

Curriculum of Diploma Programme

in

Civil Engineering



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

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

Semester – VI

Teaching & Learning Scheme

Course Codes	Category of Course	Course Titles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2415601	PCC	Environmental Engg.	03	-	04	02	09	06
2415602	PCC	Steel Structure	02	01	-	02	05	04
2415603	PEC	Programme Electives* Any One	03	-	04	02	09	06
2400604	OEC	Open Elective**/ COE (Advanced - Any One)	03	-	04	02	09	06
2415605	PSI	Major Project (Common for all programmes)	-	-	08	04	12	06
2400408	NRC	Employability Skills Development (Common for All Programmes)	01	-	-	-	01	01
2400009	NRC	Open Educational Resources	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)

*: Prestress and Precast Concrete/ Traffic Engineering and Pavement Design/ Green Building and Sustainability/ Water and Waste Water Management

** : 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)	
2415601	PCC	Environmental Engg.	30	70	20	30	20	30	200
2415602	PCC	Steel Structure	30	70	20	30	-	-	150
2415603	PEC	Programme Electives* - Any One	30	70	20	30	20	30	200
2400604	OEC	Open Elective**/ COE (Advanced - Any One)	30	70	20	30	20	30	200
2415605	PSI	Major Project (Common for all programmes)	-	-	20	30	50	100	200
2400408	NRC	Employability Skills Development (Common for All Programmes)	25	-	-	-	-	-	25
2400009	NRC	Open Educational Resources	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.
 *: Prestress and Precast Concrete/ Traffic Engineering and Pavement Design/ Green Building and Sustainability/ Water and Waste Water Management
 **: 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.

J) Theory Session Outcomes (TSOs) and Units: T2415601

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
<p>TSO1.a Identify the possible sources of water For a given locality.</p> <p>TSO1.b Justify the need of planned water Supply system for a given locality.</p> <p>TSO1.c Forecast the population at the end of specified decade for a given city using relevant method of estimation.</p> <p>TSO1.d Carryout the testing for the given Physical, chemical and biological properties of water.</p>	<p>Unit 1.0: Sources, Demand and Water Quality Assessment:</p> <p>1.1 Sources of water: Surface and subsurface sources of water, Intake structures: Types, Purposes and its Location.</p> <p>1.2 Water demand: Importance and necessity for planned water supplies, Various types of Water demand, Per capita demand, factors affecting per capita demand, Water supply scheme and its flow diagram, Variations in demand.</p> <p>1.3 Population forecasting: Design period, Methods of population forecasting, (Simple problems on population forecasting).</p> <p>1.4 Characteristics and Testing of water: Necessity of water analysis, Characteristics of water: Physical, Chemical and Biological; Physical Testing of water – Turbidity & color, Chemical Testing of water - Total Solids (TS), Hardness, Chlorides, Dissolved oxygen (DO), pH, Fluoride, Nitrogen(N) and its compounds.</p> <p>1.5 Bacteriological/Biological tests: E-coli, B- coli index, MPN (Most probable number); Sampling of water, Guidelines, Specification of drinking water quality as per IS-10500:2012.</p>	CO1
<p>TSO2.a Explain the process of water treatment to make it potable.</p> <p>TSO2.b Use relevant type of filter in water purification process at given location.</p> <p>TSO2.c Suggest the relevant method of disinfection process for a given sample of water.</p> <p>TSO2d. Draw the flow diagram of conventional water treatment plant.</p>	<p>Unit2.0: Purification of Water</p> <p>2.1 Water Treatment: Water Treatment-Concept, Screening, settling operation, Sedimentation and its types, Sedimentation tank, Coagulation and its Mechanism, Coagulants, Flocculation, Mechanism of Flocculation, Sedimentation aided with coagulation.</p> <p>2.2 Filtration: Theory, Purposes and Types of Filters, Construction, Mechanism and Operation of Slow Sand, Rapid Sand and Pressure Filter.</p> <p>2.3 Disinfection: Methods of Disinfection, Kinetics of disinfection, Chlorination and Practices of Chlorination, Calculation of Doses of chlorine.</p> <p>2.4 Water treatment Plant: Purpose, Construction and its flow diagram.</p>	CO2
<p>TSO 3a. Select a relevant type of pipe material for the conveyance of water for the given locality.</p> <p>TSO 3b. Explain the relevant method of water distribution with labeled sketch.</p> <p>TSO 3c. Use Hardy cross method to determine the equivalent size of pipe for the given distribution system.</p>	<p>Unit-3.0: Distribution and Conveyance of Water</p> <p>3.1 Conveyance system: Need, Purposes and advantages, Pipes Material used for conveyance of water, Plumbing system, House Water Connection, Different Cocks and valves, pipe fixtures and fittings, Types of joints.</p> <p>3.2 Distribution System: Need, Purposes and Advantages, Methods of Distribution-Gravity, Pumping (Pressure)and Combined System.</p> <p>3.3 Layout of distribution networks-Need of distribution layout, Types- Dead end system, Grid iron system, Radial system and Circular System; Detection of leakage in the distribution pipes.</p> <p>3.4 Pipe network Analysis: Hardy-Cross method,</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
	equivalent pipe method, Appurtenances in the distribution system.	
<p><i>TSO 4a.</i> Explain the need and importance of sanitation for the given building.</p> <p><i>TSO 4b.</i> Select the relevant type of pipe for a given sewerage system.</p> <p><i>TSO 4c.</i> Suggest the relevant type of sanitary fittings suiting for the given location in a building.</p> <p><i>TSO 4d.</i> Suggest the relevant type of sewers for a given sewerage system.</p> <p><i>TSO 4e.</i> Carryout testing and maintenance for a given sewerage system.</p>	<p>Unit-4.0: Domestic Sewages and Sewerage System:</p> <p>4.1 Building Sanitation: Need and importance of sanitation, Definitions-Sewage, Sullage, Types of sewage, Definition of the terms related to building sanitation.</p> <p>4.2 Pipes for sewerage system: Soil pipe, Sullage pipe, Vent pipe.</p> <p>4.3 Building Sanitary Fittings: Water closets – Indian and European type, flushing cistern, washbasin, sinks, Urinals; Traps- types, qualities of good trap; Systems of plumbing - one pipe, two pipe, single stack; Drainage systems: Principle, Need and Layout of drainage system.</p> <p>4.4 System of Sewerage and Sewer appurtenances: Types of Sewers, System and Layout of sewerage, self-cleansing velocity and non-scouring velocity, Laying.</p> <p>4.5 Testing and Maintenance of sewers: Inspection chambers and Manholes-component parts, location and spacing; Sewer Inlets, Street Inlets.</p>	CO4
<p><i>TSO 5a.</i> Determine BOD and COD of a given sample of sewage water.</p> <p><i>TSO 5b.</i> Explain sewage treatment processes.</p> <p><i>TSO 5c.</i> Describe various component of sewage disposal process.</p> <p><i>TSO 5d.</i> Explain the sludge treatment process.</p> <p><i>TSO 5e.</i> Explain the various activities involved In solid waste disposal process.</p> <p><i>TSO 5f.</i> Design a septic tank for the given building project with labeled sketch (Plan and Elevation).</p>	<p>Unit-5.0: Sewage Treatment and Waste Management-</p> <p>5.1 Analysis of sewage: Characteristics of Sewage- B.O.D., C.O.D, and its Significance; Aerobic and Anaerobic Processes; Bihar state pollution control board norms for disposal of treated sewage, Objective of sewage treatment and flow diagram of conventional sewage treatment plant.</p> <p>5.2 Treatment of Sewage: Screening, Types of Screens, Grit removal, Skimming, Sedimentation of sewage, Aerobic and Anaerobic process, Sludge digestion, Trickling filters.</p> <p>5.3 Sludge and its treatment: Activated sludge process, Disposal of sewage, Oxidation-Pond, Oxidation ditch, Septic tank, Recycling and Reuse of domestic waste, Sludge characteristics, Sludge treatment process, disposal of sludge, Design of Septic tank.</p> <p>54 Solid waste disposal: composting, incineration, Introduction to sanitary landfill.</p>	CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2415601

