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 – VI
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				
2420601	**PCC**	**Utilization of Electrical Energy**	02	01	-	02	05	04
2420602	**PCC**	**Electrical Installation, Testing and Commissioning**	03	-	04	02	09	06
2420603	**PEC**	**Programme Electives*** - Any One	03	-	04	02	09	06
2400604	**OEC**	**Open Electives**/ COE** (Advanced - Any One)	03	-	04	02	09	06
2420605	**PSI**	**Major Project** (Common for all programmes)	-	-	08	04	12	06
2400408	**NRC**	**Employability Skills Development** (Common for All Programmes)	01	-	-	-	01	01
2400110	**NRC**	**Community/ Society Development**	01	-	-	-	01	01
Total			**13**	**1**	**20**	**12**	**46**	**30**

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

Legend:

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

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

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

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

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

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

*: Data Communication / Industrial Drives/ Electrification of Building Complexes

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

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

Semester - VI
Assessment Scheme

Course Codes	Category of course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2420601	**PCC**	**Utilization of Electrical Energy**	30	70	20	30	-	-	150
2420602	**PCC**	**Electrical Installation, Testing and Commissioning**	30	70	20	30	20	30	200
2420603	**PEC**	**Programme Electives*** - Any One	30	70	20	30	20	30	200
2400604	**OEC**	**Open Electives**/ COE** (Advanced - Any One)	30	70	20	30	20	30	200
2420605	**PSI**	**Major Project** (Common for all programmes)	-	-	20	30	50	100	200
2400408	**NRC**	**Employability Skills Development** (Common for All Programmes)	25	-	-	-	-	-	25
2400110		**Community/Society Development**	25	-	-	-	-	-	25
Total			**170**	**280**	**100**	**150**	**110**	**190**	**1000**

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

Legend:

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

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

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

*: Data Communication / Industrial Drives/ Electrification of Building Complexes

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

Note:

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

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: T2420601

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a. Define the given terms related to Illumination. TSO 1b. State the laws of Illumination. TSO 1c. Explain the working principle of LED light. TSO 1d. List different types of LED light fitting. TSO 1e. Describe the constructional details of the given LED lights fitting. TSO 1f. Select LED light for the given application(s)	**Unit 1.0 Illumination** 1.1 Definition of Illumination 1.2 Light, Luminous flux, Luminous intensity, Lumen, Candle power, Lux or Meter candle, mean horizontal candle power (MHCP), Mean spherical candle power (MSCP), Mean hemispherical candle Power (MHSCP), Reduction factor, Lamp efficiency, Utilization factor, Depreciation factor, Space height ratio, Solid angle, Absorption factor, Reflection factor. 1.3 Laws of Illumination - Inverse square law, Lamberts Cosine law. 1.4 LED light; Working Principle. 1.5 Types of LED lights, features and its applications; • Gallium Phosphide (GaP) • Aluminum Gallium Phosphide (AlGaP) • Gallium Nitride (GaN) • Gallium Arsenide (GaAs) • Gallium Arsenide Phosphide (GaAsP) • Aluminum Gallium Arsenide Phosphide (AlGa AsP) • Gallium Indium Nitride (GaInN) • Silicon Carbide (SiC) • Zinc Selenide (ZnSe)	**CO1**
TSO 2a State the advantages of electrical heating. TSO 2b List the essential requirement of the given heating elements. TSO 2c Explain the causes of failure of heating elements. TSO 2d Describe the given type of heating system with the help of neat sketch and detail out the safety precautions followed. TSO 2e Explain the working of given type of arc furnace. TSO 2f Carry out a given type of welding following safety precautions.	**Unit2.0 Electrical Heating and Welding.** 2.1 Need and significance of Electrical heating; 2.2 Essential requirements of a good heating element, 2.3 Materials of heating element - Nickel chromium alloy, Iron chromium aluminum alloy, Molybdenum dislicide and silicon carbide 2.4 Causes of failure of heating element. 2.5 Methods of Electric heating: • Resistance heating, • Arc heating, • High frequency heating: • Induction heating, • Dielectric heating.	CO1, CO2

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 2g Explain the use of welding transformer for different welding applications. TSO 2h Explain the use of rectifier circuit for different welding applications. TSO 2i Write the steps of safe practices followed during heating and welding.	2.6 Electric arc furnace, types, working and applications of; • Direct • Indirect 2.7 Welding, types, working and applications of; • Resistance welding • Electric arc welding 2.8 Welding transformers and rectifiers. 678 during heating and welding.	
TSO 3a Explain the function of major components of an electric drive with the help of a block diagram. TSO 3b State the factors governing selection of electric motors in an electric drive. TSO 3c Steady state and transient characteristics of various Motors. TSO 3d Differentiate between (i) AC and DC drive. (ii) Individual and group drive	**Unit-3.0 Electrical Drives** 3.1 Block diagram: Source, Power modulator, Electric motor, Control unit, sensing unit and load. 3.2 Motors used for Electrical drives; DC series, Shunt and Separately excited motors, three phase Induction motor. 3.3 Torque/speed, Torque/Current and Speed/Current characteristics of DC series, Shunt and Separately excited motors, Induction motor. 3.4 Comparison of AC, DC drives and Individual, group drive.	CO3
TSO 4a Explain the characteristics of Ideal traction system TSO 4b Compare the Electric and Diesel traction. TSO 4c Explain the various traction electrification system. TSO 4d Explain the various overhead electrical power supply in traction system. TSO 4e Explain the various components in electric traction system with the help of a Block diagram. TSO 4f Enlist the advantages of pantograph collector over other types of current collectors in overhead lines. TSO 4g Describe the general power supply arrangements in any one metro system in India. TSO 4h Describe the different traction systems used worldwide.	**Unit-4.0 Electric Traction Drives** 4.1 Requirement of Ideal traction system 4.2 Type of traction system used in India. • Electric Traction • Diesel Traction 4.3 System of track electrification: • DC system • Single phase 25KV A.C. • Composite system. 4.4 Electrical Power supply in Traction system: Sub Sectioning and Parallel Post (SSP), Sectioning Post (SP), Traction sub station 4.5 Block diagram of AC Electric locomotive and function of each part. 4.6 Current collecting system: Overhead wire and conductor rail system, Current collector (Pantograph types). 4.7 Traction services: Urban, Suburban, Main line services, Metro rail and Monorail.	CO4, CO3
TSO5a State economic aspect of electrical energy. TSO5b Differentiate between different charges of electricity. TSO5c Calculate electric tariff for a given consumer.	**Unit-5.0 Economics of Utilizing Electrical Energy** 5.1 Economic Aspects of Utilizing Electrical Energy. 5.2 Pricing of Electrical Energy: • Fixed Charges • Semi Fixed Charges • Running Charges.	CO5

Major Theory Session Outcomes (TSOs)		Units		Relevant Cos Number(s)
TSO5d	Improve power factor using static capacitor.	5.3	Tariff, Formulation of Electrical Tariffs and Types – Domestic, Commercial and Industrial Consumers.	
TSO5e	Differentiate between Energy efficiency and energy conservation.	5.4	Power Factor, Causes and disadvantages of Low Power Factor, Power Factor Improvement - using Static Capacitors, its locations, Most Economical Power Factor. Automatic Power Factor Controller	
TSO5f	Describe the energy conservation measures used in Electric heating, refrigeration, air conditioning and illumination.	5.5	Energy efficiency and Energy efficient equipment (Star lebelling)	
		5.6	Energy Conservation: Importance and need of Energy Conservation	
		5.7	Measures for Energy Conservation in - (i) Electric Heating (ii) Refrigeration and Air Conditioning (iii) Illumination	

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

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

L) Suggested Term Work and Self Learning: **S2420601** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

i. List various applications of different Lighting schemes used in our daily life.
ii. List applications of different modes of heat transfer.
iii. Compare the various types of power supply required for different types of welding.
iv. Draw the characteristics of a welding generator
v. List importance and need of **Energy conservation.**
vi. Prepare a report on various types of traction system.
vii. Prepare a report on various tariff structure of Bihar.
viii. Prepare energy bill based on energy consumption of institute.

b. Micro Projects:

- Design a circuit to test whether a given Illumination control circuit is working or not.
- Build a circuit of lighting of a four wheeler.
- Build a circuit of efficient lighting of auditorium.
- Build circuit for electric arc furnace showing the arrangements of OCBs, control panels, CTs through relays, furnace transformer and arrangement of electrode movement.
- Build and test inverter circuit for emergency lighting.
- Prepare a model of Railways traction system.
- Design a motor controller circuit that can control the speed and direction of the chosen motor.

