuous path control and Sensor based path control	
TSO 4a. Explain various robot programming languages. TSO 4b. Programme robot for a given simple job. TSO 4c. Describe the procedure to simulate the given robot movements using the relevant software.	**Unit– 4.0 Introduction to Robot Programming** 4.1 Need and functions of programming 4.2 Methods of robot programming: Manual Teaching, Teach Pendant, Lead through, Programming languages. Programming with graphics. 4.3 Programming languages: Types, features and applications 4.4 Controller programming 4.5 Simulation for robot movement	**CO5**
TSO 5a. Select a robot for the given application. TSO 5b. Describe various applications of Robotics. TSO 5c. Explain safety norms in robot handling. TSO 5d. Describe maintenance procedure for the given robot. TSO 5e. Describe common problems in robot operations and suggest remedial action.	**Unit– 5.0 Robotics Applications and Maintenance aspects** 5.1 Application robots including special types 5.2 Robot maintenance: Need and types 5.3 Common troubles and remedies in robot operation. 5.4 General safety norms, aspects and precautions in robot handling	**CO1, CO2, CO3, CO4**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504H

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1 Identify parts of Robot on the basis of function. LSO 1.2 Identify joint type & link parameters (link length, link twist, and Link offset), rotational vs. linear motion, used in robot.	1.	Identify components and different configurations of robots.	CO1
LSO 2.1Identify different types of robot end effecters. LSO 2.2 Use Mechanical grippers to hold objects. LSO 2.3 Use Vacuum grippers to hold objects.	2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2
LSOs 3.1 Assemble the complete robot using the components as per the procedure LSO 3.2 Apply the functionalities available in rotor trainer kit. LSO 3.3 Test for various configurations. LSO 3.4 Test for various degrees of freedom.	3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2
LSO 4.1 Identify various types of sensors used in robotic application. LSO 4.2 Measure angular motion using Synchros. LSO 4.3 Detect objects using optical sensors.	4.	Use different types of robotic sensors for a specific situation.	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 5.1 Interface stepper motor. LSO 5.2 Control robot with stepper motor interfacing.	5.	Perform robot control with stepper motor interfacing	CO3
LSO 6.1 Draw the labelled sketch of individual parts and robot arm. LSO 6.2 Assemble the arm using the parts as per the procedure. LSO 6.3 Interface the motor drive and operate.	6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3
LSO 7.1 Use open source or available relevant software to develop pick and place programme. LSO 7.2 Perform simulation.	7.	Perform pick and place operation using Simulation Control Software.	CO5
LSO 8.1 Develop programme for using a robot arm with three degrees of freedom. LSO 8.2 Execute the programme.	8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5
LSO 9.1 Apply stepper motor control with direction control and step control logic simulation. LSO 9.2 Perform basic PLC programming LSO 9.3 Develop ladder logic programs LSO 9.4 Use programming timers	9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5
LSO 10.1Develop a program for a simple application. LSO 10.2 Execute the robot programme.	10.	Program to execute a simple robot application (like painting, straight welding) using a given configuration.	CO4, CO5

L) Suggested Term Work and Self Learning: S2400504H 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 stair climb robot using robotic components.
2. Develop RF controller robot using robotic components.
3. Develop robot for metal detection application using robotic components.
4. Develop line follower robot using robotic components.
5. Develop solar floor cleaner robot using robotic components.
6. Develop solar tracker system using robotic components.
7. **Develop a greenhouse managing robot for a horticulture application.**

c. Other Activities:

1. Seminar Topics: Recent developments in the field of robotics
2. Visits: Visit an automation industry and prepare report for various types of robots employed there and details of any one type of special purpose robot used
3. Case Study: Identify a robotic application in automobiles and present a case study
4. Self-Learning Topics:
   - History of industrial robot
   - Sociological consequences of Robots