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant Cos Number(s)
<i>LSO1.1</i> Determine pH value of given water sample.	1.	Determine pH value of given sample of water.	CO1
<i>LSO2.1</i> Determine the turbidity of given water sample using turbidity meter.	2.	Determine the turbidity of the given sample of water.	CO1

LSO3.1	Determine suspended, dissolved and total solids of given sample of water.	3.	Determine suspended, dissolved and total solids of given sample of water.	CO1
LSO4.1	Determine the dissolved oxygen in a given sample of water using DO apparatus.	4.	Determine the dissolved oxygen in a sample of water.	CO1
LSO5.1	Determine residual chlorine in a given water sample.	5.	Determine residual chlorine in a given sample of water.	CO2
LSO6.1	Determine the optimum dose of coagulant in a given raw water sample.	6.	Determine the optimum dose of coagulant in a given raw water sample by jar test.	CO2
LSO7.1	Prepare a report on water treatment plant.	7.	Prepare a report of field visit to nearby water treatment plant.	CO2
LSO8.1	Draw labeled sketch of valves used in water supply pipe line.	8.	Draw sketches of various valves used in water supply line.	CO3
LSO9.1	Prepare a report on plumbing system.	9.	Prepare a report on plumbing system by site visit of nearby newly constructed building.	CO4
LSO10.1	Prepare a report of site visit to the given sewage treatment plant with labeled sketch of it.	10.	Visit to nearby sewage treatment plant.	CO5
LSO11.1	Determine BOD of given sample of sewage water using BOD apparatus.	11.	Determine BOD of given sample of sewage water using BOD apparatus.	CO5
LSO12.1	Determine COD of given sample of sewage water using COD apparatus.	12.	Determine COD of given sample of sewage water using COD apparatus.	CO5

L) Suggested Term Work and Self Learning: S2415601 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

- 1.Explain the various sources of water.
- 2.Enlist the various methods of population forecast. Explain any one with suitable example.
- 3.Discuss the physical and chemical characteristics of water.
- 4.Differentiate between slow sand and rapid gravity filter.
- 5.Write short notes on the following-
 - (i) Hardy cross method of pipe network analysis.
 - (ii) Activated sludge process.
 - (iii) Trickling Filter.
 - (iv) Oxidation Pond.

b. Micro Projects:

1. Prepare a report on physical, chemical and biological characteristics of given sample of water.
2. Draw a plan and elevation of Septic tank for 50 user.
3. Enlist the various units used in water treatment process and draw a neat sketch of each unit.
4. Prepare a model of water treatment plant.
5. Prepare a model of Trickling filter.

c. Other Activities:

1. Seminar Topics:
 - (a) Treatment of wastewater.
 - (b) Population forecasting methods.
 - (c) Layout of distribution network.
 - (d) Bihar state pollution control board norms for disposal of treated sewage.
 - (e) Sludge and its treatment.

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: T2415602**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO1a. Describe the advantages and disadvantages of steel as a construction material.</p> <p>TSO 1b. Explain the different types of steel sections commonly used in steel structures with neat and clean sketch.</p> <p>TSO1c. Identify suitable dimensions and sectional properties of a given steel section using steel table.</p> <p>TSO 1d. Describe different types of loads acting on a given steel structure.</p> <p>TSO 1e. Explain the advantages of limit state method over working stress method.</p> <p>TSO 1f. Suggest partial safety factor for a given type of load combination using IS: 800-2007.</p>	<p>Unit-1.0 Basics of Steel Structure</p> <p>1.1 Need and importance of steel structures with examples, Types of steel structures, Advantages and disadvantages of steel structure.</p> <p>1.2 Steel Sections and its types, Grades of steel sections, Mechanical properties of steel sections.</p> <p>1.3 Use of steel table and relevant standards IS: 808-1989 and IS Handbook No. 1/ SP: 6(1)-1964.</p> <p>1.4 Types of Loads acting on steel structures as per IS 875-1987 Part I to V.</p> <p>1.5 Methods of Design of Steel Structure: Working stress method and Limit state method, Advantages of limit state method over working stress method, Types of limit states- limit state of strength and limit state of serviceability, Partial factor of safety for loads and for materials as per IS: 800-2007.</p>	CO1
<p>TSO 2a. Explain different types of connections used in steel structures.</p> <p>TSO 2b. Draw failure pattern of a given structural joint under a given loading condition.</p> <p>TSO 2c. Describe various codal provisions applicable for design of connections.</p> <p>TSO 2d. Calculate strength of a given type of connection using given data.</p> <p>TSO 2e. Design a given type of connection under the axially loading condition for a given steel section.</p>	<p>Unit-2.0 Design of Connections (Limit State Method)</p> <p>2.1 Types of Connections: Riveted, Bolted and Welded Connections.</p> <p>2.2 Bolted Connection: Types of bolts, Types of bolted joints, Failure of bolted joints, Assumptions in the analysis of bolted joint.</p> <p>2.3 Specification for bolted joint, Strength and efficiency of bolted joint, Design of bolted joints for axially loaded plates, single and double angle members as per IS: 800-2007.</p> <p>2.4 Welded Connection: Types of welds-Butt weld and fillet weld, Assumptions in the analysis of welded connections.</p> <p>2.5 Analysis and design of butt weld: Specifications for butt weld, Strength of butt weld, Design of butt weld for axially loaded plates as per IS: 800-2007.</p> <p>2.6 Analysis and design of fillet weld: Specifications for fillet weld, Strength of fillet weld, Design of fillet weld for axially loaded plates, single and double angle members as per IS: 800-2007.</p>	CO2
<p>TSO 3a. Identify suitable steel section for a tension member of a given steel structure.</p> <p>TSO 3b. Calculate net sectional area for a tension member of a given steel structure.</p> <p>TSO 3c. Explain modes of failure for an axially</p>	<p>Unit-3.0 Design of Tension Member (Limit State Method)</p> <p>3.1 Types of sections used for tension members, Net sectional area for flats and plates, Effective</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>loaded tension member of a given steel structure.</p> <p>TSO 3d. Compute strength of a given axially loaded tension member using specified data.</p> <p>TSO 3e. Design a tension member for a given steel structure using specified data.</p>	<p>net area for angles.</p> <p>3.2 Type of failure, Design strength of tension member governed by yielding of gross section, rupture of net section and block shear as per IS: 800-2007.</p> <p>3.3 Analysis and Design of axially loaded single and double angle tension members with bolted and welded connection as per IS: 800-2007.</p> <p>3.4 Introduction to gusset plate, lug angle and tension splice (meaning and purpose only).</p>	
<p>TSO 4a. Identify suitable steel section for a compression member of a given steel structure.</p> <p>TSO 4b. Explain codal provisions for effective length and slenderness ratio.</p> <p>TSO 4c. Compute strength of a given axially loaded compression member using specified data.</p> <p>TSO 4d. Design a compression member for a given steel structure using specified data.</p> <p>TSO 4e. Explain the purpose of lacing and battening system with neat labeled diagrams.</p>	<p>Unit-4.0 Design of Compression Member (Limit State Method)</p> <p>4.1 Types of sections used for compression members, Effective length, radius of gyration and slenderness ratio. Permissible value of slenderness ratio, Calculation of Design compressive stress as per IS 800:2007.</p> <p>4.2 Analysis and Design of axially loaded compression members (single and double angles, single and double channel, I-section, I-section with cover plate on flanges) with bolted and welded connection as per IS: 800-2007.</p> <p>4.3 Introduction to built-up sections, column splice, lacing and battening (Meaning and purpose), Diagrams of single & double lacing and battening system. (No Numerical on lacing and battening)</p>	CO4
<p>TSO 5a. Identify suitable steel section for a beam of a given steel structure.</p> <p>TSO 5b. Classify cross section of a steel beam based on yielding behavior.</p> <p>TSO 5c. Differentiate between laterally supported and unsupported beam.</p> <p>TSO 5d. Compute bending strength of a given steel beam using specified data.</p> <p>TSO 5e. Design a steel beam section using specified data.</p> <p>TSO 5f. Identify various elements of a given steel roof truss.</p>	<p>Unit-5.0 Design of Steel Beams (Limit State Method)</p> <p>5.1 Types of sections used for steel beams, Classification of cross sections (plastic, compact, semi-compact and slender), Meanings of Laterally supported beams and laterally unsupported beams.</p> <p>5.2 Bending strength of laterally supported beam and laterally unsupported beam, Shear strength of beam as per IS: 800-2007.</p> <p>5.3 Analysis and design of laterally supported and unsupported beams (rolled I-sections only) with relevant checks as per IS: 800-2007.</p> <p>5.4 Introduction to element of the steel roof truss, built-up beam, plate girder and gantry girder (meaning and purpose only).</p>	CO5