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: T2420602

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Describe the procedure for unloading of the given heavy electrical equipment at site. *TSO 1b.* Describe the procedure for handling, inspection and storage of the given static and rotating electrical equipment. *TSO 1c.* Describe the procedure to select tools/ instruments for installation of the given electrical equipment. *TSO 1d.* Describe the installation procedure of the given equipment.	**Unit-1.0 Installation of Electrical Equipment** 1.1 Unloading of electrical equipment at site. 1.2 Inspection of electrical equipment at site. 1.3 Storage of electrical equipment at site. 1.4 Foundation of electrical equipment at site. 1.5 Alignment of electrical machines. 1.6 Technical report, Inspection, storage and handling of transformer, switchgear and motors. 1.7 Tools/Instruments necessary for installation. 1.8 Installation of electrical equipment.	**CO1**
TSO 2a. Explain the importance of testing the given type of electrical machine. *TSO 2b.* Explain the need for the given type of test/s on the specified machine. *TSO 2c.* Explain the concepts of given type of tests. *TSO 2d.* Describe the pre-commissioning test of the given electrical equipment/machines. *TSO 2e.* Describe the procedure of tests on the given electrical equipment/machines.	**Unit-2.0 Testing of Electrical Equipment** 2.1 Testing: Need and standards, tolerances. 2.2 Testing Types: Routine, Type and Special Tests, Methods of testing: Direct, indirect and regenerative with advantages and applications. 2.3 Tests before commissioning of electrical equipment-Electrical and Mechanical test. 2.4 Preparations before commissioning of power transformer. 2.5 Testing (Routine, Type and Special Tests) of Transformer, Induction motor, alternator, synchronous motor and electrical power installation.	**CO1, CO2**
TSO 3a. Describe the commissioning procedure to be adopted for commissioning the given equipment. *TSO 3b.* Explain the standard tests to be performed on the given type of insulation oil. *TSO 3c.* Describe the procedure of measuring insulation resistance of the given electrical equipment/machines. *TSO 3d.* Explain the various factor affecting the insulation resistance. *TSO 3e.* Explain the procedure of drying the winding of the given type of electrical equipment/machines. *TSO 3f.* Explain the need for gradual loading of electrical equipment	**Unit-3.0 Commissioning of Electrical Equipment** 3.1 Commissioning of power transformer, three phase induction motor and switchgears. 3.2 Transformer oil: Properties, testing and filtering/purifying, standard tests as per IS code. 3.3 Measurement of insulation resistance and Polarization Index, Factors affecting the insulation resistance of insulating materials. 3.4 Drying the winding of electrical equipment. 3.5 Test report on commissioning and test certificate. 3.6 Gradually loading of electrical equipment. 3.7 Final inspection after commissioning.	**CO3, CO4**
TSO 4a. Explain the need for maintenance for the given type of electrical equipment. *TSO 4b.* Explain the relevant type of maintenance required for the given type of electrical equipment.	**Unit-4.0 Maintenance and Troubleshooting of Electrical Equipment** 4.1 Importance of maintenance, Reasons of failure of electrical equipment.	**CO3, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4c. Prepare maintenance schedule for the given type of electrical equipment. *TSO 4d.* Explain the reason of failure of electrical equipment due to poor maintenance. *TSO 4e.* State the probable faults due to poor maintenance in various electrical equipment. *TSO 4f.* List the various causes of fault in electrical machines *TSO 4g.* Describe the common troubles in electrical equipment. *TSO 4h.* Prepare trouble shooting chart for the given electrical equipment, machines and domestic appliances.	4.2 Maintenance: routine, breakdown, preventive and predictive maintenance 4.3 Recommended Maintenance Schedules: transformer, induction motor (single phase and three phase), three phase alternator, synchronous motor, circuit Breaker, overhead line, storage Battery. 4.4 Probable faults due to poor maintenance in transformer, induction motor, circuit breaker, overhead lines and battery 4.5 Causes of faults in electrical equipment (Internal and external). 4.6 Instruments and tools for trouble shooting. 4.7 Common troubles in electrical equipment –DC Machines, AC Machines, Transformers, Circuit-breaker, under-ground cable, electrical Installation. 4.8 Need of trouble shooting chart, troubleshooting chart for DC Motor, DC Generator, Transformer, Synchronous Motor, Induction Motor, Circuit-breaker. 4.9 Trouble shooting chart for Domestic appliances-electrical iron, ceiling fan, washing machine, Air cooler, Vacuum cleaner, fluorescent tube light: Construction, working and troubleshooting chart	
TSO 5a. Describe the safety actions for the given situation. *TSO 5b.* Explain the hazards involved for the given situation and action. *TSO 5c.* Describe the responsibilities of the supervisor in the given hazardous or accident situation. *TSO 5d.* Explain the level of accountability of the supervisor in the given hazardous or accident situation. *TSO 5e.* Explain the monitoring actions to be taken by the supervisor while working in the given hazardous or accident situation. *TSO 5f.* Describe the procedure to be followed for installation of fire extinguishers *TSO 5g.* State the principal characteristics and related precautions for safety of equipment earthed by the specified class.	**Unit-5.0 Electrical Accidents and Safety** 5.1 Safe Practices: Safety, hazard, accident, major accident hazard, responsibility, authority, accountability, monitoring, I.E. Act & statutory regulations for safety of persons and equipment working with electrical installation, Dos & Don'ts for substation operators as listed in IS 5.2 Electric Shocks: Meaning & causes of electrical accidents, factors on which severity of shock depends, Procedure for rescuing the person who has received an electric shock, methods of providing artificial respiration. 5.3 Precautions to be taken to avoid fire due to electrical reasons, operation of fire extinguishers. Fire extinguishers-Fixed installation and portable devices. 5.4 Earthing of electrical equipment (refer IS code IS 3043-1987): Objectives, classification of electrical equipment with regard to protection against electric shock: class 0 to III.	**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: P2420602

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Prepare layout of the wiring	1.	Preparation of layout of wiring for installation of given machine with specification	CO1
LSO 2.1. Perform routine test on single phase Induction motor.	2.	Routine test of single phase Induction motor	CO2
LSO 3.1. Perform routine test on three phase Induction motor	3.	Routine test on three phase Induction motor	CO2
LSO 4.1. Test insulating oil	4.	Testing of insulating oil	CO2
LSO 5.1. Prepare test reports of an electrical machine after commissioning.	5.	Preparation of test report of an electrical machine after commissioning.	CO3
LSO 6.1. Measure insulation resistance of a winding/cables/wiring installation	6.	Measurement of insulation resistance of a winding/cables/wiring installation	CO3
LSO 7.1. Prepare maintenance schedule for power transformer.	7.	Preparation of maintenance schedule of power transformer.	CO4
LSO 8.1. Prepare maintenance schedule for induction motor.	8.	Preparation of maintenance schedule for induction motor.	CO4
LSO 9.1. Troubleshoot a ceiling fan	9.	Troubleshooting of a ceiling fan	CO4
LSO 10.1 Measure earth resistance of a Installation.	10.	Measurement of earth resistance of installation of building/domestic wiring and appliances by different methods	CO4

L) Suggested Term Work and Self Learning: S2420602 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

i. Prepare a foundation plan for installation of a given motor**.**
ii. Prepare installation report of a given rotating electrical machine.
iii. Prepare a commissioning report of installed electrical equipment.
iv. Prepare the specification of the commonly used hand tools by electrician.
v. Prepare a chart on the procedures to be followed for artificial respiration of an electrocuted person.

b. Micro Projects:

1. Prepare a report on diagnosis of transformer oil sample by conducting various tests on it.
2. Record the procedures and obtain the typical values of the earth resistance used for equipment earthing of a given installation. Comment on the result obtained as per IS.
3. Prepare a breakdown maintenance report for repair of a given domestic appliance.

c. Other Activities:

1. Seminar Topics:
   - Foundation of transformer.
   - Testing of Induction motor as per IS.
   - Safety sign used for electrically hazardous area.
2. Visits: Visit electrical machine manufacturing unit and collect data of various tests conducted on it.

J) Theory Session Outcomes (TSOs) and Units: T2420603A

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the function of the given component in the process of data Communication. *TSO 1b.* Describe the given data transmission method with its frame format *TSO 1c.* Explain the given source of noise and its effect. *TSO 1d.* Analyze the computer network considering particular topology. *TSO 1e.* Classify networks on the basis of the given parameter.	**Unit-1.0 Fundamentals of Data Communication and Network Topology** 1.1 Data communication and its characteristics • Basic block diagram of data communication system • Components of data communication: Transmitter, Receiver, Medium, Message, error, noise, Protocol. • Standards, Standard organizations 1.2 Data Transmission: Serial, Parallel Synchronous, Asynchronous, Isochronous transmission 1.3 Transmission characteristics: Signaling rate, data rate, bit rate, baud rate 1.4 Need of computer networks, Network criteria, advantages of networking, Schematic diagram, working 1.5 Network topologies: Mesh, Star, Bus, Tree, Ring and Hybrid topologies: working, disadvantages and applications. 1.6 Network Classification: • Based on Transmission Technologies: Point to-point, Multipoint • Physical size (scale): PAN, BAN, LAN, MAN, WAN, VPN • Based on Architecture: Peer to Peer, Client Server, advantages of Client Sever over Peer-to-Peer Model	**CO1**
TSO 2a. Describe the function of the given layer of TCP/IP Reference model. *TSO 2b.* Explain the relationship of layers with addresses in TCP/IP. *TSO 2c.* Differentiate between various addressing schemes for TCP/IP. *TSO 2d.* Describe the functions of the given layer of OSI reference model.	**Unit-2.0 Network Models** 2.1 TCP/IP protocol suite with define protocols in respective Layers: Physical layer, Data Link Layer, Network Layer, Transport Layer, and Application Layer 2.2 Addressing in TCP/IP: Physical, logical, Port and specific 2.3 The ISO-OSI model: Physical layer, Data Link Layer, Network Layer, Transport Layer, Session Layer, Presentation Layer, Application Layer	**CO2**
TSO 3a. Describe the principle of given multiplexing technique. *TSO 3b.* Select the transmission media for transmitting the given signal for the given application. *TSO 3c.* Describe the construction of the given cable with labeled sketches. *TSO 3d.* Compare different types of Transmission medium on the basis of given parameter *TSO 3e.* Explain with sketches working of the given type of modem. Compare different multiplexing/ switching techniques based on the given parameters.	**Unit-3.0 Physical Layer** 3.1 Multiplexing: Basic concept • Frequency- Division Multiplexing • Wavelength- Division Multiplexing • Synchronous Time-Division Multiplexing 3.2 Transmission medium: classification based on electromagnetic wave spectrum 3.3 Guided Media- Performance and applications • Twisted pair (UTP, STP)cable-connector • Coaxial cable-connector	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	• Fiber-optic cable-connector 3.4 Introduction of Unguided Media- Radio waves, microwaves, Infrared and their applications 3.5 Modems classification: Broadband modem, DSL-ADSL, HDSL, VDSL 3.6 Switching: • Circuit-switched networks • Packet switched networks- Datagram approach, virtual circuit approach	
TSO 4a. Describe the services provided by Data Link Layer. *TSO 4b.* Describe the technique of the given error control method with examples. *TSO 4c.* Explain with sketches the given type of flow control used in the data link layer with justification. *TSO 4d.* Compare the characteristics of given type of Protocol. *TSO 4e.* Select the appropriate protocol for error free transmission of given data.	**Unit-4.0 Data Link Layer** 4.1 Framing 4.2 Flow control 4.3 Error control • Types of errors: Single bit and Burst errors • Error detection and correction 4.3 Protocol • Sliding window protocol: One-bit sliding window protocol 4.4 Point to Point Protocol: service provided by PPP, Frame format PPP and Transition phases of PPP **4.5** Ethernet and IEEE 802.3 4.6 MAC Addresses and Switching	**CO4**
TSO 5a. Justify the function of the given network device. *TSO 5b.* Differentiate between class-full and classless addressing. *TSO 5c.* Explain the role of NAT in address depletion. *TSO 5d.* Explain the given type of Routing with example. *TSO 5e.* Describe the services provided by the transport layer/network layer /Application layer. *TSO 5f.* Describe the given type of network security technique. *TSO 5g.* Explain the fundamental concepts of SSL/TLS protocols. *TSO 5h.* Explain the security implications of use of different protocol versions. *TSO 5i.* Differentiate between symmetric and asymmetric encryption algorithms used in SSL/TLS.	**Unit-5.0 Network, Transport and Application Layer** 5.1 Network devices: • Repeater • Hub • Bridge • Switches • Router • Gateway 5.2 Network layer Logical addressing: IPv4 Addresses: address space notations, class-full addressing, and class-less addressing 5.3 Network Address Translation (NAT), IPv6 addresses, Need for IPv6, Structure and address space 5.4 Network layer-Multicast Routing Protocols: Unicast, Multicast and Broadcast routing and applications of Transport Layer 5.5 Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP) 5.6 Process to process delivery: UDP, TCP, RTP, SCTP, ports format and uses. 5.7 Application Layer services: Concept of DNS, FTP, HTTP/HTTPS, FTP and SMTP, DNS and DHCP.	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	5.8 Network Security Protocols (SSL/TLS) 5.9 Security services: concepts of message and entity security service, Firewall	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420603A