J) Theory Session Outcomes (TSOs) and Units: T2400504I

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the use of transformers in power systems. *TSO 1b.* List the various types of transformers. *TSO 1c.* Explain the exact and approximate equivalent circuits of a transformer. *TSO 1d.* Explain the relations between input and output quantities through phasor diagrams. *TSO 1e.* List the necessity of open and short circuit tests and explain how they should be performed. *TSO 1f.* Explain the concept of voltage regulation and efficiency and list the ways to improve them in transformers.	**Unit-1.0 Transformer Fundamentals** 1.1 Use of Transformers. 1.2 Types of Transformers. 1.3 The equivalent circuit of a transformer. 1.4 Phasor Diagrams 1.5 Open circuit and short circuit tests. 1.6 Voltage regulation and efficiency.	**CO1**
TSO 2a. Explain the different constructional parts of a transformer. *TSO 2b.* List the different types of core and its construction and sections. *TSO 2c.* Explain the different types of windings and the necessity of insulation. *TSO 2d.* Explain the different types of cooling. *TSO 2e.* List the different tank structure. *TSO 2f.* Explain the necessity of transformer oil.	**Unit-2.0 Transformer Construction** 2.1 Constructional Parts. 2.2 Core Construction and Core Sections. 2.3 Windings and Insulation. 2.4 Cooling: Natural Cooling, Forced Oil cooling and Internal Cooling. 2.5 Tanks. 2.6 Transformer oil.	**CO1, CO2**
TSO 3a. Explain the different connections and vector groups. *TSO 3b.* Explain the three phase to two phase and three phase to single phase connection. *TSO 3c.* List the different types of tap changing positions. *TSO 3d.* Explain the open delta configuration.	**Unit-3.0 Transformer Operation** 3.1 Connection for transformers: star/star, star/delta, delta/star. Zig-zag/star. 3.2 Three phase to two phase connections: Scott connection. 3.3 Three phase to one phase connection. 3.4 Tap changing: On-load and off-load tap changing positions. 3.5 Three phase banks of single phase transformers: Open delta configuration.	**CO3, CO4**
TSO 4a. List the classification of transformer protection. *TSO 4b.* Explain the Buchholz relay and its use in transformers. *TSO 4c.* Explain the different types of transformer protection and the use of indicators in transformers.	**Unit-4.0 Transformer Protection** 4.1 Classification of transformer protection. 4.2 Buchholz Relay 4.3 Differential protection 4.4 Over current, Over voltage and surge protection. 4.5 Temperature indicators, oil level indicators, oil preservation systems, silica gel breather, gas sealed conservators.	**CO3, CO4**

TSO 5a. Explain the objectives of testing of transformers. *TSO 5b.* List the different types of tests. *TSO 5c.* Explain different transformer tests including the Sumpner's test. *TSO 5d.* Explain the insulation and impulse tests.	**Unit-5.0 Transformer Testing** 5.1 Objectives of transformer testing. 5.2 Polarity Test, DC Resistance and voltage ratio tests. 5.3 Magnetizing current and core loss tests. 5.4 Temperature rise test, back to back connection. 5.5 Insulation and Impulse Tests.	**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: P2400504I

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Knowledge of performing these tests on LV and HV sides. *LSO 1.2.* Determine the equivalent circuit parameters of a transformer.	1.	Conduct open circuit and short circuit tests on a transformer	**CO1**
LSO 2.1. Explain the concept of regulation and efficiency at different loads.	2.	Perform load tests on a transformer.	**CO1**
LSO 3.1. Perform Heat run test on a transformer without being subjected to physical load. *LSO 3.2.* Explain the concept of applying rated voltage and rated current through phantom loading.	3.	Perform the Sumpner's test on two identical transformers.	**CO1**
LSO 4.1. Understand various three phase transformer connections and vector groups.	4.	Perform various connections on three phase transformers and understand vector groups.	**CO2**
LSO 5.1. Explain the Scott connection. *LSO 5.2.* Understand the necessity of conversion.	5.	Three phase to Two phase connection	**CO3, CO4, CO5**
LSO 6.1. Understand the necessity of conversion.	6.	Three phase to single phase connection.	**CO3, CO4, CO5**
LSO 7.1. Explain the concept of open delta configuration in case of any single phase transformer failure.	7.	Perform open delta connection from banks of single phase transformers.	**CO3, CO4, CO5**
LSO 8.1. Explain the concept of CT connections in differential protection. *LSO 8.2.* Understand the working principle of Buchholz Relay.	8.	Understand the differential protection with different CT connections and the working of Buchholz relay.	**CO3, CO4, CO5**
LSO 9.1. Explain the concept of dot convention.	9.	Perform a polarity test on a transformer.	**CO4, CO5**
LSO 10.1. Understand the transformer's failures.	10.	Perform the impulse test on a transformer.	**CO5**