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

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

L) Suggested Term Work and Self Learning: S2415602 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.

J) Theory Session Outcomes (TSOs) and Units: T2415603A

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
<p>TSO 1a. Explain the principles of pre-stressing used in the given structural component.</p> <p>TSO1b. Describe the applications of pre-stressed concrete elements in the given situation.</p> <p>TSO1c. Describe the utility of PSC in the given situation.</p> <p>TSO1d. Justify the need of high strength construction materials for PSC.</p> <p>TSO1e. Select the relevant type of pre-stressing materials for the given loading condition.</p>	<p>Unit-1.0: Introduction to Pre-stressed Concrete (PSC)</p> <p>1.1 Principles of pre-stressed concrete and basic terminology.</p> <p>1.2 Applications, advantages and disadvantages of pre-stressed concrete.</p> <p>1.3 Materials used and their properties, Necessity of high-grade materials, Admixtures for concrete.</p> <p>1.4 Types of Pre-stressing steel -Wire, Cable, tendon, Merits-demerits and application.</p>	CO1
<p>TSO2a. Select the relevant method of pre-stressing for a given structural element.</p> <p>TSO2b. Differentiate the systems of pre-tensioning and post-tensioning with their merits/demerits.</p> <p>TSO2c. Explain Hoyer system of pre-tensioning with diagram.</p> <p>TSO2d. Explain relevant procedure of post-tensioning based on the given criteria with diagram.</p> <p>TSO2e. Identify the reasons for loss of pre-stress in the given element.</p> <p>TSO2f. Explain the BIS recommendations for percentage loss in the given pre-stressing method.</p>	<p>Unit-2.0: Methods and Systems of Pre-Stressing</p> <p>2.1 Methods of Pre-stressing – Internal and External pre-stressing, Pre and Post tensioning- applications.</p> <p>2.2 Systems for pre-tensioning – process, applications, merits and demerits.</p> <p>2.3 Systems for post-tensioning - process, applications, merits and demerits</p> <p>2.4 Losses of Pre-stress: - loss due to elastic shortening of concrete, loss due to creep of concrete, loss due to shrinkage of concrete, loss due to relaxation of stress, loss due to friction and loss due to slip (simple numerical problems on determination of losses of Pre-stress.</p> <p>2.5 BIS recommendation for percentage loss in case of pre and post tensioning.</p>	CO2
<p>TSO 3a. Explain the assumptions made in the analysis of PSC beams.</p> <p>TSO3b. Explain the effect of given cable profile on fiber stresses.</p> <p>TSO3c. Calculate maximum stresses induced in the given beam for a given cable profile.</p>	<p>Unit-3.0: Design and Analysis of Pre-Stressed Rectangular Beam Section</p> <p>3.1 Basic assumptions in analysis of pre-stressed concrete beams.</p> <p>3.2 Cable Profile in simply supported rectangular beam section – concentric, eccentric, straight and parabolic. Effect of cable profile on maximum stresses at mid span and at support.</p> <p>3.3 Numerical problems on determination of maximum stresses at mid span with linear (concentric and eccentric) cable profiles only.</p>	CO3
<p>TSO4a. Explain the advantages and disadvantages of precast concrete.</p> <p>TSO4b. Select the relevant structural/ Non-structural precast concrete element in the given situation.</p> <p>TSO4c. Explain the application of precast concrete elements in different construction works.</p> <p>TSO4d. Explain the testing procedure for precast components.</p>	<p>Unit-4.0: Precast Concrete Elements</p> <p>4.1 Advantages and disadvantages of precast concrete members.</p> <p>4.2 Non-structural Precast elements - Paver blocks, Fencing Poles, Transmission Poles, Manhole Covers, Hollow and Solid Blocks, kerb stones as per relevant BIS specifications.</p> <p>4.3 Structural Precast elements – Canal lining, Box culvert, bridge panels, foundation</p> <p>4.4 Testing of Precast components as per BIS standards.</p>	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
<p>TSO5a. Describe various components for a given prefabricated building.</p> <p>TSO5b. Explain material characteristics, plans and standard specifications in a given prefabricated building.</p> <p>TSO5c. Select relevant Prefab system and structural scheme in the given situation.</p>	<p>Unit-5.0: Prefabricated Building Structure</p> <p>5.1 Precast Structural Building components such as slab panels, beams, columns, footings, walls, lintels and chajjas, staircase elements.</p> <p>5.2 Prefabricated building using precast wall panels, floor systems - Material characteristics, Plans & Standard specifications.</p> <p>5.3 Prefab systems and structural schemes and their classification including design considerations.</p>	CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2415603A

Practical/ Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant Cos Number(s)
LSO 1.1. Identify the given pre-stressing steel.	1	Prepare the report and collect the samples of different types of pre-stressing wires/cables/strands.	CO1
LSO2.1. Compare the percentage losses in a given Pre-tensioned and post-tensioned member.	2	Compare the various losses occurring in the pre tensioning and post tensioning of members with their respective percentage.	CO2
LSO3.1. Compare the stress distribution for different types of cable profiles.	3	Prepare the report and compare stress distribution for different types of cable profiles.	CO3
LSO4.1. Compare the experimental and theoretical values of Compressive strength of the given solid precast block.	4	Determine the compressive strength of given solid precast block.	CO4
LSO5.1. Compare the experimental and theoretical values of Compressive strength of the given hollow precast block.	5	Determine the compressive strength of given hollow precast block.	CO4
LSO6.1 Compare the experimental and theoretical values of Compressive strength of the given paver block.	6	Determine the compressive strength of given paver block.	CO4
LSO 7.1. Calculate the load carrying capacity of given manhole cover.	7	Perform load test on a given manhole cover as per IS 12592:2002 Annex c	CO4
LSO 8.1. Explain the manufacturing process of a given precast non-structural element in a manufacturing unit.	8	Prepare a detailed report of field visit to a manufacturing unit (of precast elements such as fencing pole, electric pole Transmission Poles, Manhole Covers, Hollow and Solid Blocks, kerb stones with reference to the manufacturing process)	CO4
LSO 9.1 Explain the manufacturing process of a given precast building element in a manufacturing unit. given beam e.	9	Prepare a detailed report of field visit to a manufacturing unit (of precast elements such as slab panels, beams, columns, footings, walls, lintels and chajjas, staircase elements with reference to the manufacturing process)	CO4
LSO 10.1 Calculate the flexural strength of a given wall panel on site.	10	Determine the flexural strength of wall panels on site.	CO5