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO1.1 Identify the type of network topology used in your lab *LSO1.2* Prepare Report.	1.	Analyze the type of network topology used in your lab and prepare technical specifications.	CO1
LSO 2.1 Connect a given number of computers in a ring topology. *LSO 2.2* Verify data transfer in ring topology.	2.	Connect computers in ring topology and transfer the data.	CO1
LSO 3.1. Connect a given number of computers in hybrid topology. *LSO 3.2.* Verify data transfer for hybrid topology.	3.	Connect computers in hybrid topology and test the performance.	CO2
LSO 4.1 Establish WAN Network. *LSO 4.2* Configure WAN network. *LSO 4.3* Test WAN network.	4.	Install/configure/Test peer-to-peer WAN and sharing of resources.	CO2, CO3
LSO 5.1 Configure and Install point-to-point network. *LSO 5.2* Test point-to-point network.	5.	Commissioning of Point-to-Point network in the laboratory.	CO3
LSO 6.1 Connect the devices on LAN by patch cord and cross connection. *LSO 6.2* Test the LAN connection.	6.	Prepare patch cord and cross connection cables used for LAN connection.	CO1, CO3
LSO 7.1 Install a LAN network using Switches/hubs. LSO 7.2 Test LAN network.	7.	Test the performance of the Hub/Switches used in LAN network.	CO4, CO5
LSO 8.1 Apply error detection methods. *LSO 8.2* Find the error bit in the given data stream by using the different error detection methods.	8.	Locate the error bit using error detection methods.	CO4
LSO 9.1 Apply error correction method. *LSO 9.2* Correct the error in a given data stream by applying the different error correction methods.	9.	Correction of the error using error correction methods for the given data bits.	CO4
LSO 10.1 Test the performance of given network using route command.	10.	Route command to test the performance of the given network.	CO5
LSO 11.1 Test and install Router, Repeater and Bridge.	11.	Install and test Router, Repeater and Bridge.	CO5
LSO 12.1 Assign IP address to the PC connected to the internet.	12.	IP address assignment to the PC connected to the internet.	CO5
LSO 13.1 Internet connectivity configuration.	13.	Configure/Test Internet connectivity.	CO1, CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 14.1 Use FTP protocol to transfer file from one system to another system.	14.	Transfer file using FTP protocol.	CO2, CO5
LSO 15.1 Install a Firewall for the network security.	15.	Network security firewall installation.	CO5
LSO 16.1 Interconnect two PCs using RS232 cable *LSO 16.2* Configure the modem. *LSO 16.3* Test the data transfer between two PC.	16.	Transfer of data between two PC interconnected using RS232 cable and null modem.	CO1, CO2
LSO 17.1 Maintain the network devices- Router, Hub.	17.	Test the performance of the following network devices: Repeater, Hub.	CO5
LSO 18.1 Maintain the network devices- Bridge, Switches, Router.	18.	Test the performance of the following network devices: Bridge, Switches, Router.	CO5

L) Suggested Term Work and Self Learning: S2420603A 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.

- Describe any four types of computer network topologies.
- Explain the function of the data link layer.
- Compare twisted pair cable and coaxial cable.
- Differentiate between OSI and TCP/IP model.
- List the functions of the application layer.
- Describe the firewall working in detail.

b. Micro Projects:

- Perform Network Configuration Management for the small LAN network.
- Use a Secure File Transfer Application and transfer the file on the network.
- Maintain the Network Monitoring Dashboard.
- Use simulation software and test the performance of Network and Remote Desktop Application.
- Prepare a small report on IoT Sensors and Data Visualization.

c. Other Activities:

1. Seminar Topics:
   - 5G Technology and Its Impact on Data Communication
   - Network Security in the Age of Cyber Threats
   - IoT (Internet of Things) and Networking
   - Cloud Networking and Data Communication
   - Blockchain Technology and Networking
   - Wireless Networking Technologies
   - Network Monitoring and Analysis Tools
   - Wi-Fi Security and Best Practices
2. Visit: Visit to nearby Internet service provider and prepare a report of it in detail.
3. Self-Learning Topics:
   - Network Security Fundamentals
   - Wireless Networking Technologies

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: T2420603B

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the need and significance of electric drives. TSO 1b. Describe the fundamental building blocks and its function with the help of a block diagram. TSO 1c. Write the fundamental torque equation of motor load system specifying each parameter. TSO 1d. Describe briefly four quadrant operation in an electric drive with need labeled sketches. TSO 1e. Classify the different components of load torque. TSO 1f. Identify stable and unstable region of operation in T-ω characteristics of a three-phase induction motor.	**Unit-1.0 Fundamentals of Electric Drives** 1.1. Need and significance of Electric Drives 1.2. Functional Block diagrams of an electric drives 1.3. Fundamental torque Equation 1.4. Multi-quadrant operation 1.5. Components of Load torque 1.6. Nature and classification of Load torque 1.7. Steady State Stability (derivation not required)	**CO1**
TSO 2a. Interpret the Characteristics of the given DC Motors. TSO 2b. Describe briefly the methods for speed control of the given DC Motor. TSO 2c. Describe various Braking methods of a given DC motor. TSO 2d. List different speed control methods of three phase induction motor. TSO 2e. Describe various Braking methods of a given three phase induction motor with the help of neat sketch. TSO 2f. Explain various classes of motor duty. TSO 2g. Calculate motor rating for various load application.	**Unit-2.0 Basics of DC and AC Motors** 2.1 DC Motors: Characteristics and speed control of Series, Shunt and Separately Excited DC Motors 2.2 DC motor: Braking – Plugging, Rheostatic, and Regenerative 2.3 3-phase induction Motor: Characteristics and speed control of Squirrel cage IM and Slip ring IM 2.4 3-phase induction Motor: Braking - Plugging, Rheostatic, and Regenerative. 2.5 Classes of motor duty 2.6 Determination of Motor Rating	**CO1, CO2**
TSO 3a. Describe the working of the given type of single-phase SCR drives to control the speed of dc separately excited motor with the help of neat sketches. TSO 3b. Describe the working of the given type of three phase SCR drives to control the speed of dc separately excited motors with the help of neat sketches. TSO 3c. Control the speed of a DC series motor using converters.	**Unit-3.0 DC Drives** 3.1 Single phase SCR Drives of DC separately excited motor: • Half wave converter • Full wave converter • Semi-converter • Dual converter 3.2 Three Phase SCR Drives of DC separately excited motor: • Half wave converter • Full wave converter	**CO1, CO2, CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3d. Describe speed control techniques of separately excited DC motor using chopper. TSO 3e. Describe speed control techniques of DC series motor using chopper. TSO 3f. Draw the labeled sketch of functional blocks of chopper-controlled DC Drive in Solar and battery powered vehicles	• Semi-converter 3.3 Rectifier control of DC Series motor. 3.4 Chopper Control of separately excited DC motor. 3.5 Chopper Control of DC series motor 3.6 Use of a chopper control drive in Solar and battery powered vehicles.	
TSO 4a Describe the need significance and working of soft starter for starting a three phase IM. TSO 4b Explain working principle of AC voltage controller. TSO 4c Explain working principle of cyclo-converter. TSO 4d Describe variable frequency control of 3-phase induction motor using cyclo-converter. TSO 4e Describe the working of Variable Frequency Drive (VFD) with the help of a neat labelled sketch mentioning the fundamental principle on which it works. TSO 4f Describe variable frequency control of 3-phase induction motor using VSI. TSO 4g Describe variable frequency control of 3-phase induction motor using CSI. TSO 4h Describe PWM technique in AC drives with the help of neat sketches TSO 4i Describe slip power recovery control of 3 phase induction motor using scherbius drive. TSO 4j Describe rotor resistance control of 3-phase slip ring induction motor using Converters.	**Unit-4.0 AC Drives** 4.1 Need, significance and working of soft starters 4.2 Stator voltage control using AC voltage controller 4.3 Cycloconverter 4.4 Variable Frequency Control (VFD) 4.5 Voltage Source Inverter Control 4.6 AC drives using PWM technique 4.7 Current Source Inverter Control 4.8 Basics of Slip power recovery 4.9 Rotor Resistance Control	**CO1, CO2, CO4**
TSO 5a. Describe the working of microprocessor-controlled AC/DC drive with the help of neat sketches. TSO 5b. Describe the working of microcontroller-controlled AC/DC drive with the help of neat sketches. TSO 5c. Describe the working of stepper motor using microcontroller.	**Unit-5.0 Advanced Techniques of Motor Control** 5.1 AC/DC drive using microprocessor control 5.2 AC/DC drive using microcontroller control. 5.3 Stepper motor drives employing microcontroller	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420603B

