

Curriculum of Diploma Programme

in

Electrical 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	CourseTitles	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				
2420501	PCC	Switchgear and Protection	03	-	04	02	09	06
2420502	PCC	Solar & Wind Power Technology	03	-	04	02	09	06
2420503	PCC	Energy Conservation and Audit	02	-	01	02	05	04
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
2420506	PSI	Summer Internship- II (After 4 th Sem) / Industrial Training (Common for all programmes)	-	-	02	04	06	03
2420507	PSI	Minor Project (Common for all programmes)	-	-	02	02	04	02
Total			11	-	21	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 Assessment (ELA)	
2420501	PCC	Switchgear and Protection	30	70	20	30	20	30	200
2420502	PCC	Solar & Wind Power Technology	30	70	20	30	20	30	200
2420503	PCC	Energy Conservation and Audit	30	70	10	15	10	15	150
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
2420506	PSI	Summer Internship- II (After 4 th Sem) / Industrial Training (Common for all programmes)	-	-	20	30	20	30	100
2420507	PSI	Minor Project (Common for all programmes)	-	-	10	15	10	15	50
Total			120	280	120	180	120	180	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 activities.

J) Theory Session Outcomes (TSOs) and Units: T2420501

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the need of protection system.</p> <p><i>TSO 1b.</i> Describe the functions of various elements of protection system.</p> <p><i>TSO 1c.</i> Classify different types of faults.</p> <p><i>TSO 1d.</i> Explain the significance of back up protection.</p> <p><i>TSO 1e.</i> Calculate the short circuit current for the given condition.</p> <p><i>TSO 1f.</i> Select a suitable current limiting reactor for the given situation.</p> <p><i>TSO 1g.</i> Draw single line diagram for the given power system network.</p> <p><i>TSO 1h.</i> Justify the need of per unit system in power system</p>	<p>Unit-1.0 Fundamentals of Protection System</p> <p>1.1 Necessity & the function of protection system</p> <p>1.2 Normal & Abnormal conditions in a power system</p> <p>1.3 Faults: Symmetrical and unsymmetrical</p> <p>1.4 Protective zones: primary & backup Protection</p> <p>1.5 Short circuit fault calculation for symmetrical fault</p> <p>1.6 Current limiting reactors: need & their Arrangements.</p> <p>1.7 Single-line representation of a simple power system</p> <p>1.8 Per unit system: Introduction, simple numerical on PU system.</p>	CO1
<p><i>TSO 2a.</i> Explain the basic terminology related to fuse.</p> <p><i>TSO 2b.</i> Describe the construction & operation of HRC fuse.</p> <p><i>TSO 2c.</i> Explain the operation of isolators.</p> <p><i>TSO 2d.</i> Differentiate between Fuse, circuit breaker and Isolator</p> <p><i>TSO 2e.</i> Explain various current capacity of circuit breaker.</p> <p><i>TSO 2f.</i> Describe arc quenching methods of circuit breaker.</p> <p><i>TSO 2g.</i> Explain the operation of various circuit breakers.</p> <p><i>TSO 2h.</i> Classify the given circuit breaker based on the rating and their uses.</p> <p><i>TSO 2i.</i> Describe the procedure to select a suitable circuit breaker for the given application.</p>	<p>Unit-2.0 Protective Devices</p> <p>2.1 Fuse: necessity of fuse, working principle, material used in fuse.</p> <p>2.2 Types of fuses: Cartridge type, HRC fuse</p> <p>2.3 Isolators: working principle, Vertical break, Horizontal break & Pantograph type.</p> <p>2.4 Circuit Breaker: Arc formation process, methods of arc extinction (High resistance and low resistance), Restriking voltage, RRRV</p> <p>2.5 Miniature Circuit breaker, Moulded case circuit breaker, Residual current circuit breaker and earth leakage circuit breaker (working and their application)</p> <p>2.6 Classification of Circuit Breakers: Miniature circuit breaker (MCB), Moulded Case Circuit Breaker (MCCB), Air Circuit Breaker, Air Blast Circuit Breaker, Oil Circuit breaker- Minimum and bulk oil circuit breaker, vacuum circuit breaker, Sulphur hexafluoride: - working, construction, specifications, and application</p> <p>2.7 Ratings of circuit breakers</p> <p>2.8 Selection of HT & LT circuit breakers</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the significance of protective relays in power systems.</p> <p><i>TSO 3b.</i> Interpret the given quality requirement of the protective relay.</p> <p><i>TSO 3c.</i> Explain various parameters and terminology related to protective relays.</p> <p><i>TSO 3d.</i> Explain the working principle of the given relay.</p> <p><i>TSO 3e.</i> Explain the operation of microprocessor-based relay</p> <p><i>TSO 3f.</i> Classify the overcurrent relay on the basis of its time-current characteristics.</p>	<p>Unit-3.0 Protective Relays</p> <p>3.1 Introduction to protective relays</p> <p>3.2 Fundamental quality requirements: selectivity, speed, sensitivity, reliability, simplicity, economy</p> <p>3.3 Basic relay terminology: Protective relay, relaying time, pick up current, reset current, current setting, plug setting multiplier, Time setting multiplier.</p> <p>3.4 Protective relays: Electromagnetic and Induction relay, thermal relay, overvoltage relay, static relay.</p> <p>3.5 Microprocessor-based protection relay</p> <p>3.6 Characteristics of various Overcurrent relay,</p>	CO1, CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 3g.</i> Classify various types of distance relay</p> <p><i>TSO 3h.</i> Explain the operation of the directional relay.</p> <p><i>TSO 3i.</i> Describe the operational aspects of differential protection scheme.</p>	<p>3.7 Distance relay: Reactance relay, impedance relay and Mho relay.</p> <p>3.8 Directional relay: need and operation</p> <p>3.9 Differential protection</p>	
<p><i>TSO 4a.</i> Classify the different types of faults in an alternator.</p> <p><i>TSO 4b.</i> Explain the given protection scheme used for the alternator.</p> <p><i>TSO 4c.</i> Classify the various types of faults in a motor.</p> <p><i>TSO 4d.</i> Explain the protection scheme for the given motor.</p> <p><i>TSO 4e.</i> Classify different types of faults in a transformer.</p> <p><i>TSO 4f.</i> Explain the given protection scheme in a transformer.</p> <p><i>TSO 4g.</i> Describe the operation of Buchholz relay.</p> <p><i>TSO 4h.</i> Explain the operation of differential protection.</p>	<p>Unit-4.0 Alternator, Motor and Transformer Protection</p> <p>Alternator</p> <p>4.1 Abnormalities and faults</p> <p>4.2 Protection: Overcurrent, overvoltage-undervoltage, earth fault, overheating and field failure.</p> <p>4.3 Reverse watt metric relay</p> <p>Motor</p> <p>4.4 Abnormalities & faults</p> <p>4.5 Protection: Overcurrent, Overload, Overvoltage, Undervoltage, overheating.</p> <p>Transformer</p> <p>4.6 Abnormalities and faults</p> <p>4.7 overcurrent, earth fault and overheating protection</p> <p>4.8 Buchholz relay- Construction, operation, merits and demerits</p> <p>4.9 Differential protection: alternator and transformer</p>	CO1, CO2, CO3, CO4
<p><i>TSO 5a.</i> Enlist the various faults in a bus bar and transmission line</p> <p><i>TSO 5b.</i> Explain the given type of differential protection scheme for protection of bus bar.</p> <p><i>TSO 5c.</i> Explain the working of distance protection scheme used in a transmission line.</p> <p><i>TSO 5d.</i> Explain the importance of three-zone protection in a transmission line.</p> <p><i>TSO 5e.</i> Explain the operation of pilot wire protection</p>	<p>Unit-5.0 Busbar & Transmission Line Protection</p> <p>5.1 Bus bar & Transmission line- Abnormalities & Faults.</p> <p>5.2 Bus bar protection- differential protection (low impedance and high impedance).</p> <p>5.3 Transmission line- distance, three zone of protection and pilot wire protection.</p>	CO1, CO2, CO3, CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420501