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

J) **Theory Session Outcomes (TSOs) and Units: T2415603B**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the importance of traffic engineering in Civil Engineering.</p> <p><i>TSO 1b.</i> Establish the relationship between speed, volume and density of traffic.</p> <p><i>TSO 1c.</i> Explain the characteristics of road users and the vehicles passing through given road section.</p> <p><i>TSO 1d.</i> Explain the factors affecting the reaction time for the given situation.</p> <p><i>TSO 1e.</i> Explain the importance of PIEV theory in traffic engineering.</p>	<p>Unit-1.0 Fundamentals of Traffic Engineering:</p> <p>1.1 Traffic engineering- Definition, objectives and scope.</p> <p>1.2 Relationship between speed, volume and density of traffic.</p> <p>1.3 Road users' characteristics- Physical, mental, emotional factors.</p> <p>1.4 Vehicular characteristics- Width, height, weight, speed, efficiency of brakes.</p> <p>1.5 Reaction time based on PIEV theory (Perception, Intellection, Emotion and Volition).</p>	CO1
<p><i>TSO 2a.</i> Analyse the data of traffic volume count to study the traffic characteristics across the given road section.</p> <p><i>TSO 2b.</i> Explain different methods used in the traffic volume count for a given location.</p> <p><i>TSO 2c.</i> Describe procedure of undertaking the origin and destination study using the relevant methods for the study area.</p> <p><i>TSO 2d.</i> Analyse the spot speed study data collected for the given road section.</p>	<p>Unit-2.0 Traffic Studies:</p> <p>2.1 Traffic Studies- Types, purpose, information required for traffic studies.</p> <p>2.2 Methods of collection of traffic volume count data and analysis of data.</p> <p>2.3 Necessity of Origin and Destination study and its methods.</p> <p>2.4 Speed studies - Spot speed studies and its presentation.</p> <p>2.5 Types and Sources of Data (Road Side Interviews, Home Interview Surveys, Commercial Vehicle Surveys)</p>	CO1, CO2
<p><i>TSO 3a.</i> Describe importance of traffic signs.</p> <p><i>TSO 3b.</i> Classify the traffic signs as per IRC guidelines.</p> <p><i>TSO 3c.</i> Identify the given road marking in the given situation.</p> <p><i>TSO 3d.</i> Apply traffic markings in a given road section.</p>	<p>Unit-3.0 Traffic Signs and Pavement Markings:</p> <p>3.1 Traffic control devices –definition, necessity, types.</p> <p>3.2 Importance, Necessity and objects of traffic signs.</p> <p>3.3 Classification of traffic signs as per Indian Road Congress (IRC) guidelines.</p> <p>3.4 Traffic markings- definition, Types of traffic markings- Carriage way, Kerb, object marking and reflector marking.</p>	CO3
<p><i>TSO 4a.</i> Compare the characteristics of rigid and flexible pavement.</p> <p><i>TSO 4b.</i> Explain various components of</p>	<p>Unit-4.0 Pavement and its Components:</p> <p>4.1 Objects and requirements of pavements.</p>	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 4c.</i> Describe the given type of pavement.</p> <p><i>TSO 4d.</i> Describe various construction & maintenance aspects of flexible & rigid pavements.</p> <p><i>TSO 4e.</i> Explain the process involved in the structural evaluation of flexible and rigid pavements</p>	<p>4.2 Types of Pavements: Flexible Pavement and Rigid Pavement.</p> <p>4.3 Pavement components: Sub-grade, Sub-base, Base Course and wearing course.</p> <p>4.4 Construction and maintenance of flexible and rigid pavements.</p> <p>4.5 Structural evaluation of flexible and rigid pavements.</p>	
<p><i>TSO 5a.</i> Explain the factors affecting design of given type of Pavement.</p> <p><i>TSO 5b.</i> Calculate design wheel load for at least three types of traffic loads.</p> <p><i>TSO 5c.</i> Explain stresses and joints of rigid pavement.</p>	<p>Unit-5.0 Introduction to Pavement Design:</p> <p>5.1 Factors affecting design of pavements.</p> <p>5.2 Flexible Pavement- Tyre pressure, Equivalent Single Wheel Load (ESWL), Terminologies used in flexible pavement design.</p> <p>5.3 Rigid Pavement- Wheel load stresses, temperature stresses and critical combination of stresses.</p> <p>5.4 Types of Joints of rigid pavement.</p>	CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2415603B

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Explain Carry flow chart of Traffic engineering organization.	1.	Draw flow chart of Traffic engineering organization in transportation department of city.	CO1
<i>LSO 2.1.</i> Carry out traffic volume count data and O&D survey for given traffic area.	2.	Methods of collection of traffic volume count data and O-D survey for given area.	CO2
<i>LSO 3.1.</i> Draw various traffic signs for a given traffic location.	3.	Study the various traffic sign for given traffic location.	CO3
<i>LSO 4.1.</i> Draw the various type of Road marking.	4.	Study the various types of road marking.	CO3
<i>LSO 5.1.</i> Prepare the spot speed diagram for given traffic condition.	5.	Draw the spot speed diagrams.	CO3
<i>LSO 6.1.</i> Plan a seminar by a town planner/engineer.	6.	Seminar on any aspect of the traffic engineering.	CO2, CO3, CO4, CO5
<i>LSO 7.1.</i> Typical C/S of different types of roads. <i>LSO 7.2.</i> Types of Joint in Rigid Pavement.	7.	Study the types of pavement in your city.	CO4, CO5
<i>LSO 8.1.</i> Calculate wheel road stresses in given road.	8.	Study the wheel road stresses in given road.	CO4, CO5
<i>LSO 9.1.</i> Conduct a seminar by researcher in the field of traffic engineering to understand the recent development.	9.	Seminar on relevant topics	CO2, CO3, CO4, CO5