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Control speed of DC shunt motor using single phase full wave converter LSO 1.2. Plot torque speed characteristics of the DC shunt motor. LSO 1.3. Plot torque- current characteristics of the DC shunt motor.	1.	Speed control of DC shunt motor using single phase full wave converter.	CO3, CO2
LSO 2.1. Control speed of DC shunt motor using single phase semi converter. LSO 2.2. Plot torque speed characteristics of the DC shunt motor. LSO 2.3. Plot torque- current characteristics of the DC shunt motor.	2.	Speed control of DC shunt motor using single phase semi converter.	CO3, CO2
LSO 3.1. Control speed of DC series motor using single phase full wave converter. LSO 3.2. Plot torque speed characteristics of the DC series motor. LSO 3.3. Plot torque- current characteristics of the DC series motor.	3.	Speed control of DC Series motor using single phase full wave converter.	CO3, CO2
LSO 4.1. Control the speed of DC series motor using single phase semi converter. LSO 4.2. Plot torque speed characteristics of the DC series motor. LSO 4.3. Plot torque- current characteristics of the DC series motor.	4.	Speed control of DC Series motor using single phase semi converter.	CO3, CO2
LSO 5.1. Control the speed of DC shunt motor by armature voltage control method using step down chopper. LSO 5.2. Plot torque- current characteristics of the DC shunt motor. LSO 5.3. Plot torque- Speed characteristics of the DC shunt motor.	5.	Speed control of DC Shunt motor by armature voltage control method using step down chopper.	CO3, CO2
LSO 6.1. Control speed of DC series motor by armature voltage control method using step down chopper. LSO 6.2. Plot torque speed characteristics of DC series motor. LSO 6.3. Plot torque current characteristics of DC series motor.	6.	Speed control of DC series motor by armature voltage control method using step down chopper.	CO3, CO2
LSO 7.1. Control the speed of three phase squirrel cage induction motor using Variable frequency Drive (VFD). *LSO 7.2.* Plot torque speed characteristics of three phase squirrel cage induction motor *LSO 7.3.* Plot torque slip characteristics of three phase squirrel cage induction motor	7.	Speed control of three phase squirrel cage induction motor using VFD.	CO4, CO2
LSO 8.1. Control the speed of three phase wound rotor induction motor using rotor resistance control method. LSO 8.2. Plot torque slip characteristics of three phase Slip induction motor	8.	Speed control of three phase wound rotor induction motor using rotor resistance control method.	CO2, CO4,

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 8.3. Plot torque speed characteristics of three phase squirrel cage induction motor.			
LSO 9.1. Control the speed of DC shunt motor drives using microcontroller. LSO 9.2. Plot torque speed characteristics of DC shunt motor. LSO 9.3. Plot torque- current characteristics of DC shunt motor.	9.	Perform Speed control of DC shunt motor drives using microcontroller	CO5, CO3, CO2
LSO 10.1. Control the speed of DC shunt motor drives using microcontroller. LSO 10.2. Plot torque speed characteristics of DC shunt motor. LSO 10.3. Plot torque- current characteristics of DC shunt motor.	10.	Perform Speed control of squirrel cage IM drives using microcontroller.	CO5, CO4, CO2

Note: The entire above practical can be performed using MATLAB/SIMULINK software

L) Suggested Term Work and Self-Learning: S2420603B Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

i. A drive has the following parameters, T= 150-0.1N, N-m, Where N is the speed in rpm. Load torque T_l=100N-m. Initially the drive is operating in steady state. The characteristics of load torque are changed to T_l =100N-m. Calculate initial and final equilibrium speed.
ii. Explain the importance of steady state stability in Electric Drives.
iii. Compare between AC and DC drives
iv. A DC chopper is used to control the speed of a separately-excited DC motor. The DC supply voltage is 220 V, armature resistance R_a =0.2Ω and motor constant $K_a \times \phi$=0.08 V/rpm. This motor drives a constant torque load requiring an average armature current of 25A. Determine (a) the range of speed control (b) the range of duty cycle D. assumed the motor current to be continuous.
v. Collect information about the ratings of commonly used power converters.
vi. Compare the various methods of speed control of DC motors.
vii. Describe variable frequency of induction motor is more efficient than stator voltage control.
viii. Why PWM technique is considered superior to other techniques? Also mention the types of PWM techniques along with diagrams.
ix. Compare CSI and VSI drives.
x. Explain the working principle of an elementary stepper motor.

b. Micro Projects:

(i) Calculate the power rating of single-phase induction motor required for the academic building and hostel of your institute for water lifting.
(ii) Build Step down chopper to control the speed of a small rating dc series motor.
(iii) Build single phase full wave converters for speed control of a small rating DC shunt motor.
(iv) Build an elementary single-phase inverter using MOSFET/IGBT and filter circuit components comprising inductor and capacitor.
(v) Design drive mechanism of a battery-operated bicycle of rating 24V/36V/48V, 250W/500/W/1000W using Brushless DC motor.

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: T2420603C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. List different elements used in the given type of electrical installations. TSO 1b. Interpret different electrical engineering drawings/symbols of the given electrical installation. TSO 1c. Describe the criteria for selection of electrical accessories for the given applications. TSO 1d. Describe the criteria for selection of earthing system as per site condition. TSO 1e. State the tests to be performed before charging the new wiring/installation TSO 1f. State the illumination requirements for the economical illumination design of a given building. TSO 1g. Describe the illumination design procedure for the given applications.	**Unit – 1.0 Elements of Electrification** 1.1 Elements of Electrical installation and fittings 1.2 Electrical Engineering Drawings: Symbols, Plans and wiring Diagrams. 1.3 Electrical Accessories: Wires, Switch Board, Cable, Mains and Sub mains, circuit breakers (MCB, MCCB, ELCB, RCCB etc.). 1.4 Earthing System (Pipe earthing, Plate earthing, Chemical earthing) 1.5 Testing of wiring and installation 1.6 Illumination requirements in residential, Commercial and public Building 1.7 Economical illumination design	**CO1**
TSO 2a Describe the selection of wiring scheme for the given residential building. TSO 2b State the applicable norms and guidelines for the residential building. TSO 2c Prepare wiring layout for the given residential building TSO 2d Calculate number of circuits for the given load. TSO 2e Interpret the Schedule of Rates. TSO 2f Prepare estimate for the given electrical installation. TSO 2g Describe the testing procedure of new wiring and installations in a residential building.	**Unit– 2.0 Electrification of Residential Buildings** 2.1 Type of wiring- Concealed, Surface. 2.2 Norms and guidelines for wiring and fittings. 2.3 Wiring layout of a residential building. 2.4 Calculation of total Electrical Loads. 2.5 Calculation of number of circuits. 2.6 Schedule of rates (SOR), Point Wiring System. 2.7 Estimation of material requirements. 2.8 Requirements of approval from electrical inspection department. 2.9 Testing of wiring installation and preparation of test report.	**CO1, CO2**
TSO 3a Differentiate electrification of Residential, commercial and public building electrical Installations. TSO 3b State the applicable norms and guidelines for the Commercial and Public Installation TSO 3c State the Fundamental considerations for planning of an electrical installation system	**Unit-3.0 Electrification of Commercial Complexes and Public Buildings** 3.1 Commercial and Public Building. 3.2 Residential, commercial and public building electrical Installations: Comparison 3.3 Norms and guidelines for wiring and installations.	**CO2, CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3d Prepare wiring layout for the given Commercial and Public Installations TSO 3e Prepare the list of special requirements of hotels, theaters, library and cultural halls etc. from electrification points of view TSO 3f Use appropriate illumination scheme for interior applications TSO 3g State the design factors considered for the illumination of Interior location of Commercial and public buildings. TSO 3h Describe the various lighting arrangement for the given applications. TSO 3i Describe the testing procedure of new wiring and installations in a commercial and public building.	3.4 Fundamental considerations for planning of an electrical installation system 3.5 Wiring layout of a Commercial Complexes and Public Buildings 3.6 Special requirements of hotels, theaters, library and cultural halls etc. from electrification points of view 3.7 Illumination scheme for Interior Applications. 3.8 Design considerations of illumination for Commercial and Public buildings. 3.9 Different types of lighting arrangements 3.10 Requirements of approval from electrical inspection department. 3.11 Testing of wiring installation and preparation of test report.	
TSO 4a Define Multistoried Buildings. TSO 4b Describe the given methods of service connection for the Multistoried Buildings TSO 4c Design Distribution Panel, Bus bar and Rising Mains for the given multistoried buildings. TSO 4d Estimate the size of distribution cable and mains wiring system for the Multistoried Buildings. TSO 4e Identify the appropriate location for Mounting and Positioning of Switchboards, Distribution boards, main switch TSO 4f Select the relevant energy Metering system for the given applications.	**Unit – 4.0 Distribution System for Multistoried Buildings** 4.1 Multistoried Buildings 4.2 Different Methods of service connection 4.3 Underground service connection of multistoried buildings. 4.4 Distribution panels and Bus bar system, Rising Mains: Design 4.5 Cables and Wiring system: Estimating and Costing 4.6 Switchboards, Distribution boards, main switch: Mounting arrangements and Positioning 4.7 Meter connection-bifurcation of metering-meters as per consumers demand, use of digital – meters for prevention of theft of power.	**CO3, CO4**
TSO 5a Appreciate the significance of safety rules to be followed in a Multistoried building. TSO 5b Describe the installation procedure of the given safety devices and systems in the multistoried buildings. TSO 5c Describe the testing procedure of the given safety devices and systems in the multistoried buildings TSO 5d Apply the norms of the National Building Code and IE rules in the electrification of Multistoried building complexes.	**Unit – 5.0 Electrical Safety and IE Rules** 5.1 Importance of safety rules. 5.2 Safety precaution in electrical installation of multistoried building. 5.3 Safety devices in multistoried buildings • Fire Alarm System • Smoke Detection System • Safety for Lifts and Escalators • Earthing System • Lightning Arrestors arrangements • Use of ELCB and MCBs/MCCBs in an installation • Electronic safety locks at the entrance • DG system 5.4 National Building Code 5.5 Indian Electricity Act.	**CO2, CO3, CO 4, CO 5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	5.6 IE rules	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420603C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify elements of electrical installations and fittings	1.	Identification of elements of electrical installations and fittings	CO1
LSO 2.1 Draw the plan and wiring diagram for a given lab LSO 2.2 Interpret the plan and wiring diagram	2.	Drawing of plan and wiring diagram for a given lab	CO1
LSO 3.1 Select the Electrical Accessories for the given electrical installation	3	Selection of Electrical Accessories	CO 1
LSO 4.1 Use Lux meter for measuring intensity of light LSO 4.2 Compare output of luxmeter with actual power consumed by the lights	4	Measurement of intensity of light using Lux meter and compare output w.r.t power consumed	CO 1
LSO 5.1 Design economical illumination system for the given building using relevant software	5	Design of economical illumination system for a given building using relevant software	CO 1
LSO 6.1 Draw wiring layout for a particular building as per the load requirement.	6	Drawing of the wiring layout of 2 BHK residential building.	CO1, CO2
LSO 7.1 Prepare estimate for the wiring and fitting of the given load conditions.	7	Wiring for the given load condition.	CO1, CO2
LSO 8.1 Test the given wiring installations.	8	Testing of wiring installation using relevant meters	CO1, CO2
LSO 9.1 Draw wirings Tube light wiring, Go down and Parallel loop wiring.	9	Tube light wiring, Go down wiring and Parallel loop wiring.	CO1, CO2
LSO 10.1 Select appropriate wiring material for the given project LSO 10.2 Prepare the estimate of materials and accessories for the given project	10	Selection of an appropriate wiring material and preparation of list of materials and accessories for given project	CO1, CO2
LSO 11.1 Draw the wiring of Stair case	11	Drawing of wiring of Stair case	CO1, CO2
LSO 12.1 Select the appropriate earthing system using measuring and testing instruments for a particular application	12	Selection of appropriate earthing system	CO1, CO2
LSO 13.1 Select the Fuse and MCB for the given load.	13	Selection of Fuse and MCB for a given application.	CO1, CO2
LSO 14.1 Draw a complete wiring diagram of the residential house using Autocad software	14	Wiring diagram of the residential house using Autocad software	CO1, CO2
LSO 15.1 Draw a complete wiring diagram, of any one of the commercial complexes	15	Draw a complete wiring diagram, of any one of the Commercial complexes. (Cinema, hotel, library, Cultural hall, hospital etc.	CO2, CO3