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant Cos Number(s)
<p>LSO 1.1 Draw a single-line diagram of a 3-phase transmission line.</p> <p>LSO 1.2 Identify symbols of various power system components.</p>	1.	Single line diagram of 3-phase transmission line	CO1
LSO 2.1. Identify symmetrical and unsymmetrical faults using the fault analyzer kit	2.	Identification of symmetrical and unsymmetrical faults using a fault analyzer	CO1
LSO 3.1. Test the performance of HRC fuse by load test	3.	Testing of HRC fuse by load test	CO2
LSO 4.1 Test the performance of MCB by load test.	4.	Testing of MCB by load test	CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant Cos Number(s)
LSO 5.1 Dismantle the circuit breaker available in the laboratory and identify its components.	5.	Dismantling of the given circuit breaker.	CO2
LSO 6.1 Test the performance of MCCB by load test.	6.	Testing of MCCB by load test	CO2
LSO 7.1 Test the performance of ELCB by load test.	7.	Testing of ELCB operation by load test.	CO2
LSO 8.1 Test the performance of the air circuit breaker using the ACB kit.	8.	Testing of Air Circuit Breaker	CO1, CO2
LSO 9.1 Test the performance of the SF6 circuit breaker using the SF6 kit	9.	Testing of SF6 circuit breaker	CO1, CO2
LSO 10.1 Test the performance of the Vacuum circuit breaker using the VCB kit.	10.	Testing of Vacuum circuit breaker	CO1, CO2
LSO 11.1 Test the performance of the overcurrent relay using the overcurrent relay kit.	11.	Testing of overcurrent relay	CO1, CO3
LSO 12.1 Test the performance of the differential relay for a given transformer using a differential relay kit.	12.	Testing of differential relay for given transformer	CO1, CO3, CO4
LSO 13.1 Test the performance of differential relay for a given alternator using a differential relay kit.	13.	Testing of differential relay for given alternator	CO1, CO3, CO4
LSO 14.1 Test the performance of distance relay by distance relay kit	14.	Testing of distance relay for transmission line protection	CO1, CO3, CO5
LSO 15.1 Test the performance of Low impedance differential relay for a given busbar protection kit	15.	Testing of Low impedance differential relay for Busbar protection	CO1, CO3, CO5
LSO 16.1 Test the performance of High impedance differential relay for a given busbar protection kit	16.	Testing of High impedance differential relay for Busbar protection	CO1, CO3, CO5

L) **Suggested Term Work and Self Learning: S2420501** 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.

1. A 3-phase, 20 MVA, 10kV alternator has an internal reactance of 5% and negligible resistance. Find the external reactance per phase to be connected in series with the alternator so that the steady current on short-circuit doesn't exceed 8 times the full load current.
2. Justify the use of reactors in power systems.
3. List out the possible causes of short-circuit in the power system.
4. Explain the importance of base kVA in short circuit calculations.
5. Explain the various arrangements of short-circuit current limiting reactors used in power system.
6. Explain if the change in base kVA affect the value of short circuit current.
7. A circuit breaker is rated as 1500A, 1000 MVA, 33 kV, 3 second, 3 phase oil circuit breaker. Find (i) rated normal current (ii) breaking capacity (iii) rated symmetrical breaking current (iv) rated making current (v) short time rating
8. Explain the importance of short-time rating in circuit breakers.
9. Differentiate between overcurrent and current differential relay based on operation, construction and application.

- 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: T2420502**

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO.1a	Define the given terms related to solar radiation and geometry.	Unit-1.0 Solar PV Systems 1.1 Solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability. 1.2 Solar PV system, Block diagram and its components. 1.3 Solar Cell fundamentals, Technologies- Amorphous, monocrystalline, polycrystalline. 1.4 V-I characteristics of a PV cell, PV module, Panel, array. 1.5 Series and parallel connection PV Cell and panels. 1.6 Batteries: battery capacity, battery charging-rate, battery efficiency, energy and power density, 1.7 PV sizing for a given application 1.8 Power Electronic Converters for Solar Systems. 1.9 Maximum Power Point Tracking (MPPT). 1.10 Off grid and ON Grid solar system.	CO-1
TSO.1b	Describe the general arrangement of solar power plant.		
TSO.1c	Explain the given type of solar cell Technologies.		
TSO.1d	Interpret the V-I characteristics of a PV cell.		
TSO.1e	Describe the series and parallel connection of solar panels.		
TSO.1f	Explain the given term(s) related to battery used in solar PV system.		
TSO.1g	Describe the sizing process of PV solar system for the given applications.		
TSO.1h	Explain the working principle of converter used in solar PV system.		
TSO.1i	Use maximum power point tracking system for tracking the maximum power generation.		
TSO.1j	Describe the features of given type of solar PV system.		
TSO.2a	Explain solar thermal energy systems.		
TSO.2b	Explain Solar absorption and radiation.		
TSO.2c	Explain the working principle of the given solar heating systems.		
TSO.2d	Identify the components of the given solar water heating systems.		
TSO.2e	Interpret the specifications of the given solar water heating systems.		
TSO.2f	Describe the installation and maintenance procedure of the given solar water heating system.		
TSO.2g	Explain the working principle of given type of solar cooking system.		
TSO.2h	Describe the use of solar power for refrigeration and air conditioning.		
TSO.3a	State the History of wind power, Indian and Global statistics.	Unit-3.0 Wind Resource Assessment 3.1 History of wind power, Indian and Global statistics.	CO3
TSO.3b	Calculate the relation between wind speed and power.		

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.3c Interpret the wind resources assessment.</p> <p>TSO.3d Explain the different types of monitoring station instrumentation.</p> <p>TSO.3e Interpret the data related to wind profile of a particular site.</p> <p>TSO.3f Maintain the monitoring station.</p>	<p>3.2 Energy and Power in Wind, Wind energy Dynamics.</p> <p>3.3 Wind Resource assessment;</p> <ul style="list-style-type: none"> • Initial Site identification • Wind speed measurement (Cup anemometer, Ultrasonic anemometer, Propeller Aerometer). <p>3.4 Monitoring station instrumentation: sensors, Data loggers, Data storage Devices, Tower sensors support hardware, grounding and lighting protection.</p> <p>3.5 Data collection and analysis</p> <p>3.6 Installation of monitoring station.</p>	
<p>TSO.4.a Interpret the basic block diagram of WECS.</p> <p>TSO.4.b Explain the given terms related to wind turbine technology.</p> <p>TSO.4.c Classify the given type of wind power plant based on the construction and capacity.</p> <p>TSO.4.d Explain the functions of the given WPP components.</p> <p>TSO.4.e Explain with sketches rotation principle of the wind turbine rotor.</p>	<p>Unit-4.0 Wind Power Systems</p> <p>4.1 Block diagram of wind energy conversion systems (WECS).</p> <p>4.2 Wind turbine terminologies: Cut-in, cut-out and survival wind speed, threshold wind speed, rated power, nominal power and wind power curve.</p> <p>4.3 Types of wind power plant: small and large wind turbine, Horizontal and vertical axis, constant and variable speed, geared, direct drive and semi geared (hybrid)</p> <p>4.4 Major parts and function of WPP: Rotor blades, hub, nacelle, tower, electric substation, nacelle layout of geared turbine, main shaft, electric generators, electronic control panel.</p> <p>4.5 Rotation Principle: Lift and Drag principle, thrust and torque of wind turbine rotor.</p>	CO4
<p>TSO 5.1 Explain the working principle of SWT.</p> <p>TSO.5.2 Explain the working principle of electric generators used in SWT.</p> <p>TSO.5.3. Describe the SWT tower features.</p> <p>TSO.5.4 Describe the maintenance procedure of small wind turbine.</p> <p>TSO.5.5 Describe the maintenance procedure of given type of fault in SWT.</p>	<p>Unit-5.0 Working of small wind turbines (SWT)</p> <p>5.1 Working of SWTs.</p> <p>5.2 Electric generators in SWTs: permanent magnet synchronous generators, induction generators.</p> <p>5.3 SWT towers: lattice tubular type, hydraulic towers, ladders, cables.</p> <p>5.4 Maintenance of small wind turbine:</p> <ul style="list-style-type: none"> • Installation of different types of small wind turbines (SWT). • Preventive maintenance of SWT components. • Common mechanical faults in SWTs. • Common electrical faults in SWTs. 	CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420502