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: T2400504J

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the need for Optical fiber and 5G Technologies. *TSO 1b.* Define numerical aperture. *TSO 1c.* Classify optical fiber modes with proper sketch. *TSO 1d.* Explain with examples modes of wave propagation through an optical fiber. *TSO 1e.* Classify optical fiber	**Unit-1.0 Introduction of Optical Fibers** 1.1 Introduction to general optical fiber communication (OFC) system 1.2 Basic optical laws and definitions 1.3 Structure of optical cable- core, cladding, cover 1.4 Numerical aperture 1.5 Optical fiber modes and configurations–mode analysis for optical propagation through fibers 1.6 Classification of optical fiber, single mode fiber, graded index fiber	**CO1**
TSO 2a. Explain the reason for attenuation in the optical fiber cable. *TSO 2b.* Describe fiber losses with examples. *TSO 2c.* Explain various aspects of dispersion *TSO 2d.* Describe how to optimize the dispersion *TSO 2e.* Describe how to generate R-I profile *TSO 2f.* calculate cut-off wavelength, and mode field diameter	**Unit-2.0 Transmission Characteristics of Optical Fiber** 2.1 Attenuation in Optical Fiber 2.2 Fiber Losses (Material, Scattering, Splice, Absorption, Radiative) 2.3 Dispersion (Chromatic, Modal, Material, Waveguide, Polarization mode) 2.4 Dispersion optimization of single mode fiber, characteristics of single mode fiber 2.5 R-I Profile 2.6 Cut off wavelength, dispersion calculation, and mode field diameter	**CO2**
TSO 3a. Explain the need for a source and detector in an optical fiber	**Unit-3.0 Optical Sources and Detectors** 3.1 Sources- Intrinsic and extrinsic	**CO3**

system. *TSO 3b.* Describe about direct and indirect bandgap materials used for make fiber sources. *TSO 3c.* Describe the basic operating principle of optical sources such as LED and Lasers in detail. *TSO 3d.* Describe the detection process and noise inthe optical detectors.	material,direct and indirect band gaps 3.2 LED structures- Surface-emitting and Edgeemitting LED 3.3 Optical Source: Laser diodes, Laser source driver circuit,modes and threshold conditions, Rate equations, external quantum efficiency, resonant frequencies, single-mode laser,external modulation, temperature effort 3.4 Detectors: PIN photodetector, Avalanchephotodiodes, Photodetector noise, noisesources, SNR, detector response time, Avalanche multiplication noise, and temperature effects	
TSO 4a. Describe the basic operations of the given type of optical preamplifier. *TSO 4b.* Analyze the performance of the given optical receiver in detail. *TSO 4c.* Describe the power launching and lensing with respect to the optical fiber system. *TSO 4d.* Describe the fiber splicing process with the help of a suitable sketch. Describe the procedure of optical power measurement.	**Unit-4.0 Optical Receiver, Coupling andMeasurements** 4.1 Basic receiver operation, preamplifiers, digital signal transmission, error sources,Front-end amplifiers, probability of error, and receiver sensitivity. 4.2 Power Launching, Lensing Schemes for Coupling Management, coupling losses, 4.3 Fiber Splicing, and Optical power measurement	**CO4**
TSO 5a. Explain the historical development and technological advancements of wireless communication. *TSO 5b.* Compare different wireless communication systems on the basis of technology, data rate, spectrum, QoS, advantages, and services. *TSO 5c.* Describe WLAN principle, standards, and their practical applications. *TSO 5d.* Describe the concept, architecture, and applications of WLL systems, and their role in telecommunications.	**Unit-5.0 Fundamentals of 5G Communication** 5.1 Evolution of mobile radio systems 5.2 Types of Wireless Communication Systems 5.3 Overview of modern mobile communication system (2G, 3G, 4G, 5G) 5.4 Wireless Local Area Network 5.5 Wireless Local Loop 5.6 Service Requirement: Data Rate, Number of users, mobility, energy consumption, spectrum, service quality	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504J

Practical/Lab Session Outcomes (LSOs)	Sl. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify the fiber cable, optical source, detector and other components of the given optical fiber system.	1.	Identification of various components of Optical fiber communication system	**CO1**
LSO 2.1. Measure the numerical aperture of the given optical fiber cable.	2.	Measurement of Numerical aperture	**CO1**
LSO 3.1. Measure the attenuation and signal loss in optical fiber using optical time-domain reflectometry (OTDR). *LSO 3.2.* Measure the signal loss in optical fibers using optical time-domain reflectometry (OTDR).	3.	Attenuation and Signal Loss Measurement	**CO2**
LSO 4.1 Perform tests on fiber optic cables to identify faults using tools like visual fault locators and OTDR. *LSO 4.2* Troubleshoot faults using tools like visual fault locators and OTDR.	4.	Fiber Optic Cable Testing and Troubleshooting	**CO2, CO3**
LSO 5.1 Test the performance of the given optical source.	5	Performance of optical source (LED, LASER)	**CO3**
LSO 6.1. Test the performance of the given optical detector.	6	Performance of optical doctor (Photo diode, PIN diode)	**CO3**
LSO 7.1. Learn techniques for splicing optical fibers. *LSO 7.2.* Install connectors, crucial for network deployment and maintenance.	7	Optical Fiber Splicing and Monitorization	**CO4**
LSO 8.1. Conduct BER test. *LSO 8.2.* Evaluate the performance of optical communication links. *LSO 8.3.* Evaluate the reliability of optical communication links.	8	Analyze the optical communication system.	**CO4**
LSO 9.1. Noise Modelling and its effect on Wireless Data Transmission	9.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	**CO5**
LSO 10.1 Effect of fading on wireless data transmission in terms of outage probability	10.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	**CO5**