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 16.1	Determine the cost of electrical installation of any Commercial and Public Building	16	Calculating the load and estimate the cost of electrical installation of any Commercial and Public Building	CO2, CO3
LSO 17.1	Prepare a field visit report after observing electrical installation and wiring of any Commercial and Public Building	17	Observe the electrical installation of any Commercial and Public Building and prepare the field visit report	CO2, CO3
LSO 18.1	Determine the load for lift, escalators, air conditioning in Commercial and Public Building	18	Estimation of Load for lift, escalators, air conditioning in Commercial and Public Building	CO2, CO3
LSO 19.1	Interpret test report of an electrical installation of a Commercial and Public Building	19	Preparation of test report of an electrical installation of a Commercial and Public Building.	CO2, CO3
LSO 20.1	Design an economical illumination system for any Commercial and Public Building	20	Design of an economical illumination system for any Commercial and Public Building	CO 2, CO 3
LSO 21.1	Calculate the size of distribution panel, Bus bar and Rising Mains for any Multistoried Buildings	21	Calculation of size of distribution panel, Bus bar and Rising Mains for any Multistoried Buildings	CO2, CO3, CO4
LSO 22.1	Prepare report of Estimating and Costing of Cables and Wiring system for any Multistoried Buildings	22	Preparation of report of Estimating and Costing of Cables and Wiring system for any Multistoried Buildings	CO2, CO3, CO4
LSO 23.1	Identify the appropriate location for Mounting and Positioning of Switchboards, Distribution boards, main switch	23	Selection of appropriate location for Mounting and Positioning of Switchboards, Distribution boards, main switch	CO2, CO3, CO4
LSO 24.1	Use of Meter connection, bifurcation of metering-meters as per consumers demand	24	Using the Meter connection, bifurcation of metering-meters as per consumer's demand	CO2, CO3, CO4
LSO 25.1	Measure energy using digital energy meter	25	Energy measurement using digital Energy meters	CO2, CO3, CO4
LSO 26.1	Testing of safety Devices in electrical installation in a Commercial and Public Building	26	Testing of safety Devices in electrical installation in a Commercial and Public Building	CO1, CO2, CO3, CO4, CO5
LSO 27.1	Undertake mock drill for using fire extinguisher for safety against fire.	27	Mock drill for using fire extinguisher for safety against fire	CO5
LSO 28.1	Perform electrical tests for Commercial and Public Building as per IE	28	Perform electrical tests for commercial and high-rise buildings as per IE	CO1, CO2, CO3, CO4, CO5

L) Suggested Term Work and Self Learning: S2420603C Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments:**
Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

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

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

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

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

Practical/Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	CO-2
LSO 3.1 Perform clustering operations using k-means algorithm	3	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2
LSO 4.1 Perform clustering operations using EM algorithm	4	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2
LSO 5.1 Build artificial neural network LSO 5.2 Test artificial neural network	5	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4

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

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

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

b. Micro Projects:

Use python programming for the solutions of Microproject problems

1. (a) Create a Bar plot to get the frequency of the three species of the Iris data.
   (b) Create a Pie plot to get the frequency of the three species of the Iris data.
   (c) Write a Python program to create a graph to find relationship between the sepal length and width.

1. (a) Write a Python program to split the iris dataset into its attributes (X) and labels (y). The X variable contains the first four columns (i.e. attributes) and y contains the labels of the dataset.

   (b) Write a Python program using Scikit-learn to split the iris dataset into 70% train data and 30% test data. Out of total 150 records, the training set will contain 120 records and the test set contains 30 of those records. Print both datasets.

3. Conduct performance analysis of Classification Algorithms (any 2) on a specific dataset.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a. Write the steps to install Python. TSO.1. b. Explain given types of variables in python. TSO.1. c. Explain use and importance of Tuple, Dictionary, operators in python TSO.1. d. Explain use of array in python. TSO.1. e. Explain use of 2-Dimensional Array in python TSO.1. f Explain uses of given type of Conditional statement in python.	**Unit-1.0 Python Basics: -** 1.1 Installation of Python 1.2 Variables, Print () function, Escape character sequence and run python Program 1.3 Python Tuple, Dictionary, operators 1.4 Python arrays, create, reverse and append data into it. 1.5 Python 2 Dimensional arrays. 1.6 Python Conditional statement.	**CO-1 and CO-5**
TSO.2. a. Explain uses of given type of do & while loops in python TSO.2. b. Explain working of break, continue and pass statement in python TSO.2. c. Write the benefits of using OOP methodology in python. TSO.2. d. Explain given type of string operation related to python. TSO.2. e. Explain given function in python TSO.2. f Explain use of Lambda function in python.	**Unit 2.0 Python Advance: -** 2.1 Python Do & while loops 2.2 Python break, continue, pass statements 2.3 Python OOPs Class, Object, Inheritance and Constructor 2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length 2.5 Python Functions, Built-in functions and user defined functions 2.6 Lambda function and uses	**CO-1 and C05**
TSO.3. a. Differentiate between Cloud and IoT cloud. TSO.3. b. Explain features of Cloud in IoT environment TSO.3. c. List features of various types of Cloud TSO.3. d. List features of cloud services like SaaS, PaaS and IaaS TSO.3. f List advantages of cloud data storage. TSO.3. g Explain Arduino architecture and its applications. TSO.3.h Explain Raspberry pi architecture and its applications.	**Unit-3.0 Cloud Features: -** 3.1 Cloud computing and IoT cloud 3.2 Benefits of cloud in IoT 3.3 Types of Cloud public, private and hybrid 3.4 Cloud services like SaaS, PaaS and IaaS 3.5 Cloud connectivity and Data storage on Cloud. 3.6 Arduino: Architecture, Programming, and Applications 3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications	**CO-1, CO-2 and CO-5**
TSO.4. a. Explain wired network TSO.4. b. Explain short range wireless network TSO.4. c. Explain M2M communication TSO.4. d. Explain various generation of wireless network TSO.4. e. Explain the importance of LWPAN in IoT TSO.4. f Differentiate between SigFox & LoRaWAN TSO.4. g Explain use of NB-IOT (Narrow Band IOT) TSO.4.h Create heterogenous network using RFID.	**Unit.4.0 IoT Networking and Application: -** 4.1 Wired and short-range wireless network 4.2 M2M – 2G, 3G, 4G & 5G networks 4.3 LPWAN – Low Power Wide Area Networks 4.4 SigFox & LoRaWAN. 4.5 NB-IOT (Narrow Band IOT) 4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors- Cables-Readers- encoder/ printers for smart labels-Controllers software 4.7 RFID advantages over Bar codes.	**CO-1 and CO-4**
TSO.5. a. Identify suitable framework for IoT app development TSO.5. b. Identify various stages of selected app TSO.5. c. Develop the app.	**Unit. 5.0 IoT App Development**: - 5.1 Framework selection for IoT app development 5.2 Identify stages of app to be developed. 5.3 Develop, Implement, and Deploy the App 5.4 Testing and Integration	**CO-4 and CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5. d. Implement and deploy the app TSO.5. e Maintain and improve the app based on the feedback	5.5 Maintain and improve	