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1. 1. Test the solar cell	1.	Testing of solar cell available in the laboratory	CO1
LSO 1. 2. Test the performance of PV cell, PV module and PV panel	2.	V-I characteristics of a PV cell, module and Panel.	CO1
LSO 1. 3. Connect the solar panels in series and parallel	3.	Series and parallel connection of solar cell.	CO1
LSO 1. 4. Test the battery for its performance	4.	Testing of batteries on No load and with load	CO1
LSO 1. 5. Connect solar panels for the desired load.	5.	Preparation of a solar PV array for 100 watt load using available panels.	CO1
LSO 1. 6. Connect solar inverter with solar PV system	6.	Connection of solar inverter with solar PV system.	CO1
LSO 1. 7. Install PV panel with battery for a given load	7.	Installation of PV panel with battery for a given load	CO1
LSO 1. 8. Install PV panel without battery for a given load	8.	Installing PV panel without battery for a given load	CO1
LSO 2.1. Dismantle solar cooker	9.	Dismantling solar cooker (Box type, Dish type and heat transfer type).	CO2
LSO 2.2. Assemble solar cooker.	10.	Assembling solar cooker (Box type, Dish type and heat transfer type).	CO2
LSO 3.1. Draw the graph different speed and power for small wind power plant	11.	Tabulation of different speed and power for small wind power plant.	CO3
LSO 3.2. Measure of different wind speed using anemometer.	12.	Measurement of different wind speed using anemometer.	CO3
LSO 3.3. Explain the installation of monitoring station.	13.	Do the installation of monitoring station.	CO3
LSO 4.1 Identify given parts of wind power plants	14.	Identification of given parts of wind power plants.	CO4
LSO 4.2 Identify specified parts inside the nacelle of small wind power plants	15.	Identification of specified parts inside the nacelle of small wind power plants.	CO4
LSO 5.1 Check the performance of PMSG.	16.	Test the performance of PMSG.	CO5
LSO 5.2 Check the performance of Induction generator	17.	Test the performance of Induction generator.	CO5
LSO 5.3 Simulate of mechanical faults in SWTs	18.	Simulation of mechanical faults in SWTs.	CO5
LSO 5.4 Simulate of Electrical faults in SWTs.	19.	Simulation of Electrical faults in SWTs	CO5
LSO 5.5 Maintain of small power wind turbine.	20.	Maintenance of small power wind turbine.	CO5

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J) **Theory Session Outcomes (TSOs) and Units: T2420503**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Write the energy scenario of conventional and non-conventional energy sources in India as on date. TSO 1b. Describe briefly energy conservation initiatives by Government of India TSO 1c. Explain the concept of Energy conservation, energy audit and salient features of Energy conservation act 2001. TSO 1d. Differentiate between energy conservation and energy efficiency. Give one example for each. TSO 1e. Describe the role of Bureau of Energy Efficiency (BEE) and TSO 1f. Describe the role of Bihar Renewable Energy Development Agency (BREDA) TSO 1g. Interpret the Star Labeling of the given electrical equipment. TSO 1h. Choose the mandatory and voluntary appliances from the given list of various star labelled appliances	Unit-1.0 Energy Conservation Basics 1.1 Energy Scenario: Primary and Secondary energy sources, Energy demand and supply, National scenario of energy generation of both conventional and non-conventional energy 1.2 Difference between Energy conservation and energy efficiency with examples. 1.3 Energy conservation Policy in India 1.4 Energy conservation initiatives by Gol: [i] Standards and Labelling [ii] Energy Conservation Building Codes (ECBC) [iii] Promotion of Energy Efficient LED Bulbs [iv] Promotion of Electric Vehicle 1.5 Energy conservation and Energy audit; concepts and difference. 1.6 Energy Conservation Act 2001; relevant clauses of energy conservation 1.7 BEE/BREDA, NPC, MNRE and its Roles 1.8 Star Labeling: Need and its benefits, Mandatory and voluntary appliances	CO1
TSO 2a. Describe briefly the energy conservation techniques in an induction motor TSO 2b. Describe the significant features of energy efficient motors listing their advantages and limitations. TSO 2c. Describe briefly the energy conservation techniques in a Transformer TSO 2d. Describe the significant features of the given energy efficient transformer, listing their advantages and limitations TSO 2e. Describe the significant features of a given energy efficient Transformer, listing their advantages and limitations	Unit-2.0 Energy Conservation in Electrical Machines 2.1 Energy conservation techniques in induction motor: a) Improving Power quality. b) Motor survey c) Matching motor with loading. d) Minimizing the idle and redundant running of motor. e) Operating in star mode. f) Rewinding of motor. g) Replacement by energy efficient motor-significant features, advantages, applications and limitations. h) Periodic maintenance 2.2. Energy conservation techniques in Transformer a) Load sharing	CO2, CO1

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
<p>TSO 2f. Describe briefly the use of a given energy conservation equipment in a given electrical system</p>	<p>b) Parallel operation c) Isolating techniques d) Replacement by energy efficient transformers- Amorphous transformers; Epoxy Resin cast transformer and Dry type of transformer. e) Periodic maintenance 2.3 Energy Conservation Equipment: a) Soft starters b) Automatic star delta convertor c) Variable Frequency Drives d) Automatic p. f. controller (APFC) e) Intelligent p. f. controller (IPFC) f) Active Harmonic filters (AHF).</p>	
<p>TSO 3a. Explain the aggregated technical and commercial losses in the power system</p> <p>TSO 3b. Describe the scenario of power system at the national/state level.</p> <p>TSO 3c. Describe briefly the methods to reduce the specified technical losses in the electrical installation</p> <p>TSO 3d. Describe the strategies to reduce the specified commercial losses in the power system</p> <p>TSO 3e. Describe the criteria for Selecting the relevant energy conservation instruments for the given system with justification</p> <p>TSO 3f. Describe the given energy conservation techniques for the specified lighting installation.</p>	<p>Unit-3.0 Energy Conservation in Electrical Installation Systems</p> <p>3.1 Aggregated Technical and commercial losses (ATC); Power system at state, regional, national level.</p> <p>3.2 Technical losses-Causes and measures to reduce by a) Controlling I²R losses. b) Optimizing distribution voltage c) Balancing phase currents d) Compensating reactive power flow</p> <p>3.3 Commercial losses: causes and remedies</p> <p>3.4 Energy conservation instruments: a) Maximum Demand Controller, b) KVAR Controller, c) Automatic Power Factor controller (APFC). d) Intelligent p. f. controller (IPFC)</p> <p>3.5 Energy Conservation in Lighting System: a) Relamping with energy efficient LED lamps. b) Using energy efficient luminaries c) Improving lighting controls- infrared sensors, automatic timers, motion sensors (PIR and ultrasonic sensors), and dimmers, Smart control d) Centralized street light control - GSM/GPRS based systems and SCADA system e) Replacing energy inefficient accessories with new energy efficient fixtures and ballast f) Installation of separate transformer servo stabilizer for lighting. g) Periodic survey and adequate maintenance programs.</p>	CO3, CO2
<p>TSO 4a. Describe the need and significance of co generation system</p> <p>TSO 4b. Identify the cogeneration system for the given facility.</p> <p>TSO 4c. Describe the given type of Co-generation with the help of a neat sketch.</p>	<p>Unit-4.0 Energy Conservation through Cogeneration and Tariff</p> <p>4.1 Co-generation and its significance 4.2 Types of Cogeneration: a) On the basis of sequence of energy use - Topping cycle - Bottoming cycle b) On the basis of technology</p>	CO3, CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
<i>TSO 4d.</i> Describe the tariff system for reducing the electricity bill.	<ul style="list-style-type: none"> - Steam turbine Cogeneration - Gas turbine cogeneration - Reciprocating engine Cogeneration 4.3 Factors governing the selection of cogeneration system. 4.4 Advantages of cogeneration. 4.5 Tariff and Types of tariff structure: <ul style="list-style-type: none"> - LT and HT Tariff - Special tariffs - Time-off-day tariff - Peak- off-day tariff - Power factor tariff - Maximum Demand tariff - Load factor tariff and - Availability Based Tariff (ABT). 4.6 Application of tariff system to reduce energy bill. 4.7 Recent BSPHCL tariffs for different consumers.	
<i>TSO 5a.</i> Define energy audit justifying its need and significance <i>TSO 5b.</i> List different types of energy audit <i>TSO 5c.</i> Describe the use of relevant energy audit instruments for the specified energy audit with examples <i>TSO 5d.</i> Develop questionnaires for energy audit of the projects <i>TSO 5e.</i> Develop the energy flow diagram of the given facility/ apparatus. <i>TSO 5f.</i> Calculate the Simple Pay Back period' for the given situation. <i>TSO 5g.</i> Prepare the energy auditreport for the given facility/apparatus.	Unit-5.0 Energy Audit of Electrical Systems 5.1 Energy audit (definition as per Energy Conservation act), need and significance in energy consumption pattern 5.2 Types of energy audit 5.3 Energy audit instruments and their use 5.4 Questionnaire for energy audit projects 5.5 Energy flow diagram (Sankey diagram) 5.6 Simple payback period, 5.7 Procedure of Energy Audit (walk through audit and detailedaudit). 5.8 Energy Audit report format.	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: P2420503