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

J) **Theory Session Outcomes (TSOs) and Units: T2415603D**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO1a Explain the terms, “Surface water and Groundwater”. TSO1b Specify the permissible limit of given parameter of drinking water as per BIS. TSO1c List down the types of water pollutant along with the corresponding diseases. TSO1d Justify the importance of treatment of water and wastewater.	Unit-1.0 Introduction to Water and Waste Water 1.1 Water and its characteristics– Surface water and Ground water. 1.2 Drinking water quality requirements as per BIS and WHO. Water Quality Index. 1.3 Sources of Water Pollution, Diseases and control 1.4 Objective and necessity of treatment of water and waste water.	CO1
TSO2.a Explain the components of water cycle. TSO 2.b Explain the necessity of conservation of water to meet the demand of the people. TSO2.c Select the relevant method of treatment for the given sample of water TSO2.d Explain the mechanism of Roof top rain water harvesting for the given building. TSO2.e Suggest the relevant technique to recharge the ground water at a given location.	Unit-2.0 Water Management and Treatment 2.1 Water cycle and impact of human activity on water cycle. 2.2 Water Conservation – Introduction, Importance and methods. Purpose of water conservation – Drinking, Agriculture, Power generation, Industrial conservation. 2.3 Treatment of water: Screening, Sedimentation, Coagulation and Flocculation, Disinfection, Softening. 2.4 Water harvesting: Roof top rain water harvesting, subsurface barrier, Farm ponding. 2.5 Ground water recharge – Need and Importance Methods and Design criteria.	CO2
TSO3.a Identify the source of domestic waste water for the given area. TSO3.b Select the relevant type of sewerage system for the given area. TSO3.c Apply the preliminary treatment on the given sample of wastewater. TSO3.d Explain the need of disinfection of given sample of treated water. TSO3.e Explain the avenues available for the recycling of treated waste water.	Unit-3.0 Domestic Waste Water 3.1 General Conditions-Source of waste water and its characteristics. 3.2 Flow of waste water: Types of sewerage system, factors affecting selection of sewerage system. 3.3 Treatment of wastewater: Screening, Grit chamber, Coagulation and Flocculation, Filtration. 3.4 Disinfection and Softening of treated water. 3.5 Recycling of treated waste water for various recreational purposes	CO3
TSO4.a Identify the type of waste water based on its origin. TSO4.b Apply the relevant technique of physical treatment on given sample of wastewater. TSO 4.c Explain the role of microorganism in treatment of biodegradable waste water.	Unit-4.0 Industrial Waste Water 4.1 Source of waste water and its characteristics– Waste Water from Pulp and Paper Industry, Sugar Industry, Rubber Industry. 4.2 Physical Treatment of Waste Water– Screening, Grit Chamber, Oil and Grease	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO4.d Suggest the relevant natural method of waste water disposal as per provisions of relevant IS code.</p> <p>TSO4.e Describe the factors that affect the self-purification capacity of given stream/river.</p> <p>TSO 4.f Identify the use of treated industrial waste water for the given situation.</p>	<p>removal, Primary and Secondary Settling Tank, Aeration.</p> <p>4.3 Biological Treatment by microorganism in Aerobic and Anaerobic condition.</p> <p>4.4 Natural method of waste water disposal –By Land treatment and by Dilution, Indian Standards for disposal of waste water.</p> <p>4.5 Self-purification capacity of stream/River –Self-purification zones, Factors affecting self-purification capacity of stream.</p> <p>4.6 Management of effluent after treatment within and outside industry-Cooling Tower, Boiler feed water, Irrigation, Land scape watering.</p>	
<p>TSO5.a Carry out the relevant technique to treat the given sample of water.</p> <p>TSO5.b Select the relevant method of treatment for given sample wastewater.</p> <p>TSO5.c State the advantages of IoT based smart water supply monitoring system.</p>	<p>Unit-5.0 Advanced Water and Waste Water Treatment Technique</p> <p>5.1 Water Treatment Technique-Reverse Osmosis; Membrane Filtration; Electrodialysis.</p> <p>5.2 Waste Water Treatment Technique – Phytoid technology; Enhanced Biological Phosphorous Removal; Air Stripping; Electro flocculation treatment; Activated Carbon Adsorption; SBR technique; Rotating Biological Contractor.</p> <p>5.3 Smart Water Supply and monitoring system – Purposes and advantages, IoT based smart water supply monitoring system and water Quality monitoring system.</p>	CO5

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2415603D

Practical/ Lab Session Outcomes	S. No.	Laboratory Experiment/ Practical Titles	Relevant Cos Number (s)
LSO1.1 Determine water quality index of given sample of water.	1.	Determine the water quality index based on the given data of BOD, TSS, DO, Conductivity and Temperature.	CO1
LSO2.1 Assess the impact of water pollutant on living creatures and plants.	2.	Prepare a detailed report on the type of pollutants present in the nearby pond/river and measures to control it.	CO1
LSO3.2 Undertake a site visit to a water conservation site in nearby area.	3.	Prepare a detailed report on water conservation project in your area with Relevant information of literature, collection of posters, images, video clippings, etc.	CO2
LSO 4.1 Summarize the functioning of rain water harvesting implemented on specified public building.	4.	Prepare a report of visit to Rainwater harvesting implemented on Residential or Public building with the labeled sketch, Design parameter, required calculation, etc.	CO2
LSO5.1 Assess the impact of ground water recharge on water quality.	5.	Prepare a report on different methods of ground water recharge assessing the impact of ground water recharge on ground water quality.	CO2
LSO6.1 Determine the optimum dose of Coagulant for treating the given sample of waste water.	6.	Find out the optimum dose of coagulant required to treat given sample of turbid water.	CO3
LSO7.1 Perform chlorine disinfection and lime softening of given filtered waste water.	7.	Find out the amount of residual chlorine present in given sample of treated water.	CO3

Practical/ Lab Session Outcomes	S. No.	Laboratory Experiment/ Practical Titles	Relevant Cos Number (s)
LSO8.1 Undertake the relevant activities of waste water treatment with its reuse for the given locality.	8.	Prepare a visit report on reuse and recycling of waste water adopted in a residential Colony.	CO3
LSO9.1 Analyze the working of waste water treatment plant based on characteristics of effluent.	9.	Draw a labeled sketch of the Industrial waste water treatment plant with a brief report on its working.	CO4
LSO10.1 Analyze the IS Recommendations used for disposal of given sample of waste water	10.	Prepare a summary report on IS Recommendations used for waste water disposal using dilution method.	CO4
LSO11.1 Summarize the Phytoid technology technique used in treatment of waste water.	11.	Prepare a site visit report to waste water treatment plant implementing Phytoid Technology for treatment of wastewater.	CO5
LSO12.1 Draw a labelled sketch of smart water monitoring system.	12.	Draw the Layout of an IoT based smart water monitoring system.	CO5

L) Suggested Term Work and Self Learning: S2415603D

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

b. Micro Projects:

1. Draw an IOT based Smart Water Monitoring System that can detect the flow of water and record volume of water that flows through the pipe for a given period of time.
2. Enlist the parameter and permissible value of industrial waste to be checked before disposal in water stream.

c. Other Activities:

1. Seminar Topics:

- Functioning of water treatment plant.
- Biological waste water treatment technique.
- Phytoid Technology: An Advanced Waste Water Treatment Technique.
- Smart water metering system.

2. Self-Learning Topics:

- Physical properties of drinking water.
- Chemical properties of waste water.
- Identify the treatment required for given sample of water.
- Types of foreign substances present in given sample of waste water.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
<p>TSO 1a. Describe the basic terminology of Machine learning</p> <p>TSO 1b. Explain the concept of dataset and ways to handle them</p> <p>TSO 1c. illustrate the process of dataset division</p> <p>TSO 1d. Explain process involved in machine learning</p>	<p>Unit – 1.0: Introduction to Machine Learning</p> <p>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</p>	CO-1
<p>TSO 2a. Identify the category or class of a particular dataset using KNN algorithm</p> <p>TSO 2b. Use Linear regression for predictive analysis</p> <p>TSO 2c. Predict the categorical dependent variable using Logistic Regression</p> <p>TSO 2d. Use SVM for classification problems in Machine Learning</p> <p>TSO 2e. determine the performance of the classification models</p> <p>TSO 2f. evaluate the performance of the classification model using ROC-curve</p> <p>TSO 2g Explain characteristics of Unsupervised learning.</p> <p>TSO 2h. Explain different clustering methods</p> <p>TSO 2i. Implement K-means clustering algorithm to group the unlabeled dataset</p>	<p>Unit 2.0: Supervised and Unsupervised Learning</p> <p>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)</p> <p>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</p>	CO-2
<p>TSO 3a. Explain Structure and working of Biological Neural Network.</p> <p>TSO 3b. differentiate between Artificial Neural Network and Biological Neural Network</p> <p>TSO 3c. State key historical points in development of ANN</p> <p>TSO 3d. Explain the architecture of an artificial neural network</p>	<p>Unit 3.0: Introduction to Neural Networks</p> <p>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.</p>	CO-3
<p>TSO 4a. Use neuron McCulloch – Pitts model in designing logical operations</p> <p>TSO 4b. Apply Rosenblatt's Perceptron to solve linear classification problems</p> <p>TSO 4c. Implement Adaptive Linear Neuron (Adaline) training algorithm in neural network</p> <p>TSO 4d. Use Backpropagation neural training algorithm</p> <p>TSO 4e. Use ART (Adaptive Resonance Theory) learning model</p> <p>TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network</p>	<p>Unit 4.0: Neural Networks Models and Learning Methods</p> <p>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.</p>	CO-4
<p>TSO 5a. Illustrate the features of Tens or flow</p> <p>TSO 5b. Manipulate tensors</p> <p>TSO 5c. Explain features of Tens or Board visualization</p> <p>TSO 5d Explain the concept and features of Tens or flow playground</p>	<p>Unit-5.0: Tensor flow</p> <p>features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension and two-dimension tensor, Tensor handling and manipulations, Tensor board</p>	CO-5