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Python installation LSO 1.2 Prepare and run python program on given problem LSO 1.3 Prepare python program on Dictionary, Tuple and operators. LSO 1.4 Prepare program on arrays LSO 1.5 Prepare a program on 2-dimensional array LSO 1.6 Create program on conditional statement	1.	1.1 Install given version of Python on the computer system. 1.2 Prepare a python program using print() function and run it. 1.3 Access given value from the tuple 1.4 Print the given value of key from the dict. 1.5 Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes 1.6 Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array. 1.7 Write a python program to check whether person is eligible for voting or not. (accept age from the user) 1.8 Write a python program to check whether the entered number is even or odd. 1.9 Write a python program to check whether entered number is divisible by another entered number. 1.10 Write a python program to display “Yes” is entered number is divisible by 5 otherwise display “No”	CO-1
LSO 2.1 Prepare python program on Do & while loops LSO 2.2 Prepare python program on break and continue statement. LSO 2.3 Prepare Python program using break and continue statements LSO 2.4 prepare python program using OOP LSO 2.5 Prepare Python program using functions	2.	2.1 Prepare a python program which can print first 10 even and odd numbers using while statement 2.2 Write a python program which can print first 10 integers and its square using while/for loop. 2.3 Write a python program which can print sum of first 10 natural numbers using while/for loop. 2.4 Write a python program which can identify the prime number between the range given using while/for loop. 2.5 Consider a situation where you want to iterate over a string and want to print all the characters until a letter ‘e’ or ‘s’ is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		2.6 Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use. 2.7 Create a Class with instance attributes 2.8 Create a Vehicle class without any variables and methods 2.9 Write a Python function to find the Max of three numbers. 2.10 Write a Python program to reverse a string.	
LSO 3.1 Signup for free cloud storage LSO 3.2 Store data into cloud and retrieve it.	3.	3.1 Create a free cloud account 3.2 Store data on cloud and retrieve it	CO-3
LSO 4.1 Design various types of network cables LSO 4.2 Connect computer in LAN. LSO 4.3 Connect devices using wireless network LSO 4.4 Connect machine with machine LSO 4.5 Connect devices using IEEE 802 LSO 4.6 Connect devices using LPWAN LSO 4.7 Connect devices using RFID	4	4.1 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool. 4.2 Connect the computers in Local Area Network 4.3 Connect 2 or more devices using Bluetooth 4.4 Connect 2 or more devices using infrared 4.5 Connect 2 more machine using m2m 4.6 Connect 2 or more different devices using access point 4.7 Connect 2 devices using LPWAN (Smart Meter) 4.8 Connect 2 or more devices using RFID	CO-4
LSO 5.1 Develop a IoT app LSO 5.2 Develop IoT applications using smartphones.	5.	5.1 Identify a problem and develop an app 5.2 Building a temperature monitoring system using sensors and Smartphone	CO-5

L) Suggested Term Work and Self Learning: S2400604C 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 Python programming language.
2. Develop a small software in python to solve a IoT data analysis.
3. Create a id on free cloud storage and share data on it for others.
4. Create a heterogenous network and connect different dives.
5. Create a an IoT app for the identified problem

c. Other Activities:

1. Seminar Topics: - “Future of wireless network.”
2. “Smart electricity billing “, “Cloud computing and IoT”

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	**Unit-1.0 Engineering mechanics for Drone Technology** 1.1 Drone Mechanics • Free body diagram of drone • Method of finding resultant of force system • Equilibrium of coplanar force system 1.2 Center of Gravity • Centroid of plane figure • Center of gravity of solid bodies 1.3 Force analysis in drone • Force analysis in drone • Forces of flight • Principle axes and rotation of aerial systems 1.4 Dynamics of machine • Static and dynamic force analysis • Gyroscopic motions	**CO-1**
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	**Unit-2.0 Drone Frame and Components** 2.1 Drone frame design • Calculation principle for drome frame sizes • Quadcopter frame design • Smart materials for UAV frame • Green material uses in drone 2.2 Advance Drones component • GPS, Interfacing of GPS hardware • Thermal and chemical sensor • Tilt and LiDAR sensor 2.3 RF transmitter and receiver • RF blocks • RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	**CO-2**
TSO 3a. Identify features and specifications of FCB use in different application	**Unit-3.0 Advance flight controller Board (FCB)** 3.1 Specification and ports of FCB 3.2 Software for FCB	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 3b. Explain ports of any given advance flight controller board. TSO 3c. Write steps of software installation of flight controller board. TSO 3d. Describe installation and calibration steps of radio telemetry with FCB. TSO 3e. Write steps of calibration of accelerometer and ESC with FCB. TSO 3f. Describe interfacing of GPS with FCB.	• Software installation 3.3 Radio Communication with FCB • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC 3.7 GPS interface with FCB 3.8 Safety features of advance FCB	
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	**Unit-4.0 Maintenance and assembling of Drone** 4.1 Need and scope of drone maintenance 4.2 Types of maintenance 4.3 Routine drone maintenance and its checklist • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling	**CO-4**
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	**Unit-5.0 Advance Drone Application** 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in • Military • Precision Agriculture	**CO-5**

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

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

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

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

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

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

b. Micro Projects:

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

c. Other Activities:

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

d. Self-Learning Topics:

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

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)	
2400604E	3D Printing and Design (Advanced)	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

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

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

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

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

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

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

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

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

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

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

b. Micro Projects:

1. Prepare a list of solid, liquid and powder form 3D printing raw materials stating their cost, colour opacity, flexibility and weight per unit volume.
2. Download 5 videos of 3D printing of different components using FDM, SLA and SLS each. 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.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Describe how does a PLC communicate? TSO.1b Differentiate between parallel and series communication TSO.1c Describe the data transfer mechanism for the given communication protocols. TSO.1d Describe the given communication protocol used in PLC communication. TSO.1e Summarize PLC to PLC communication procedure TSO.1f Describe the common procedure to interface the PLC with other given hardware.	**Unit-1.0 Industrial automation communication and Interfacing** 1.1 Analog and Digital Communications on Plant Floors 1.2 Introduction to Industrial Networking 1.3 RS232-422-485 standards for data communication 1.4 Industrial Ethernet 1.5 Concept of Fieldbus 1.6 MODBUS protocol 1.7 Highway Addressable Remote Transducer (HART) Protocol 1.8 Interfacing of Programmable Logic Controller with other hardware	**CO-1**
TSO.2a Specify the proper I/O addressing format of the given PLC. TSO.2b Explain the use of different relay type instructions for the given operation. TSO.2c Describe how a program is executed with the help of Program Scan cycle TSO.2d Develop ladder logic program using arithmetic functions to perform the given operation. TSO.2e Develop ladder logic programs using logical and comparison instructions to perform the given operation TSO.2f Develop ladder logic programs using on delay, off delay and reset/retentive timer in a given PLC to create a delay in operation. TSO.2g Develop ladder logic programs using Up, Down and UP-down counter in a given PLC to count the number of products	**Unit-2.0 PLC Programming** 2.1 PLC I/O addressing in ladder logic 2.2 PLC programming instructions using ladder logic and relay type instructions 2.3 Program Scan cycle 2.4 PLC arithmetic functions - Addition, subtraction, multiplication, division instructions, increment decrement, trigonometric 2.5 PLC logical functions - AND, OR, XOR, NOT functions, PLC compare and convert functions. 2.6 Programming Timer –Addressing a timer block, status bits, On delay, Off Delay and reset/retentive timer 2.7 Programming Counter- Addressing a counter block, status bits, Up and Down counter, up-down counter, counter examples, register basics 2.8 Develop ladder logic for various simple applications	**CO-2**
TSO.3a Describe Requirements for PLC enclosure. TSO.3b Describe Proper grounding techniques. TSO.3c Describe noise reduction Techniques. TSO.3d Explain preventive maintenance procedure associated with PLC system to reduce environmental impact TSO.3e Identify faults in the given PLC system TSO.3f Explain the procedure for Troubleshooting PLC system TSO.3g Prepare preventive maintenance plan for the PLC system	**Unit-3.0 Installation and maintenance of PLC systems** 3.1 PLC enclosure, grounding requirements, noise generating inductive devices, leaky inputs and outputs, techniques to reduce electrical noise and leakage. 3.2 Introduction to PLC Trouble shooting and maintenance, trouble shooting of hardware and software. 3.3 Diagnostic LED Indicators in PLCs 3.4 Common problems • Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory • External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI),	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3h Use safety equipment's. TSO.3i Follow safe practices	Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated Circuitry, Field Input and Output Devices, Communication Issues. • Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer 3.5 Troubleshooting of Specific Components of the PLC System • Power Supply Troubleshooting • I/O Modules Troubleshooting • Troubleshooting PLC Program Errors • Troubleshooting the Working Environment of a PLC • Replacement of CPU 3.6 PLC trouble shooting flowchart 3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system. 3.8 Safety procedure and safety equipment's.	
TSO.4.a Describe the function of given element of a SCADA system. TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC). TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application. TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.	**Unit-4.0 SCADA and DCS** 4.1 Introduction, need, benefits and typical applications of SCADA and DCS 4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA 4.3 Comparison of SCADA with DCS 4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture 4.5 Creating SCADA Screen HMI for simple object, Steps for linking SCADA object (defining Tags and items, creating trends etc.,) with PLC ladder program using OPC, configuring simple applications using SCADA: Traffic light control, water distribution, pipeline control, Power generation, transmission and distribution etc. 4.6 Procedure to maintain the SCADA based PLC system.	**CO-3**
TSO.5a Identify different components used for automation in the given system TSO.5b Select automation components for a given situation TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible. TSO.5d Prepare plan for sustainable automation as per the requirement.	**Unit-5.0 Applications of Industrial Automation** 5.1 **Manufacturing-** Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation. 5.2 **Health Care-** microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci 5.3 **Defense- guided rockets and missiles,** counter measures, UAV drones, launcher, radar antenna, engagement control system 5.4 **Automobile –B**reak monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps,	**CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	Intelligent Parking Assist System, Driverless/Autonomous Cars 5.5 **Agriculture-** harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor **5.6 Mining-** Mine planning system, mine picture compilation, mine control system, seismic imagining, laser imaging, Rig control system, automated drilling, automated exploration, automated truck	