Practical/Lab Session Outcomes (LSOs)	S. No	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Identify star labelled appliances and compare them for various star ratings <i>LSO 1.2.</i> List the significance of star ratings	1.	Identification of Star labelled electrical appliances and compare data sheets of various star ratings	CO1
<i>LSO 2.1.</i> Implement energy conservation techniques in a 3-phase induction motor <i>LSO 2.2.</i> Identify the effect of voltage reduction on motor performance and energy consumption	2.	Determination of reduction in power consumption in star mode operation of 3 phase Induction motor compared to delta mode	CO2

Practical/Lab Session Outcomes (LSOs)	S. No	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.1. Identify the power factor improvement strategies by APFC	3.	Use of APFC unit for improvement of p. f. of electrical load.	CO2, CO3
LSO 4.1. Identify the power factor improvement strategies by IPFC	4.	Use of IPFC unit for improvement of p. f. of electrical load.	CO2, CO3
LSO 5.1. Compare power consumption of different types of TL with choke, electronic ballast and LED lamps by direct measurements	5.	Comparison of power consumption of different types of TL with choke, electronic ballast and LED lamps by direct measurements	CO3
LSO 6.1. Determine the reduction in power consumption by replacement of different lamps in a class room / laboratory by energy efficient lamps	6.	Comparison of reduction in power consumption by replacement of different lamps in a class room / laboratory by energy efficient lamps	CO3
LSO 7.1. Suggest suitable tariff for energy conservation and reduction of energy bill for an industrial customer LSO 7.2. Interpreting electricity bill of an industrial consumer	7.	Tariff for industrial consumer for reducing the electricity bill	CO3
LSO 8.1. Suggest suitable tariff for energy conservation and reduction of energy bill for a commercial customer LSO 8.2. Interpreting electricity bill of a commercial customer	8.	Tariff for commercial consumer for reducing the electricity bill	CO3
LSO 9.1. Suggest suitable tariff for energy conservation and reduction of energy bill for a residential customer LSO 9.2. Interpreting electricity bill of a residential customer	9.	Tariff for residential consumer for reducing the electricity bill	CO3, CO4
LSO 10.1. Estimate energy saving by improving power factor and load factor for given case	10.	Energy saving by improving power factor and load factor for given case	CO3
LSO 11.1. Prepare a sample energy audit questionnaire for a given facility	11.	Energy audit questionnaire for the given facility.	CO5
LSO 12.1. Prepare energy audit report of your electrical department.	12.	Energy audit report of electrical department	CO5

L) **Suggested Term Work and Self Learning: S2420503** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

- i. Compare the energy conserved by an energy efficient motor with a standard motor and prepare a report.
- ii. Carry out internet survey (BEE) to collect information and prepare a report related to any 2 Energy conservation projects.
- iii. Collect the catalogues of various star labeled equipment's and prepare a report on it.
- iv. Write report on performance of motor after rewinding.
- v. Compile the energy saved in at least 5 star labeled consumer appliances and prepare a report.
- vi. Prepare a report on special features of energy efficient transformers.
- vii. Collect information about energy efficient luminaries and prepare a report on it.
- viii. Compare the energy conserved in different types of lamps and prepare a report.
- ix. Visit a facility adopting cogeneration system and prepare a presentation.

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: T2400504B**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Elaborate the use of Artificial Intelligence TSO 1b. Explain various technological Drivers of 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 of AI, Techniques used in AI, Perception, Understanding and Action, Technological drivers of modern AI Knowledge: Definition, Knowledge Representation, objectives and requirements, 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 First Search, Depth First Search, Best First Search, Constraint Satisfaction Problem (CSP), Back tracking Search. Problem Definitions: N Queen Problem, 8 Puzzle 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 various operators 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 module in the Python TSO 2l. Describe procedure to Import Library and functions in the Python TSO 2m. Write program using Iterative statements.	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, relational operators, logical operators, assignment operator, augmented assignment operators. Expressions, statement, type conversion & input/output: precedence of operators, expression, evaluation of expression. 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)
	<p>string using loops, built-in functions.</p> <p>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</p> <p>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</p> <p>Python Functions: types of function (built-in functions, functions defined in module, user defined functions), creating user defined function, arguments and parameters, default parameters, positional parameters, function returning value(s), flow of execution, scope of a variable (global scope, local scope)</p> <p>Modules and Packages: Importing module using 'import' Regular Expressions, Exception Handling, PyPI Python PackageIndex, Pip Python package manager, Importing Libraries and Functions</p>	
<p>TSO 3a. Explain Data Analytics and its elements</p> <p>TSO 3b. Differentiate Data Analysis and Data Analytics</p> <p>TSO 3c. Explain the use of open source data</p> <p>TSO 3d. Differentiate Qualitative and Quantitative data analysis</p> <p>TSO 3e. Explain procedure to Install NumPy Library</p> <p>TSO 3f. Use NumPy library to perform various operations and functions on array</p> <p>TSO 3g. Write Programs using NumPy for array manipulations</p>	<p>Unit-3.0 Data Analytics and Computing with NumPy</p> <p>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.</p> <p>NumPy Library: Introduction, Installation,</p> <p>Ndarray: creating an array, intrinsic creation of an array, Data types, basic operations, aggregate functions, Indexing, slicing, Iterating, Conditions and Booleanarrays, Array</p> <p>manipulation: Joining, splitting, shape changing, sorting, Structured arrays, Reading and Writing array data on a File.</p>	CO-3
<p>TSO 4a. Apply Pandas data structure for data analysis</p> <p>TSO 4b. Write Programs using Pandas to perform various operations and functions on series.</p> <p>TSO 4c. Perform various operation in a Data Frame columns and rows</p> <p>TSO 4d. Write Programme to read and write on CSV, XLS and Text data files</p> <p>TSO 4e. Apply various data cleaning operations and prepare data.</p>	<p>Unit-4.0 Data Analysis with Pandas</p> <p>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.</p> <p>Data Frame: Defining, selecting elements, assigning values, membership, deleting a column, filtering. Index Objects: Indexing, Re-indexing, Dropping, sorting and ranking, Descriptive Statistics</p> <p>Data Loading: Reading and Writing csv, xls, text data files, Data Cleaning and Preparation: Handling missing data, removing duplicates, replacing values, Vectorized String Methods, Hierarchical Indexing, Merging and</p>	CO-4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
	Combining, Data aggregation and Grouping.	
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.