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	CO-2
LSO 3.1 Perform clustering operations using k-means algorithm	3	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2
LSO 4.1 Perform clustering operations using EM algorithm	4	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2
LSO 5.1 Build artificial neural network LSO 5.2 Test artificial neural network	5	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4
LSO 6.1 Detect features or business intelligence in the input data	6	Implement the perceptron algorithm from scratch in python.	CO-4

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

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

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

b. **Micro Projects:**

Use python programming for the solutions of Microproject problems

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

width.

2. (a) Write a Python program to split the iris dataset into its attributes (X) and labels (y). The X variable contains the first four columns (i.e. attributes) and y contains the labels of the dataset.
(b) Write a Python program using Scikit-learn to split the iris dataset into 70% train data and 30% test data. Out of total 150 records, the training set will contain 120 records and the test set contains 30 of those records. Print both datasets.
3. Conduct performance analysis of Classification Algorithms (any 2) on a specific dataset.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.1. a. Write the steps to install Python.</p> <p>TSO.1. b. Explain given types of variables in python.</p> <p>TSO.1. c. Explain use and importance of Tuple, Dictionary, operators in python</p> <p>TSO.1. d. Explain use of array in python.</p> <p>TSO.1. e. Explain use of 2-Dimensional Array in python</p> <p>TSO.1. f Explain uses of given type of Conditional statement in python.</p>	<p>Unit-1.0 Python Basics: -</p> <p>1.1 Installation of Python</p> <p>1.2 Variables, Print () function, Escape character sequence and run python Program</p> <p>1.3 Python Tuple, Dictionary, operators</p> <p>1.4 Python arrays, create, reverse and append data into it.</p> <p>1.5 Python 2 Dimensional arrays.</p> <p>1.6 Python Conditional statement.</p>	CO-1 and CO-5
<p>TSO.2. a. Explain uses of given type of do & while loops in python</p> <p>TSO.2. b. Explain working of break, continue and pass statement in python</p> <p>TSO.2. c. Write the benefits of using OOP methodology in python.</p> <p>TSO.2. d. Explain given type of string operation related to python.</p> <p>TSO.2. e. Explain given function in python</p> <p>TSO.2. f Explain use of Lambda function in python.</p>	<p>Unit 2.0 Python Advance: -</p> <p>2.1 Python Do & while loops</p> <p>2.2 Python break, continue, pass statements</p> <p>2.3 Python OOPs Class, Object, Inheritance and Constructor</p> <p>2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length</p> <p>2.5 Python Functions, Built-in functions and user defined functions</p> <p>2.6 Lambda function and uses</p>	CO-1 and CO5
<p>TSO.3. a. Differentiate between Cloud and IoT cloud.</p> <p>TSO.3. b. Explain features of Cloud in IoT environment</p> <p>TSO.3. c. List features of various types of Cloud</p> <p>TSO.3. d. List features of cloud services like SaaS, PaaS and IaaS</p> <p>TSO.3. f List advantages of cloud data storage.</p> <p>TSO.3. g Explain Arduino architecture and its applications.</p> <p>TSO.3.h Explain Raspberry pi architecture and its applications.</p>	<p>Unit-3.0 Cloud Features: -</p> <p>3.1 Cloud computing and IoT cloud</p> <p>3.2 Benefits of cloud in IoT</p> <p>3.3 Types of Cloud public, private and hybrid</p> <p>3.4 Cloud services like SaaS, PaaS and IaaS</p> <p>3.5 Cloud connectivity and Data storage on Cloud.</p> <p>3.6 Arduino: Architecture, Programming, and Applications</p> <p>3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications</p>	CO-1, CO-2 and CO-5
<p>TSO.4. a. Explain wired network</p> <p>TSO.4. b. Explain short range wireless network</p> <p>TSO.4. c. Explain M2M communication</p> <p>TSO.4. d. Explain various generation of wireless network</p> <p>TSO.4. e. Explain the importance of LWPAN in IoT</p> <p>TSO.4. f Differentiate between SigFox & LoRaWAN</p> <p>TSO.4. g Explain use of NB-IOT (Narrow Band IOT)</p> <p>TSO.4.h Create heterogenous network using RFID.</p>	<p>Unit.4.0 IoT Networking and Application: -</p> <p>4.1 Wired and short-range wireless network</p> <p>4.2 M2M – 2G, 3G, 4G & 5G networks</p> <p>4.3 LPWAN – Low Power Wide Area Networks</p> <p>4.4 SigFox & LoRaWAN.</p> <p>4.5 NB-IOT (Narrow Band IOT)</p> <p>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</p> <p>4.7 RFID advantages over Bar codes.</p>	CO-1 and CO-4
<p>TSO.5. a. Identify suitable framework for IoT app development</p> <p>TSO.5. b. Identify various stages of selected app</p> <p>TSO.5. c. Develop the app.</p> <p>TSO.5. d. Implement and deploy the app</p>	<p>Unit. 5.0 IoT App Development: -</p> <p>5.1 Framework selection for IoT app development</p> <p>5.2 Identify stages of app to be developed.</p> <p>5.3 Develop, Implement, and Deploy the App</p> <p>5.4 Testing and Integration</p>	CO-4 and CO-5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
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. 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	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		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"
3. Visit to industry for IoT implementation in industrial process.
4. Reading RFID cards using 8051- RFID in the supply chain- Vehicles parking using RFID- library management system- electronic toll payment- smart shipping containers fleet monitoring and management.
5. Building IoT Applications like pressure, air quality, temperature and motion detector using Arduino and raspberry-pi Universal boards.
6. Surveys of market for availability of various types of network devices and its pricing.
7. Product Development: Development of projects for real life problem solution app.
8. Software Development: Using Python