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Data communication from PLC to PC and vice versa	1.	Transfer the control data from PLC to PC and vice versa	CO1
LSO 1.2 Establish Communication channels between PLC s.	2.	Transfer the control data from PLC to PLC	CO1
LSO 1.3 Transfer data from sensors to PLC and from PLC to PC.	3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1
LSO 1.4 Interface the given PLC with a PC or a Laptop	4.	Interface the given PLC with a PC or a Laptop	CO1
LSO 2.1 Identify Different parts and front panel indicators of a PLC	5.	Identify the various parts and front panel status indicators of the given PLC.	CO2
LSO 2.2 Develop Ladder logic program for different arithmetic operations	6.	Develop/Execute ladder logic program for different arithmetic operations such as Addition, subtraction, multiplication, division increment, decrement, trigonometric in a given PLC	CO2
LSO 2.3 Develop Ladder logic program for different logical operations	7.	Develop/Execute ladder logic program for logical operations such as AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate along with truth table	CO2
LSO 2.4 Program Latch and Unlatch circuit in a PLC for motor operation	8.	Program the given PLC to start run and stop the given motor using latch circuit	CO2
LSO 2.5 Create delay in operation using on delay, off delay and retentive timer function in a given PLC.	9.	Test the functionality of on delay, off delay and retentive timer for its correct operation in a given PLC.	CO2
LSO 2.6 Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	10.	Test the functionality of Up, Down and Up-down counter for its correct operation in a given PLC.	CO2
LSO 2.7 Program PLC using ladder logic to control a LED/Lamp	11.	Develop/Execute a ladder logic program to put LED/lamp in the blinking mode	CO2
LSO 2.8 Program PLC using ladder logic to control a simple traffic light system	12.	Develop/Execute a ladder logic program to control a simple traffic light control system using PLC	CO2
LSO 3.1 Use hygrometer to measure the humidity inside the panel *LSO 3.2* Use thermometer to measure ambient temperature inside the panel *LSO 3.3* Use tester to determine the voltage fluctuation at the power supply terminals is within specifications	13.	Troubleshooting of PLC system	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.4 Test the ground connections of the given PLC. *LSO 3.5* A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output *LSO 3.6* Investigate the cause of Noise in the given PLC *LSO 3.7* PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure. *LSO 3.8* Troubleshoot the corrupted PLC memory. *LSO 3.9* Replace CPU and power supply fuses in a given PLC system.			
LSO 4.1 Download any open source SCADA software and install the same. *LSO 4.2* Interpret the available components in symbol factory of SCADA software *LSO 4.3* Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list) i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property. *LSO 4.4* Create historical and real time trends for the given automation	14.	Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties	CO4
LSO 5.1 Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. *LSO 5.2* Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application *LSO 5.3* Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. *LSO 5.4* Develop a Automation system to Open and close the door in the shop	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.5 Develop a line following robot with RFID sensor for supplying materials and automating workflow. *LSO 5.6* Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day. *LSO 5.7* Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.			

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

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

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

b. Micro Projects:

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

c. Other Activities:

1. Seminar Topics- PLC instructions, Timers and Counters used in a given PLC
2. Seminar Topics- Industrial Applications of PLC and SCADA, AGV, Application of automation in different area, trouble shooting of different types of PLC
3. Visits – Visit any industry with full or semi automation and prepare a report on industrial automation used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the vehicle movement process TSO 1b. Derive various equations for the movement of Vehicles TSO 1c. Compute different resistances affecting Vehicle movement. TSO 1d. Explain the dynamics of the given type of EV system.	**Unit-1.0 Vehicle Dynamics** 1.1 Vehicle Movement 1.2 Rolling Resistance: Equation, Coefficient, factor affecting rolling resistance, typical values of rolling resistance 1.3 Grading resistance 1.4 Road resistance 1.5 Acceleration resistance 1.6 Total driving resistance 1.7 Aerodynamic drag: Equation, typical values of the drag coefficient. 1.8 Vehicle dynamics • Hybrid and Electric Vehicles • DC Motor Dynamics and Control • AC Motor Dynamics and Control	**CO1**
TSO 2 a. Identify the given elements of Automobile Systems. TSO 2 b. Describe the functions of the given elements of Automobile Systems. TSO 2 c. Explain the dynamic characteristics of the Disc Braking System for the given braking steps. TSO 2 d. Describe the Procedure for testing the given AC/DC motors. TSO 2 e. Describe the Procedure of Installation and Testing of the given EV Charging Stations. TSO 2 f. Describe the Procedure for Commissioning EV Charging Stations. TSO 2 g. Explain the functions of the EV Control Unit.	**Unit-2.0 Elements of Automobile** 2.1 Suspension and Damping systems 2.2 Brake system: Half-step braking, Full step Braking 2.3 Transaxle 2.4 Elements of Noise Vibration and Harshness Control 2.5 Body balancing 2.6 Tyre Technology 2.7 AC/DC motor 2.8 Air-conditioning and Heating System 2.9 Lighting System 2.10 Automotive wiring system 2.11 Earthing and Insulation 2.12 Charging stations – Installation and Commissioning 2.13 Vehicle control unit	**CO2**
TSO 3a. Compare different power transmission systems in EVs. TSO 3b. List the main Components of the EV Power Train. TSO 3c. Explain the functions of the given EV Power Train component. TSO 3d. Describe the testing procedure of the given EV Power Train component. TSO 3e. Explain the regenerative braking operation in the given EV motor. TSO 3f. Describe the speed control mechanism of the given motor. TSO 3g. Explain various parameters of the given battery. TSO 3h. Select the suitable battery for the given EV application. TSO 3i. Describe the assembling and dismantling procedure of the given battery. TSO 3j. Describe the Mechanism of Gear and Differential Assembly.	**Unit-3.0 EV Power Transmission System** 3.1 **Transmission System**: Single and Multi-transmission system 3.2 **EV Power Train** 3.3 **EV Power Train Components**: Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger. 3.4 **Battery Parameters**: Voltage, Current, Charging rate, efficiency, energy density, power density, State of Charge (SoC), Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. 3.5 Battery Assembly and Dismantling. 3.6 Gear and Differential Assembly 3.7 Safe disposal of used battery	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.	**Unit- 4.0 Vehicle Control Unit (VCU)** 4.1 **Electronic Control Unit**: Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	**CO4**
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.	**Unit- 5.0 EV Charging Technologies** 5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	**CO5**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	• Testing of Control Disc Braking system and Control Regenerative Braking system.	CO2
LSO 2.3 Test the performance of different types of propulsion motors.	2.	• Testing of Motors	
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	• Testing of the automotive wiring system.	
LSO 3.1 Test the performance of a new set of batteries and aged batteries. LSO 3.2 Compare the performance of the battery and find the Fuel Gauge after discharging the battery. a. 0% - 100% b. 30% - 100% c. 50% - 100% LSO 3.3 Evaluate the following parameters of the given EV battery. a. Specific power b. Specific energy c. Life span and	4.	• Testing of Batteries used in EVs	CO2, CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
d. Cost parameters LSO 3.4 Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.			
LSO 3.5 Test the dynamic performance of the given motor; a) Speed and torque spectrum. b) Speed and torque oscillation c) Friction torque friction spectrum. LSO 3.6 Test the following speed-controlled performance characteristics of the given motor; a. Motor voltage over time b. Motor current over time. c. Speed and torque over time. d. Torque over speed. e. Current over speed. f. Electrical input power and the mechanical input power over speed	5.	• Speed control of Electrical Motors	
LSO 4.1 Connect the components of the EC Units with EV subsystems. LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.	6.	• Connection of Electronic Control Unit components • Troubleshooting of electronic control unit	CO4
LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	• Impacts of G2V and V2G	CO 5
LSO 5.2 Prepare a layout of a charging station	8.	• Demonstration of Charging stations	

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

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

b. Micro Projects:

1. Design and build a physical model of an EV motor and powertrain components from scratch.
2. Build and simulate communication systems of EVs using some software tools.
3. Prepare a report on "the way carbon credit works and companies utilize it to reduce their emission values".
4. Develop an EV prototype power train using locally procured hardware components.

c. Other Activities:

1. **Seminar Topics**:
   - Safe disposal process of Used Batteries.
   - Charging Technologies used for charging the EV.
   - EV power transmission systems.
2. **Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the need and scope of industrial robots. TSO 1b. Describe the concept of robot dynamics with regards to methods for orientation and location of objects. TSO 1c. Analyse robot direct kinematics for the given 2 DOF planar manipulator. TSO 1d. List types of robots TSO 1e. List safety steps while handling the given robot. TSO 1f. Interface robots with the given welding machine. TSO 1g. Interface robots with the given painting machine. TSO 1h. Interface robots with the given assembly machine.	**Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications** 1.1 Definition need and scope of Industrial robots 1.2 Robot dynamics – Methods for orientation and location of objects 1.3 Planar Robot Kinematics – Direct and inverse kinematics for 2 Degrees of Freedom. 1.4 Safety while operating and handling robot 1.5 Robot Industrial applications: • Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing • Spray painting Robots, assembly operation, cleaning.	**CO2, CO3**
TSO 2a. Explain the techniques to control robot motion. TSO 2b. Describe the given robot drive system. TSO 2c. Describe the types of grippers. TSO 2d. Design grippers for specific application. TSO 2e. Test the designed gripper for the application. TSO 2f. Use Bar code technology for robotic applications. TSO 2g. Integrate radio frequency identification technology in robotic applications. TSO 2h. Assemble an automated guided vehicle for the given situation using standard components. TSO 2i. Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components.	**Unit– 2.0 Robot Drives, Control and Material Handling** 2.1 Controlling the Robot motion. 2.2 Position and velocity sensing devices. 2.3 Drive systems – Hydraulic and Pneumatic drives 2.4 Linear and rotary actuators and control valves 2.5 Electro hydraulic servo valves, electric drives, motors 2.6 End effectors – Vacuum, magnetic and air operated grippers 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS) 2.8 Bar code technology 2.9 Radio frequency identification technology.	**CO2, CO3**
TSO 3a. Differentiate between various work cell layouts. TSO 3b. Select work cell for specific robot with justification. TSO 3c. Analyse robot cycle time. TSO 3d. Explain industrial applications of robotic cell. TSO 3e. Follow safety procedures in robotic cell.	**Unit– 3.0 Robot Cell Design and Application** 3.1 Robot work cell design, control and safety 3.2 Robot cell layouts 3.3 Multiple Robots and machine interference 3.4 Robot cycle time analysis 3.5 Industrial application of robotic cells	**CO3**
TSO 4a. List different programming languages for the robots TSO 4b. Describe artificial intelligence TSO 4c. Write a programme in the required language to operate a robot for the given task. TSO 4d. Optimise robot programming parameters. TSO 4e. Select a robot on the basis of cycle time analysis. TSO 4f. Conduct an economic analysis for use of robots.	**Unit– 4.0 Robot Programming and Economics of Robotization** 4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing	**CO1, CO4, CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4g. Follow testing methods and acceptance rules for industrial robots.	the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on investment method. 4.9 Testing methods and acceptance rules for industrial robots	
TSO 5a. Describe applications of robots in healthcare and medicine. TSO 5b. Describe applications of robots in Construction industry. TSO 5c. Describe applications of robots in Underground coal mining. TSO 5d. Describe applications of robots in uutilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	**Unit–5.0 Applications in Non-manufacturing Environments** 5.1 Applications of Robots in • Healthcare and medicine • Construction industry • Underground coal mines • Utilities, military & firefighting operations • Undersea • Space • Logistics, • Retail and Hospitality • Smart Cities • Farming and Agriculture 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	**CO5**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify Wireless Sensor Network. LSO 1.2 Use wireless sensor Network for different robotic applications	1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3
LSO 2.1 Identify different Radio Frequency (RF) Controlled Wireless LSO 2.2 Use Radio Frequency (RF) Controlled Wireless for different robotic applications.	2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2
LSO 3.1 Identify the different Voice operated robot with speaker identification technology LSO 3.2 Use different Voice operated robot with speaker identification technology for different robotic applications.	3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3
LSO 4.1 Identify the components required for a computer-controlled pick and place robot (wireless). LSO 4.2 Integrate the components for the required application.	4.	Design a computer-controlled pick and place robot (wireless)	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1 Identify the components required for a Zigbee controlled Boat with wireless video and voice transmission. LSO 5.2 Integrate the components for the required application.	5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3
LSO 6.1 Identify the components required for a PC controlled wireless Multipurpose robot for engineering applications. LSO 6.2 Integrate the components for the required application.	6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO2, CO4, CO5
LSO 7.1 Identify the components required for an unmanned arial photography LSO 7.2 Integrate the components for the required application.	7.	Design an unmanned arial photography system.	CO3, CO5
LSO 8.1 Develop a program LSO 8.2 Simulate palletizing and depalletizing operations through robots.	8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5
LSO 9.1 Develop a program LSO 9.2 Simulate direction control and step control logic for robotization	9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5
LSO 10.1 Develop a program LSO 10.2 Simulate robotising an inspection and part assembly.	10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5
LSO 11.1 Develop a program. LSO 11.2 Simulate obstacle avoidance of robots.	11.	Develop obstacle avoidance robot Programming	CO1, CO5
LSO 12.1 PLC programming. LSO 12.2 Simulate robotising of welding operation.	12.	Program and simulate welding operation using robot simulation software.	CO1, CO5
LSO 13.1 Simulate robotising of drilling operation.	13.	TPP / Offline program for drilling operation.	CO1, CO5
LSO 14.1Develop a program for an industrial application. LSO 14.2Execute the robot programme.	14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5
LSO 15.1 Use robot simulation software for Direct Kinematic analysis upto 4-axis robots LSO 15.2 Correlate the simulated results with respective mathematical calculations.	15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2

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

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

b. Micro Projects:

A suggestive list of micro-projects is given here. Similar micro-projects that match the COs could be added by the concerned course teacher. The student should strive to identify eco-friendly or recycled material prior to selection for robotic applications.

1. Develop coin separating robot.
2. Develop robot using radio frequency sensors for material handling.
3. Develop robot for land mine detection.
4. Develop a robot for car washing.

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

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

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

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

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

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

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

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

b. Micro Projects:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5c. Discuss the various types of dispersion in optical fibre design *TSO 5d.* Explain the optimization technique of single mode fibre. *TSO 5e.* Describe the working and characteristics of different optical networks. *TSO 5f.* Explain the nonlinear effect on network performance of optical fibre systems. *TSO 5g.* Explain multicarrier modulation techniques to enhance data transmission and system performance. *TSO 5h.* Describe the principles and advantages of Orthogonal Frequency Division Multiplexing (OFDM) in improving bandwidth efficiency and reducing interference. *TSO 5i.* Analyze given emerging technologies.	**Unit-5.0 Advanced Optical Fiber Communication and Emerging Technologies** 5.4 Advanced Optical Fiber: Dispersion issues, Dispersion shifted, Dispersion flattened, Dispersion Compensating fibre 5.5 Design and optimization of single-mode fibers 5.6 Optical Networks- Basic Networks SONET, SDH-wavelength-routed networks 5.7 Nonlinear effect on Network Performance, performance of various systems (WDM, DWDM + SOA) 5.8 Multicarrier Modulation Technique 5.9 Orthogonal Frequency Division Multiplexing (OFDM) 5.10 Emerging Technology: Green Communication network, Vehicle 2 everything (V2X), Aerial Communication, Satellite Communication (LEO), Tactile Internet (TI), Free Space Optics (FSO), Near Field Communication, Quantum Communication, Molecular Communication	**CO5**

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

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

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

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

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

e. Micro Projects:

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

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

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

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

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

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

a. Assignments:

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

b. Micro Projects:

1. Prepare collage for personal grooming.
2. Develop a showcase portfolio.
3. Prepare a collage of different gestures and postures of Body Language.
4. Apply Five-S in a work situation.
5. Arrange Mock Interviews, appear, and video record. Reflect on your performance.
6. Organize Group discussions on current topics and video record. Reflect on your performance

I) Theory Session Outcomes (TSOs) and Units: T2400110

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the concept of to Community/Society in Indian Context *TSO 1b.* Explain the concept of Rural and Urban Society *TSO 1c.* Differentiate between Rural and Urban Societies. *TSO 1d.* Differentiate between Underdevelopment and development. *TSO 1e.* Describe the different components of community development	**Unit-1.0 Community and Society Development Framework** 1.1 Concept of Community/Society Development 1.2 Difference between Rural and Urban Societies 1.3 Characteristics of Underdevelopment and development 1.4 Components of Community Development	**CO1**
TSO 2a. Prepare a brief report on Community Development Programmes in India considering the given criteria *TSO 2b.* Prepare a brief report on institutions engaged in community development programmes considering the given criteria *TSO 2c.* Explain the framework of sustainable community development	**Unit-2.0 Community Development Initiatives** 2.1 Community Development Programmes in India-Historical perspective 2.2 Institutions Engaged in Community Development Programmes 2.3 Contemporary Community Development Initiatives. 2.4 Sustainable Community Development	**CO1, CO2**
TSO 3a. Explain Role of Technical Intuitions in Community/Society development. *TSO 3b.* Summarise the activities undertaken by technical institutions under community development through polytechnic scheme *TSO 3c.* Prepare a plan for undertaking project to support Unnat Bharat Abhiyan	**Unit-3.0 Community Development Schemes** 3.1 Role of polytechnics in Community development. 3.2 Scheme of Community Development through Polytechnics 3.3 Unnat Bharat Abhiyan	**CO3, CO4**

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

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

a. Assignments: Specific assignments will be given to students for preparing report on community development programmes and institutions engaged in community development programmes.

b. Micro Projects:

1. Suggest solution for flowing water near a water source.
2. Identify locally available construction materials in a village.
3. Suggest a plan for disposal of solid waste in a village.
4. Prepare a plan for use of solar light equipments at streets and public places.

c. Other Activities:

1. Seminar Topics:
    - Issues of development for a village near to the institution.
    - Activities to be undertaken by the polytechnic in a village.
    - Characteristics of Development and underdevelopment.