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

Practical/ Lab Session Outcomes (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 random numbers 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 number is positive, negative or 0. 1d. Write Python program to print all prime numbers 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 a string with only single space between words, and return number of words in the string. 2b. Write a Program that inputs a line of text and print the count of Vowels in it. 2c. Write a Program that inputs a line of text and print the biggest word in it. 2d. Write a Program that inputs a line of text and 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 string to a list. 3b. Write a program to print the largest number in 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 with the elements at the odd location. 3e. Write a program to merge two dictionaries.	CO-2

Practical/ Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 4.1 Use built-in functions to solve given problem LSO 4.2 Create user defined functions to solve given problem	4	Python Functions 4a. Write a function to reverse a string. 4b. Write a function to calculate the factorial of a number.	CO-2
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 which stores the details of a student (roll no, name, dept, branch, percentage of mark) in Python 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 functions 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 your array. 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 n students in the class. 8b. Get the common items between two python NumPy arrays. 8c. Get the positions where elements of two arrays match. 8d. Remove from one array those items that exist in another. 8e. Extract all numbers between a given range from 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 file into an array. 9b. Access the mark of a student in a particular subject using indexing techniques. 9c. Select a subset of 2D array using fancy indexing (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.	CO-4

Practical/ Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
		11b. Filter multiple rows using isin. 11c. Select first n rows and last n rows 11d. Select rows randomly n rows and fraction of rows (use df. sample method) 11e. Count the number of rows with each unique value of variables 11f. Select n largest and n smallest 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 combine first 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 the data 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 less than 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 Setosa iris class using a bar chart. 14b. Format the obtained bar graph by Changing the color of each bar, Change the Edge color, Line width and Line style.	CO-5

L) **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. **Handling Two-dimensional array in NumPy**

Download the data set from

[https://archive.ics.uci.edu/ml/machine-learning-](https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data)

[databases/iris/iris.data](https://www.kaggle.com/arshid/iris-flower-dataset)<https://www.kaggle.com/arshid/iris-flower-dataset>

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, 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, CO2
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. TSO.5. c. Describe the medical applications of IoT in the agriculture field. TSO.5. d. Describe the innovative IoT applications.	Unit. 5.0 IoT Applications: - 5.1 Industrial IoT and Internet of everything 5.2 IoT for consumer electronics products 5.3 IoT for Medical applications 5.4 IoT for Agriculture 5.5 IoT for security and Law enforcement	CO-1 and CO-5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: 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. LSO 2.2 Connect Bluetooth with Arduino. LSO 2.3 Verification of data communication with Bluetooth.	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 POSTMAN Application.	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 various applications. 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.

b. Micro Projects:

1. Prepare a report on IoT Systems using Internet data.
2. Market survey to identify various types of IoT sensors and its pricing.
3. Interface IR sensor with Arduino and send the data to Arduino cloud.
4. Send IoT data using Node MCU to things Speak cloud.
5. Interface Bluetooth module with Arduino and send data using the Bluetooth module.

c. Other Activities:

1. Seminar Topics: - "Future of IoT"
"Technologies for IoT ", "Smart City and IoT"
2. Visit to industry for latest IoT setup in industrial process.
3. Surveys of market for availability of various types of sensors and its pricing.