d. **Self-Learning Topics:**

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	Unit-1.0 Engineering mechanics for Drone Technology 1.1 Drone Mechanics <ul style="list-style-type: none"> • Free body diagram of drone • Method of finding resultant of force system • Equilibrium of coplanar force system 1.2 Center of Gravity <ul style="list-style-type: none"> • Centroid of plane figure • Center of gravity of solid bodies 1.3 Force analysis in drone <ul style="list-style-type: none"> • Force analysis in drone • Forces of flight • Principle axes and rotation of aerial systems 1.4 Dynamics of machine <ul style="list-style-type: none"> • Static and dynamic force analysis • Gyroscopic motions 	CO-1
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	Unit-2.0 Drone Frame and Components 2.1 Drone frame design <ul style="list-style-type: none"> • Calculation principle for drome frame sizes • Quadcopter frame design • Smart materials for UAV frame • Green material uses in drone 2.2 Advance Drones component <ul style="list-style-type: none"> • GPS, Interfacing of GPS hardware • Thermal and chemical sensor • Tilt and LiDAR sensor 2.3 RF transmitter and receiver <ul style="list-style-type: none"> • RF blocks • RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	CO-2
TSO 3a. Identify features and specifications of FCB use in different application TSO 3b. Explain ports of any given advance flight controller board. TSO 3c. Write steps of software installation of flight controller board. TSO 3d. Describe installation and calibration steps of radio telemetry with FCB. TSO 3e. Write steps of calibration of accelerometer and ESC with FCB. TSO 3f. Describe interfacing of GPS with FCB.	Unit-3.0 Advance flight controller Board (FCB) 3.1 Specification and ports of FCB 3.2 Software for FCB <ul style="list-style-type: none"> • Software installation 3.3 Radio Communication with FCB <ul style="list-style-type: none"> • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC 3.7 GPS interface with FCB	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
	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 <ul style="list-style-type: none"> • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones <ul style="list-style-type: none"> • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling 	CO-4
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	Unit-5.0 Advance Drone Application 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in <ul style="list-style-type: none"> • Military • Precision Agriculture 	CO-5

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Use the force of gravity to compute the centre of gravity for a given drone structure.	1.	Determine Centre of gravity of different drone structure.	CO-1
LSO 2.1 Develop skills of observation and interpreting phenomenal changes on Drone model for stability and hovering.	2.	Demonstrate gyroscopic effect on a drone model	CO-1
LSO 3.1 Draw various frame to be required in designing drone structure. LSO 3.2 Use Measuring instrument in designing drone frame. LSO 3.3 Choose suitable materials for making drone frame	3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	CO-2, CO-4
LSO 4.1 Identify and measure the condition of sensors. LSO 4.2 Interface Tilt and LiDAR sensors in drone.	4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1 Identify different component of GPS module LSO 5.2 Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	CO-2
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identify different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	CO-3
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator. LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.	12.	Measure various electric parameters in drone hardware	CO-4
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:**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1d.</i> Explain procedure of Powder preparation for the given 3D printing material.</p> <p><i>TSO 1e.</i> Explain properties of the given Metal/Ceramics 3D printing material.</p> <p><i>TSO 1f.</i> Choose suitable 3D printing material on the basis of Performance Requirements and Material Properties.</p>	<p>1.3 Polymers, Metals, Non-Metals, Ceramics.</p> <p>1.4 Polymers and their properties.</p> <p>1.5 Powder Preparation and their desired properties.</p> <p>1.6 Choosing the Right 3D Printing Material on the basis of Performance Requirements and Material Properties.</p>	
<p><i>TSO 2a.</i> Explain working of a typical FDM based 3D Printer.</p> <p><i>TSO 2b.</i> Justify use of FDM based 3D printing process and material for the given component.</p> <p><i>TSO 2c.</i> Explain the Laminated Object Manufacturing process.</p> <p><i>TSO 2d.</i> Estimate the cost and time of the given FDM based 3D printed component.</p>	<p>Unit-2.0 Solid based 3D Printing Processes</p> <p>2.1 Basic principle and working of fused deposition modeling (FDM) process.</p> <p>2.2 Liquefaction, solidification and bonding.</p> <p>2.3 Laminated Object Manufacturing process.</p> <p>2.4 Cost estimation of FDM 3D printed component.</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the phenomenon of Photo Polymerization.</p> <p><i>TSO 3b.</i> Explain the working of a typical Stereo Lithography based 3D Printer.</p> <p><i>TSO 3c.</i> Explain procedure of 3D Scanning of the given component.</p> <p><i>TSO 3d.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 3e.</i> Estimate the cost and time of the given SLA based 3D printed component.</p> <p><i>TSO 3f.</i> Apply Curing process to SLA based 3D printed component.</p>	<p>Unit-3.0 Liquid based 3D Printing Processes</p> <p>3.1 Photo polymerization.</p> <p>3.2 Principle and working of stereo lithography apparatus.</p> <p>3.3 SLA based 3D printing processes.</p> <p>3.4 SLA based 3D printing process materials.</p> <p>3.5 Scanning techniques.</p> <p>3.6 Curing processes.</p> <p>3.7 Cost estimation of SLA 3D printed component.</p>	CO1, CO3
<p><i>TSO 4a.</i> Explain powder fusion mechanism.</p> <p><i>TSO 4b.</i> Explain working of a typical SLA based 3D Printer.</p> <p><i>TSO 4c.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 4d.</i> Explain Net shape process.</p> <p><i>TSO 4e.</i> Explain Binder Jet 3D printing process.</p> <p><i>TSO 4f.</i> Justify use of Binder Jet 3D printing process and material for the given component.</p> <p><i>TSO 4g.</i> Estimate the cost and time of the given SLS based 3D printed component.</p>	<p>Unit-4.0 Powder based 3D Printing Processes</p> <p>4.1 Powder fusion mechanism.</p> <p>4.2 Principle and working of Selective Laser Sintering (SLS) process.</p> <p>4.3 SLS based 3D printers.</p> <p>4.4 Laser Engineering Net Shaping process.</p> <p>4.5 Electron Beam Melting.</p> <p>4.6 Binder Jet 3D Printing.</p> <p>4.7 Materials and Process parameters for SLS based 3D printing processes.</p> <p>4.8 Cost estimation of SLS based 3D printed component.</p>	CO1, CO4
<p><i>TSO 5a.</i> Justify the need of post processing in the given 3D printed component.</p> <p><i>TSO 5b.</i> List the various post processing techniques.</p> <p><i>TSO 5c.</i> List the steps to perform post processing.</p> <p><i>TSO 5d.</i> Explain the given Cleaning related post processing approach for 3D printed component.</p>	<p>Unit-5.0 Post Processing and Quality</p> <p>5.1 Need of post processing: Functional and Aesthetic reasons.</p> <p>5.2 Steps of Post Processing: Cleaning/Support removal, Fixing, Curing or hardening, Surface finishing, Colouring.</p> <p>5.3 Cleaning: Support Removal (FDM and Material Jetting); Powder Removal (SLS and Powder Bed</p>	CO1, CO2, CO3, CO4, CO5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 5e.</i> Explain the given Surface finishing related post processing approach for 3D printed component.</p> <p><i>TSO 5f.</i> Apply simple inspection and testing techniques on the given 3D printed component.</p> <p><i>TSO 5g.</i> Identify the type of defect(s) in the given 3D printed component.</p>	<p>Fusion); Washing (SLA and Photo polymerisation).</p> <p>5.4 Fixing: Filling, Gluing, Welding.</p> <p>5.5 Surface finishing: Sanding, Polishing, Tumbling, Hydro dipping, Epoxy coating, Electro Plating, Vapour smoothing-Acetone treatment.</p> <p>5.6 Colouring, Coating, Priming and Painting.</p> <p>5.7 Inspection and testing: Digital, Visual, Physical.</p> <p>5.8 Defects and their causes.</p>	

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Use the available 3D printing software.</p> <p><i>LSO 1.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 1.3.</i> Set printing process parameters.</p> <p><i>LSO 1.4.</i> Produce a complex component using available FDM Printer.</p>	1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	CO1, CO2
<p><i>LSO 2.1.</i> Use the available 3D printing software.</p> <p><i>LSO 2.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 2.3.</i> Set printing process parameters.</p> <p><i>LSO 2.4.</i> Produce a complex component using available SLA Printer.</p> <p><i>LSO 2.5.</i> Perform curing of the SLA based 3D printed component.</p>	2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	CO1, CO3
<p><i>LSO 3.1.</i> Use the available 3D printing software.</p> <p><i>LSO 3.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 3.3.</i> Set printing process parameters.</p> <p><i>LSO 3.4.</i> Produce a complex component using available SLS Printer.</p>	3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	CO1, CO4
<p><i>LSO 4.1.</i> Use the available 3D printing software.</p> <p><i>LSO 4.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 4.3.</i> Set printing process parameters.</p> <p><i>LSO 4.4.</i> Produce a complex component using available FDM, SLA and SLS Printer.</p> <p><i>LSO 4.5.</i> Perform Cost, Time, Surface finish and Strength estimations related to 3D printed components.</p>	4.	Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength.	CO1, CO2, CO3, CO4