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: (Not Applicable)

K) Suggested Laboratory (Practical) Session Outcomes (LSOs)and List of Practical: T2400505

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment / Practical Titles	Relevant Cos Number(s)
LSO1.1	Identify the skills of a Successful Entrepreneur.	1.	Profile summary (about 500 words) of a successful entrepreneur indicating milestone achievements.	CO1
LSO1.2	Determine the charms of entrepreneurship and start-ups	2.	Discussion session with your institute's pass-out students who are successful entrepreneurs.	CO1
LSO1.3	Perform strength, weakness, opportunity, and threat analysis.	3.	SWOT analysis to arrive at your business idea of a product/service.	CO1
LSO1.4	Develop sales & marketing skills	4.	Sale of products to different customers	CO1
LSO2.1	Use creativity and put up a stall in a funfair and write a report of profit/loss.	5.	Creativity and Innovation in Business	CO2
LSO2.2	Innovate a point of sale for a product.	6.	Exhibition cum sale of products prepared out of waste.	CO2
LSO2.3	Generate different business opportunities.	7.	Business ideas (product/service) for intrapreneurial and entrepreneurial opportunities through brainstorming.	CO2
LSO1.5	Discover entrepreneurial potential.	8.	Self–assessment test to discover entrepreneurial traits.	CO1
LSO2.4	Classify domain-specific industries on business parameters.	9.	Survey industries (your stream), and grade them according to the level of scale of production, investment, turnover, and pollution to prepare a report on it.	CO2
LSO3.1	Identify entrepreneurship support institutions beneficial for the enterprise.	10.	Compile the information from the government agencies that will help you set up your business enterprise.	CO3
LSO3.2	Select a suitable funding scheme for the enterprise.	11.	Visit a bank / financial institution to enquire about various funding schemes for small-scale enterprises.	CO3
LSO3.3	Analyze the assessment procedure of bank loans.	12.	Collect loan application forms of nationalized banks / other financial institutions.	CO3
LSO3.4	Compute the financial needs of the business enterprise	13.	Compile the information from financial agencies that will help you set up your business enterprise.	CO3
LSO2.5	Select a business opportunity.	14.	Identify the business opportunity suitable for you.	CO2
LSO3.5	Carry-out market survey for a product.	15.	Market Survey for an Enterprise	CO3

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment / Practical Titles	Relevant Cos Number(s)
LSO4.1	Find out rates of industrial lands and buildings in different industrial areas.	16.	Industrial land and building for Entrepreneurship.	CO4
LSO4.2	Craft a vision statement and enabling mission statements for your chosen enterprise.	17.	Vision statement and mission statement for a Startup.	CO4
LSO4.3	Select a suitable name and brand for the business enterprise.	18.	Branding for a product and a Company.	CO4
LSO4.4	Design a logo, letterhead, and visiting card for the business.	19.	Marketing communication for business.	CO4
LSO4.5	Prepare a techno-feasibility report	20.	A techno-feasibility report of a chosen product/service.	CO4
LSO4.6	Prepare a business plan for the enterprise.	21.	Business plan for the enterprise.	CO4
LSO4.7	Develop a website for the business	22.	Online Marketing for Business.	CO4
LSO3.6	Prepare a set of short-term, medium, and long-term goals for starting a chosen small-scale enterprise.	23.	Goal setting for an enterprise.	CO3
LSO3.7	Prepare an advertising campaign for your chosen product/service.	24.	Marketing management for an enterprise.	CO3
LSO3.8	Establish a supply chain network for the enterprise.	25.	Supply Chain Management	CO3
LSO3.9	Establish a Market intelligence mechanism.	26.	Market Intelligence for Entrepreneurship	CO3
LSO4.8	Compile information about various insurance schemes covering different risk factors.	27.	Risks in business	CO4
LSO4.9	Calculate the breakeven point for the business idea chosen by you.	28.	Breakeven point for a business	CO4

L) Suggested Term Work and Self-Learning: S2400505 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 inline with the targeted COs.

i. Prepare a list of successful Entrepreneurs in the city.
ii. Prepare a list of startups in the city.
iii. Prepare a list of the nearest incubators.
iv. Prepare a list of Angel Investors and Venture Capitalists.

i. Choose any product and study its supply chain.
ii. Arrange brainstorming sessions for improvement of any product.
iii. Choose any advertisement and analyse its good and bad points.
iv. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
v. Study schemes for entrepreneurship promotion of any bank.