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)
<p>TSO 1a. Describe the various historical/evolutionary steps of drone technology</p> <p>TSO 1b. Explain Drone motion based on principle of aerodynamics.</p> <p>TSO 1c. Classify different types of drones and make chart of its application, advantages and disadvantages</p> <p>TSO 1d. Develop attitude to follow proper rules and regulations of drones flying in India.</p> <p>TSO 1e. Explore future prospects of drones in India.</p>	<p>Unit-1.0 Introduction to Drone Technology</p> <p>Introduction to Drones and UAV</p> <ul style="list-style-type: none"> • Definition • History • Drone in Indian aspect <p>Introduction to Flight Dynamics</p> <p>Various types of Drones and their respective Applications</p> <ul style="list-style-type: none"> • Multirotor drones • Fixed wing structure <p>Drone flights using an understanding of FAA</p> <ul style="list-style-type: none"> • DGCA • Digital sky platform • RPTO <p>Drone regulations-No drone zones</p>	<p>CO-1</p>
<p>TSO 2a. Explain the use and function of different types of Drone components.</p> <p>TSO 2b. Select suitable drone frame and propellers for given application.</p> <p>TSO 2c. Explain working principle and function of different sensors used in drone technology.</p> <p>TSO 2d. Write use of Gyro sensor and Accelerometer in drone.</p> <p>TSO 2e. Describe different types and capacity of Battery used in various drone applications.</p> <p>TSO 2f. State the selection criteria of motor for given drone application.</p> <p>TSO 2g. Write advantage of BLDC motors in making of Drones.</p>	<p>Unit-2.0 Drone and its components</p> <p>Drones components</p> <ul style="list-style-type: none"> • Drone frame • Propellers <p>Sensors</p> <ul style="list-style-type: none"> • Gyro sensor and Accelerometer • Speed and Distance Sensor • Temp sensor • Barometer • TOF Sensor <p>Battery</p> <ul style="list-style-type: none"> • Types and Capacity <p>Motors</p> <ul style="list-style-type: none"> • Motor types • Motor capabilities • Application of BLDC motors in drones 	<p>CO-2</p>
<p>TSO 3a. Explain four types of motion used in drone's operation.</p> <p>TSO 3b. Describe the working and applications of</p>	<p>Unit-3.0 Drone controller and motion</p> <p>Propulsion and Vertical Motion</p>	<p>CO-3</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>Electronic speed controller.</p> <p>TSO 3c. Explain the working principle of Flight controller unit used in drone.</p> <p>TSO 3d. Explain Radio communication unit used in drone.</p> <p>TSO 3e. Explain the communication of Flight controller board with motor, ESC and sensors with suitable diagram</p>	<p>Controller and Flying Instructions</p> <p>Electronic speed Controller (ESC)</p> <p>Flight Controller Board (FCB)</p> <p>Radio Communication</p> <p>Transmitter and Receiver for radio signal</p>	
<p>TSO 4a. Describe utility of different communication port used in drone.</p> <p>TSO 4b. Identify different types of connectors and write their specifications</p> <p>TSO 4c. Explain the use of drone simulator software and hardware.</p>	<p>Unit-4.0 Connections and Interfaces of Devices in Drone and Drone Simulator</p> <p>Communication Port</p> <ul style="list-style-type: none"> • PWM • RS232, RS422, RS485 • UART • CAN • I2C <p>Different types of connectors and its specification</p> <p>Drone Simulator software</p> <p>Drone simulator Hardware</p>	CO-4
<p>TSO 5a. Write basic code in Python.</p> <p>TSO 5b. Explain structure and components of a Python program.</p> <p>TSO 5c. Write syntax of loops and decision statements in Python.</p> <p>TSO 5d. Explain steps to create functions and pass arguments in Python.</p>	<p>Unit-5.0 Introduction to Python for Drone</p> <p>Python programming refreshers for IoT, AI and Drone</p> <p>Integration of devices with cloud services</p> <p>Microsoft Azure, AWS</p>	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)
<p><i>TSO 1a.</i> Explain CAD-CAM and related terminologies.</p> <p><i>TSO 1b.</i> Convert the given CAD file format into others.</p> <p><i>TSO 1c.</i> Transfer the given CAD data to CAM facilities.</p> <p><i>TSO 1d.</i> Classify 3D Printing processes.</p> <p><i>TSO 1e.</i> List the advantages of additive manufacturing processes over conventional manufacturing processes.</p> <p><i>TSO 1f.</i> List typical steps involved in 3D printing of an object from digital model.</p> <p><i>TSO 1g.</i> Explain reverse engineering steps for 3D Printing.</p>	<p>Unit-1.0 Additive Manufacturing Introduction and CAD</p> <p>1.1 CAD-CAM and its integration.</p> <p>1.2 CAD- Part and Surface modeling.</p> <p>1.3 CAD file formats.</p> <p>1.4 Additive v/s Conventional Manufacturing processes.</p> <p>1.5 Process chain for 3D Printing.</p> <p>1.6 Classification of 3D Printing Processes.</p> <p>1.7 Product design and prototyping.</p> <p>1.8 Reverse Engineering for 3D Printing.</p>	CO1
<p><i>TSO 2a.</i> Explain the given STL interface terminology.</p> <p><i>TSO 2b.</i> Use the given alternative 3D printing interface.</p> <p><i>TSO 2c.</i> Generate STL file for the given CAD file.</p> <p><i>TSO 2d.</i> Repair the given STL file.</p> <p><i>TSO 2e.</i> Apply part orientation and support techniques for the given situation.</p> <p><i>TSO 2f.</i> Perform slicing of the given CAD model using the given slicing software.</p> <p><i>TSO 2g.</i> Generate tool path using simulation software for the given situation.</p>	<p>Unit-2.0 Data Preparation for 3D Printing</p> <p>2.1 STL interface Specification, STL data generation, STL data Manipulation.</p> <p>2.2 Advantages and limitations of STL file format, Open files, Repair of STL files,</p> <p>2.3 Alternative 3D Printing interfaces.</p> <p>2.4 Part orientation and support generation, Factors affecting part orientation, Various models for part orientation determination.</p> <p>2.5 The function of part supports, Support structure design, Automatic support structure generation.</p> <p>2.6 Model Slicing and Contour Data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination.</p> <p>2.7 Tool path generation.</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the given 3D Printing process.</p> <p><i>TSO 3b.</i> Select FDM 3D Printing materials for the given application.</p> <p><i>TSO 3c.</i> Select FDM based 3D Printing processes parameters for given application with justification.</p>	<p>Unit-3.0 Additive Manufacturing Techniques</p> <p>3.1 Fused Deposition Modeling (FDM), Stereo lithography (SLA), Selective Laser Sintering (SLS), Binder Jetting, Material Jetting, Direct Energy Deposition and Laminate Object Manufacturing.</p> <p>3.2 FDM based 3D printing process details.</p> <p>3.3 3D Printing materials and selection for FDM.</p> <p>3.4 FDM Process parameter for various applications.</p>	CO3, CO4
<p><i>TSO 4a.</i> Identify various Aerospace, Electronics, Health care, Automotive, Construction, Food processing, Machine tool components that can be 3D Printed.</p>	<p>Unit-4.0 Application of 3D Printing</p> <p>4.1 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools</p>	CO3, CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<i>TSO 4b.</i> Estimate the cost and time of FDM based 3D printing of the given component.		
<i>TSO 5a.</i> Select suitable 3D Printer (FDM) and software for the given application with justification. <i>TSO 5b.</i> Analyze the effect of given FDM based 3D printing process parameters using 3D printer software simulation. <i>TSO 5c.</i> List steps to perform 3D scanning of the given object. <i>TSO 5d.</i> Repair 3D scanned digital model. <i>TSO 5e.</i> 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)
<i>LSO 1.1.</i> Use CAD software. <i>LSO 1.2.</i> Prepare digital models of simple 3D entities.	1.	Develop digital models of following simple components using any CAD software: <ul style="list-style-type: none"> • Nut • Bolt • Network cable Jack • Coat button • Spoon 	CO1
<i>LSO 2.1.</i> Prepare digital models of complex 3D entities and assemblies.	2.	Develop digital models of following assemblies using any CAD software: <ul style="list-style-type: none"> • Connecting Rod • Piston • Electric switch • Bathroom Tap • Mouse 	CO1
<i>LSO 3.1.</i> Surf web for downloading readymade free CAD models. <i>LSO 3.2.</i> 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
<i>LSO 4.1.</i> Use the given Slicing software for 3D Printing. <i>LSO 4.2.</i> 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
<i>LSO 5.1.</i> Use the available 3D printing software. <i>LSO 5.2.</i> 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
<i>LSO 6.1.</i> Produce single plastic components using available 3D printer. <i>LSO 6.2.</i> 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)
<p><i>LSO 7.1.</i> Select appropriate layer thickness, tolerance, fit.</p> <p><i>LSO 7.2.</i> Produce an assembly of plastic components using available 3D printer.</p>	7.	Print one assembly on available FDM based 3D printer with PLA/ABS material	CO3, CO4, CO5
<p><i>LSO 8.1.</i> Choose suitable material for printing flexible structure (assembly of same small pieces to give flexible fabric effect).</p> <p><i>LSO 8.2.</i> Choose suitable design/shape to create a flexible type structure.</p> <p><i>LSO 8.3.</i> Produce flexible plastic structure using available 3D printer.</p>	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
<p><i>LSO 9.1.</i> Selection of 3D printing process parameters.</p>	9.	Change printing process parameters and repeat experiment number 6.	CO4, CO5
<p><i>LSO 10.1.</i> Use of available 3D scanner.</p> <p><i>LSO 10.2.</i> Develop 3D digital model using scanning approach.</p> <p><i>LSO 10.3.</i> Modeling of complex 3D objects using 3D scanning.</p>	10.	Scan the given complex component using available 3D Scanner.	CO5
<p><i>LSO 11.1.</i> Produce a complex plastic structure using available 3D printer and scanner.</p> <p><i>LSO 11.2.</i> Apply Reverse Engineering approach to exactly 3D print an existing real object.</p>	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.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.1. a Describe Industry 4.0 and its component</p> <p>TSO.1. b Explain different types of automation systems</p> <p>TSO.1.c Identify the type of automation used in a given industry</p> <p>TSO.1.d Analyze the working of industrial processes and products for automation.</p> <p>TSO.1.e Select principles and strategies for automation for a given situation using 4R's and 1U</p> <p>TSO.1. f Select criteria for factory automation and processes automation for a given industry.</p> <p>TSO.1. g Describe briefly different systems used for industrial automation.</p> <p>TSO.1.h Describe IOT, IIOT and role of robots with respect to automation.</p>	<p>Unit-1.0 Overview of Industrial Automation</p> <p>Introduction to Industry 4.0 and its components, Issues and challenges in automation</p> <p>Need of automation in industries, Principles and strategies of automation, factory automation, process automation</p> <p>Basic elements of an automated system, Structure of Industrial Automation Advanced automation functions, Levels of automations</p> <p>Industrial control Systems- Process and Discrete system</p> <p>Types of automation system: Fixed, Programmable, Flexible Integrated Automation and its application</p> <p>Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives.</p> <p>Introduction to Internet of Things (IoT) and Industrial Internet of Things (IIOT) and its application in Automation.</p> <p>Role of robots in automation and its components.</p>	CO1
<p>TSO.2. a Explain PLC and list its advantages over relay systems.</p> <p>TSO.2.b Distinguish between PLC and a PC, PLC and dedicated controllers.</p> <p>TSO.2.c List the types of PLCs and brands available in the market.</p> <p>TSO.2.d Describe the function of each block of a PLC with the help of a block diagram.</p> <p>TSO.2.e Describe the basic sequence of operation of a PLC with a simple example.</p> <p>TSO.2.f Explain different PLC programming languages with simple examples.</p> <p>TSO.2.g Describe a simple PLC programming using ladder logic specifying I/O addressing</p> <p>TSO.2.h List the applications of PLC</p>	<p>Unit-2.0 Fundamentals of PLC</p> <p>Introduction to PLC, evolution of PLC</p> <ul style="list-style-type: none"> • 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 <p>Building blocks of PLC -CPU, Memory organization, Input-Output modules (Discrete and Analog) Specialty I/O Modules, Power supply</p> <p>PLC programming languages with simple examples:</p> <ul style="list-style-type: none"> • Functional Block Diagram (FBD), • Instruction List. • Structured text, • Sequential Function Chart (SFC), • Ladder Programming <p>PLC I/O addressing in ladder logic</p> <p>Simple programming example using ladder logic</p> <p>Applications of PLC:</p> <p>Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature control, Conveyor system control</p>	CO2
<p>TSO.3.a Identify the commonly used input field devices in PLC installations along with their symbols.</p> <p>TSO.3.b Draw symbol of various switches used in PLC installations describing the function of each switch.</p> <p>TSO.3.c Identify the various digital input devices used in a PLC installation.</p> <p>TSO.3.d Identify the commonly used sensors as input field devices found in PLC</p>	<p>Unit 3.0 – Sensors and Input field devices</p> <p>Analog input devices-Electromagnetic relays, Contactors, Motor starters, Manually operated Switches</p> <p>Toggle switch, pushbutton switch, knife switch and selector switches</p> <p>Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>installations.</p> <p>TSO.3.e Describe the working of different types of discrete sensors giving their applications.</p> <p>TSO.3.f Describe the working of different types of advanced sensors giving their applications.</p> <p>TSO.3.g Select Sensors as per the given requirement for ecofriendly automation</p>	<p>Discrete/Digital Input device, Construction and working of Sensors</p> <ul style="list-style-type: none"> • Proximity sensors- Inductive, Capacitive, Optical and ultrasonic <p>Advanced sensors- Construction and working of</p> <ul style="list-style-type: none"> • 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 <p>Angular and linear position sensor</p>	
<p>TSO.4.a Classify the actuators.</p> <p>TSO.4.b Describe the construction and working of a given actuator.</p> <p>TSO.4.c Explain the basic principle of operation of a given actuator.</p> <p>TSO.4.d Differentiate between hydraulic and pneumatic actuators</p> <p>TSO.4.e Explain the basic principle of operation of a given control valve.</p> <p>TSO.4.f Select actuators and valves as per the given requirement for ecofriendly automation.</p> <p>TSO.4.g Develop different hydraulic and pneumatic circuits for simple application.</p> <p>TSO.4.h Identify the commonly used output field devices in PLC installations</p> <p>TSO.4.i Draw the symbol of various output devices used in PLC installations describing the function of each.</p> <p>TSO.4.j Select output devices for a PLC installation as per the requirement.</p>	<p>Unit 4.0- Actuators and output devices</p> <p>Introduction to actuators, Classification of actuators</p> <p>Mechanical actuators -Translational and rotation motion, kinematic chains, cams, gears, belt and chain drives, bearings</p> <p>Hydraulic and Pneumatic actuators- linear and rotary actuators, single and double acting cylinder, directional, process and pressure control valves</p> <p>Electrical actuators</p> <ul style="list-style-type: none"> • 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 <p>Thermal actuators -Construction, working and application of Hot-And-Cold-Arm Actuators, Chevron-Type Actuators</p> <p>Magnetic actuators- Construction, working principle and application of Moving coil actuators, moving magnet actuator, Moving iron actuator</p> <p>Selection criteria of actuators</p> <p>Other Output devices- Indicators, Alarms Pilot Lights, Buzzers, Valves, Motor starters, Horns and alarms, Stack lights Control relays, Pumps and Fans.</p>	<p>CO4</p>
<p>TSO.5.a Describe the basic process control system with the help of a block diagram</p> <p>TSO.5.b Explain the types of control available in a process control</p> <p>TSO.5.c Describe the different types of controllers in a closed loop system with the help of a block diagram</p> <p>TSO.5.d Describe the construction, working and application of a given control system components.</p>	<p>Unit 5.0– Control System</p> <p>Block diagram of a basic control system</p> <p>Open and closed loop system, their transfer function</p> <p>First order and second order system and their output response and parameters</p> <p>Different types of inputs-step and ramp</p> <p>Types of control – On-off, Feed forward, Open loop and closed loop control and Transfer function</p> <p>Controllers in closed loop control</p>	<p>CO5</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	<ul style="list-style-type: none"> • Proportional Controller (P Controller) • Integral Controller (I Controller) • Derivative controller (D- Controller) • P-I Controller • P-D Controller PID Controller	

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 the steps 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 front panel 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 its use	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 its use	
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	
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 its use	
LSO 3.5. Use thermistor to measure temperature of a given material	13.	Identify different types of thermistor 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 used in industries for temperature	

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		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 study open 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 and output 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.	
LSO 5.5 Test the Output response of a P+I+D based level control system.	27.	Analyze the given water level control system with P+I+D control.	

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504G	Electric Vehicles (Basic)	03	-	04	02	09	06

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400504G	Electric Vehicles (Basic)	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at 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-1.0 Introduction to Electric Vehicle Review of Conventional Vehicle Engine System Electric Vehicle (EV) <ul style="list-style-type: none"> • The necessity of Electric Vehicle • Types of Electric Vehicles <ul style="list-style-type: none"> - 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 motors used 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 motors for EV applications. TSO 2e. Explain the motor selection criteria for particular EV applications. TSO 2f. Describe the Mechanical and Electrical Connections of Motors.	Unit-2.0 Electric Motors used in EVs Electric Motors for EV applications <ul style="list-style-type: none"> • General Characteristics of motors • Types of Motors: DC, Brushless DC, Induction, Permanent Magnet Synchronous Motors, Switched Reluctance 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 of the given batteries. TSO 3d. Explain the salient features of Lithium Ion batteries TSO 3e. Explain the Fuel Cell Storage System. TSO 3f. Identify various sensors installed for monitoring Battery condition. TSO 3g. Explain Battery Management System in EV using Block Diagram. TSO 3h. Describe the procedure of battery Disposal and Recycling	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) <ul style="list-style-type: none"> • Need of BMS • Block Diagram of BMS Battery Disposal and Recycling	CO3
TSO 4a. Identify different types of diodes and transistors. TSO 4b. Describe the testing procedure for the given Diode and Transistor. TSO 4c. Explain the working principles of the given power electronic converter circuit. TSO 4d. Describe the types of Charging Systems TSO 4e. Describe different Components of the Charging System TSO 4f. Explain the working of the Charging System using a single-line diagram.	Unit- 4.0 EV Charging Systems Power electronics in EV <ul style="list-style-type: none"> • Power electronics components • Rectifiers • DC to DC Converter • DC to AC Converter Charging System <ul style="list-style-type: none"> • Types of charging Systems • Components of Charging Systems • Single line Diagram of Charging System 	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 5a. Understand the Rules and Regulations set by the Government for selecting and manufacturing various components of an electric vehicle. TSO 5b. Understand the Policies for E-Vehicles. TSO 5c. <u>Appreciate the importance of the reduction of greenhouse gases in the environment.</u>	Unit- 5.0 Regulatory Requirements and Policies 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. <u>Carbon Footprint Issues</u>	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.	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> 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 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	4.	<ul style="list-style-type: none"> Power electronic circuits Identification of Charging systems 	CO4

L) **Suggested Term Work and Self-Learning: S2400504G** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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; Mechanical arm, 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 requirement. TSO 3f. Differentiate the various robot path controls.	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 – Types, basic principles and block diagram Robot controller; Level of Controller	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 3g. Justify the selection of actuators, drives, control system, AC servo motor and path control for making of a robot.	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 2.1 Identify 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
LSO 5.1 Interface stepper motor. LSO 5.2 Control robot with stepper motor interfacing.	5.	Perform robot control with stepper motor interfacing	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
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 10.1 Develop 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)
<p><i>TSO 1a.</i> Explain the use of transformers in power systems.</p> <p><i>TSO 1b.</i> List the various types of transformers.</p> <p><i>TSO 1c.</i> Explain the exact and approximate equivalent circuits of a transformer.</p> <p><i>TSO 1d.</i> Explain the relations between input and output quantities through phasor diagrams.</p> <p><i>TSO 1e.</i> List the necessity of open and short circuit tests and explain how they should be performed.</p> <p><i>TSO 1f.</i> Explain the concept of voltage regulation and efficiency and list the ways to improve them in transformers.</p>	<p>Unit-1.0 Transformer Fundamentals</p> <p>1.1 Use of Transformers.</p> <p>1.2 Types of Transformers.</p> <p>1.3 The equivalent circuit of a transformer.</p> <p>1.4 Phasor Diagrams</p> <p>1.5 Open circuit and short circuit tests.</p> <p>1.6 Voltage regulation and efficiency.</p>	CO1
<p><i>TSO 2a.</i> Explain the different constructional parts of a transformer.</p> <p><i>TSO 2b.</i> List the different types of core and its construction and sections.</p> <p><i>TSO 2c.</i> Explain the different types of windings and the necessity of insulation.</p> <p><i>TSO 2d.</i> Explain the different types of cooling.</p> <p><i>TSO 2e.</i> List the different tank structure.</p> <p><i>TSO 2f.</i> Explain the necessity of transformer oil.</p>	<p>Unit-2.0 Transformer Construction</p> <p>2.1 Constructional Parts.</p> <p>2.2 Core Construction and Core Sections.</p> <p>2.3 Windings and Insulation.</p> <p>2.4 Cooling: Natural Cooling, Forced Oil cooling and Internal Cooling.</p> <p>2.5 Tanks.</p> <p>2.6 Transformer oil.</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the different connections and vector groups.</p> <p><i>TSO 3b.</i> Explain the three phase to two phase and three phase to single phase connection.</p> <p><i>TSO 3c.</i> List the different types of tap changing positions.</p> <p><i>TSO 3d.</i> Explain the open delta configuration.</p>	<p>Unit-3.0 Transformer Operation</p> <p>3.1 Connection for transformers: star/star, star/delta, delta/star. Zig-zag/star.</p> <p>3.2 Three phase to two phase connections: Scott connection.</p> <p>3.3 Three phase to one phase connection.</p> <p>3.4 Tap changing: On-load and off-load tap changing positions.</p> <p>3.5 Three phase banks of single phase transformers: Open delta configuration.</p>	CO3, CO4
<p><i>TSO 4a.</i> List the classification of transformer protection.</p> <p><i>TSO 4b.</i> Explain the Buchholz relay and its use in transformers.</p> <p><i>TSO 4c.</i> Explain the different types of transformer protection and the use of indicators in transformers.</p>	<p>Unit-4.0 Transformer Protection</p> <p>4.1 Classification of transformer protection.</p> <p>4.2 Buchholz Relay</p> <p>4.3 Differential protection</p> <p>4.4 Over current, Over voltage and surge protection.</p> <p>4.5 Temperature indicators, oil level indicators, oil preservation systems, silica gel breather, gas sealed conservators.</p>	CO3, CO4
<p><i>TSO 5a.</i> Explain the objectives of testing of transformers.</p> <p><i>TSO 5b.</i> List the different types of tests.</p> <p><i>TSO 5c.</i> Explain different transformer tests including the Sumpner's test.</p> <p><i>TSO 5d.</i> Explain the insulation and impulse tests.</p>	<p>Unit-5.0 Transformer Testing</p> <p>5.1 Objectives of transformer testing.</p> <p>5.2 Polarity Test, DC Resistance and voltage ratio tests.</p> <p>5.3 Magnetizing current and core loss tests.</p> <p>5.4 Temperature rise test, back to back connection.</p> <p>5.5 Insulation and Impulse Tests.</p>	CO4, CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504I

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Knowledge of performing these tests on LV and HV sides.</p> <p><i>LSO 1.2.</i> Determine the equivalent circuit parameters of a transformer.</p>	1.	Conduct open circuit and short circuit tests on a transformer	CO1
<p><i>LSO 2.1.</i> Explain the concept of regulation and efficiency at different loads.</p>	2.	Perform load tests on a transformer.	CO1
<p><i>LSO 3.1.</i> Perform Heat run test on a transformer without being subjected to physical load.</p> <p><i>LSO 3.2.</i> Explain the concept of applying rated voltage and rated current through phantom loading.</p>	3.	Perform the Sumpner's test on two identical transformers.	CO1
<p><i>LSO 4.1.</i> Understand various three phase transformer connections and vector groups.</p>	4.	Perform various connections on three phase transformers and understand vector groups.	CO2
<p><i>LSO 5.1.</i> Explain the Scott connection.</p> <p><i>LSO 5.2.</i> Understand the necessity of conversion.</p>	5.	Three phase to Two phase connection	CO3, CO4, CO5
<p><i>LSO 6.1.</i> Understand the necessity of conversion.</p>	6.	Three phase to single phase connection.	CO3, CO4, CO5
<p><i>LSO 7.1.</i> Explain the concept of open delta configuration in case of any single phase transformer failure.</p>	7.	Perform open delta connection from banks of single phase transformers.	CO3, CO4, CO5
<p><i>LSO 8.1.</i> Explain the concept of CT connections in differential protection.</p> <p><i>LSO 8.2.</i> Understand the working principle of Buchholz Relay.</p>	8.	Understand the differential protection with different CT connections and the working of Buchholz relay.	CO3, CO4, CO5
<p><i>LSO 9.1.</i> Explain the concept of dot convention.</p>	9.	Perform a polarity test on a transformer.	CO4, CO5
<p><i>LSO 10.1.</i> Understand the transformer's failures.</p>	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)
<p><i>TSO 1a.</i> Explain the need for Optical fiber and 5G Technologies.</p> <p><i>TSO 1b.</i> Define numerical aperture.</p> <p><i>TSO 1c.</i> Classify optical fiber modes with proper sketch.</p> <p><i>TSO 1d.</i> Explain with examples modes of wave propagation through an optical fiber.</p> <p><i>TSO 1e.</i> Classify optical fiber</p>	<p>Unit-1.0 Introduction of Optical Fibers</p> <p>1.1 Introduction to general optical fiber communication (OFC) system</p> <p>1.2 Basic optical laws and definitions</p> <p>1.3 Structure of optical cable- core, cladding, cover</p> <p>1.4 Numerical aperture</p> <p>1.5 Optical fiber modes and configurations–mode analysis for optical propagation through fibers</p> <p>1.6 Classification of optical fiber, single mode fiber, graded index fiber</p>	CO1
<p><i>TSO 2a.</i> Explain the reason for attenuation in the optical fiber cable.</p> <p><i>TSO 2b.</i> Describe fiber losses with examples.</p> <p><i>TSO 2c.</i> Explain various aspects of dispersion</p> <p><i>TSO 2d.</i> Describe how to optimize the dispersion</p> <p><i>TSO 2e.</i> Describe how to generate R-I profile</p> <p><i>TSO 2f.</i> calculate cut-off wavelength, and mode field diameter</p>	<p>Unit-2.0 Transmission Characteristics of Optical Fiber</p> <p>2.1 Attenuation in Optical Fiber</p> <p>2.2 Fiber Losses (Material, Scattering, Splice, Absorption, Radiative)</p> <p>2.3 Dispersion (Chromatic, Modal, Material, Waveguide, Polarization mode)</p> <p>2.4 Dispersion optimization of single mode fiber, characteristics of single mode fiber</p> <p>2.5 R-I Profile</p> <p>2.6 Cut off wavelength, dispersion calculation, and mode field diameter</p>	CO2
<p><i>TSO 3a.</i> Explain the need for a source and detector in an optical fiber system.</p> <p><i>TSO 3b.</i> Describe about direct and</p>	<p>Unit-3.0 Optical Sources and Detectors</p> <p>3.1 Sources- Intrinsic and extrinsic material, direct and indirect band gaps</p> <p>3.2 LED structures- Surface-emitting</p>	CO3

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

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

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

Practical/Lab Session Outcomes (LSOs)	Sl. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> 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
<i>LSO 2.1.</i> Measure the numerical aperture of the given optical fiber cable.	2.	Measurement of Numerical aperture	CO1
<i>LSO 3.1.</i> Measure the attenuation and signal loss in optical fiber using optical time-domain reflectometry (OTDR). <i>LSO 3.2.</i> Measure the signal loss in optical fibers using optical time-domain reflectometry (OTDR).	3.	Attenuation and Signal Loss Measurement	CO2
<i>LSO 4.1</i> Perform tests on fiber optic cables to identify faults using tools like visual fault locators and OTDR. <i>LSO 4.2</i> Troubleshoot faults using tools like visual fault locators and OTDR.	4.	Fiber Optic Cable Testing and Troubleshooting	CO2, CO3
<i>LSO 5.1</i> Test the performance of the given optical source.	5	Performance of optical source (LED, LASER)	CO3
<i>LSO 6.1.</i> Test the performance of the given optical detector.	6	Performance of optical detector (Photo diode, PIN diode)	CO3
<i>LSO 7.1.</i> Learn techniques for splicing optical fibers. <i>LSO 7.2.</i> Install connectors, crucial for network deployment and maintenance.	7	Optical Fiber Splicing and Monitorization	CO4
<i>LSO 8.1.</i> Conduct BER test. <i>LSO 8.2.</i> Evaluate the performance of optical communication links. <i>LSO 8.3.</i> Evaluate the reliability of optical communication links.	8	Analyze the optical communication system.	CO4
<i>LSO 9.1.</i> Noise Modelling and its effect on Wireless Data Transmission	9.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	CO5
<i>LSO 10.1</i> 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: P2400505**

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

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment / Practical Titles	Relevant Cos Number(s)
LSO3.5	Carry-out market survey for a product.	15.	Market Survey for an Enterprise	CO3
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.
- v. Choose any product and study its supply chain.
- vi. Arrange brainstorming sessions for improvement of any product.
- vii. Choose any advertisement and analyse its good and bad points.
- viii. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
- ix. Study schemes for entrepreneurship promotion of any bank.

b. **Micro Projects:**