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

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

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

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.
3. Prepare a report on post processing steps and techniques used for 3D printed components using FDM, SLA, SLS.
4. Prepare a report to compare FDM, SLA, SLS based 3D printing process on the basis of cost, surface finish, printer setting time, printing time and post processing time and cost involved.
5. Download 5 videos of 3D printing processes **other than** FDM, SLA and SLS. 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.
6. Download 1 video related to inspection and testing of 3D printed components using different techniques like Visual inspection, Scanning Electron Microscopy (SEM), CT system, X-ray, Penetration testing, Infrared thermography, Leak or pressure testing for complex structures, Eddy current, Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength, Metallography

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 <ul style="list-style-type: none"> • Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory • External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI), 	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. <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • Power Supply Troubleshooting • I/O Modules Troubleshooting • Troubleshooting PLC Program Errors • Troubleshooting the Working Environment of a PLC • Replacement of CPU 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 – Break monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps,	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 imaging, 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)
<i>LSO 1.1</i> Data communication from PLC to PC and vice versa	1.	Transfer the control data from PLC to PC and vice versa	CO1
<i>LSO 1.2</i> Establish Communication channels between PLC s.	2.	Transfer the control data from PLC to PLC	CO1
<i>LSO 1.3</i> 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
<i>LSO 1.4</i> Interface the given PLC with a PC or a Laptop	4.	Interface the given PLC with a PC or a Laptop	CO1
<i>LSO 2.1</i> 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
<i>LSO 2.2</i> 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
<i>LSO 2.3</i> 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
<i>LSO 2.4</i> 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
<i>LSO 2.5</i> 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
<i>LSO 2.6</i> 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
<i>LSO 2.7</i> Program PLC using ladder logic to control a LED/Lamp	11.	Develop/Execute a ladder logic program to put LED/lamp in the blinking mode	CO2
<i>LSO 2.8</i> Program PLC using ladder logic to control a simple traffic light system	12.	Develop/Execute a ladder logic program to control a simple traffic light control system using PLC	CO2
<i>LSO 3.1</i> Use hygrometer to measure the humidity inside the panel	13.	Troubleshooting of PLC system	CO3
<i>LSO 3.2</i> Use thermometer to measure ambient temperature inside the panel			
<i>LSO 3.3</i> Use tester to determine the voltage fluctuation at the power supply terminals is within specifications			

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 3.4</i> Test the ground connections of the given PLC.</p> <p><i>LSO 3.5</i> 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</p> <p><i>LSO 3.6</i> Investigate the cause of Noise in the given PLC</p> <p><i>LSO 3.7</i> PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.</p> <p><i>LSO 3.8</i> Troubleshoot the corrupted PLC memory.</p> <p><i>LSO 3.9</i> Replace CPU and power supply fuses in a given PLC system.</p>			
<p><i>LSO 4.1</i> Download any open source SCADA software and install the same.</p> <p><i>LSO 4.2</i> Interpret the available components in symbol factory of SCADA software</p> <p><i>LSO 4.3</i> Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list)</p> <ol style="list-style-type: none"> 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. <p><i>LSO 4.4</i> Create historical and real time trends for the given automation</p>	14.	Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties	CO4
<p><i>LSO 5.1</i> Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.</p> <p><i>LSO 5.2</i> Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application</p> <p><i>LSO 5.3</i> Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.</p> <p><i>LSO 5.4</i> Develop a Automation system to Open and close the door in the shop</p>	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	CO5

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

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

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

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

b. Micro Projects:

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

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.
4. Surveys- Carry out a market/internet survey of PLC and prepare the comparative technical specifications of any one type of PLC (Micro or Mini) of different manufacturer.
5. Product Development- Develop a prototype automatic railway crossing system

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

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

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

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO 3f. Describe the speed control mechanism of the given motor.		Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. 3.5 Battery Assembly and Dismantling. 3.6 Gear and Differential Assembly 3.7 Safe disposal of used battery	
TSO 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.			
TSO 4a. Describe the Vehicle Control Unit (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 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.			
TSO 5a. Explain the Classification of Charging Technologies.		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
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.			

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.	1.	<ul style="list-style-type: none"> Testing of Control Disc Braking system and Control Regenerative Braking system. 	CO2
LSO 2.2	Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.			
LSO 2.3	Test the performance of different types of propulsion motors.	2.	<ul style="list-style-type: none"> Testing of Motors 	
LSO 2.4	Test the continuity of the automotive wiring system in the EV	3.	<ul style="list-style-type: none"> Testing of the automotive wiring system. 	
LSO 3.1	Test the performance of a new set of batteries and aged batteries.	4.	<ul style="list-style-type: none"> Testing of Batteries used in EVs 	CO2, CO3

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
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 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.	5.	<ul style="list-style-type: none"> Speed control of Electrical Motors 	
LSO 3.6	Test the following speed-controlled performance characteristics of the given motor; 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			
LSO 4.1	Connect the components of the EC Units with EV subsystems.	6.	<ul style="list-style-type: none"> Connection of Electronic Control Unit components 	CO4
LSO 4.2	Troubleshoot basic faults in the electronic control unit of EV.		<ul style="list-style-type: none"> Troubleshooting of electronic control unit 	
LSO 5.1	Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	<ul style="list-style-type: none"> Impacts of G2V and V2G 	CO 5
LSO 5.2	Prepare a layout of a charging station	8.	<ul style="list-style-type: none"> Demonstration of Charging stations 	

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

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

b. **Micro Projects:**

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
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.	kinematics for 2 Degrees of Freedom. 1.4 Safety while operating and handling robot 1.5 Robot Industrial applications: <ul style="list-style-type: none"> Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing Spray painting Robots, assembly operation, cleaning. 	
TSO 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. TSO 4g. Follow testing methods and acceptance rules for industrial robots.	Unit– 4.0 Robot Programming and Economics of Robotization 4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on	CO1, CO4, CO5

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
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.

c. Other Activities:

1. Seminar Topics: Recent developments in the industrial applications of robotics
2. Visits: Visit a robotic exhibition.
3. Case Study: Identify a robotic application in automobiles and present a case study
4. Download videos related to simple robotic applications in domestic and industrial purposes.
5. Self-Learning Topics:
 - Robotic component manufacturers

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

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

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

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

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

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

1. 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.

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

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

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

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

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

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

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

5. Micro Projects:

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

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

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

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

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

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

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

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

a. Assignments:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400009

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the difference between OER and other free educational materials.</p> <p><i>TSO 1b.</i> Describe the challenges and benefits of using OER in a class.</p> <p><i>TSO 1c.</i> Apply various aspects of evaluating OER before use</p> <p><i>TSO 1d.</i> Explain necessity to assess an OER's adaptability.</p> <p><i>TSO 1e.</i> Use preliminary search for open educational resource.</p> <p><i>TSO 1f.</i> Find OER using various resources.</p>	<p>Unit-1.0 Open Educational Resources</p> <p>1.1 OER - definition</p> <p>1.2 What is NOT OER.</p> <p>1.3 Benefits of using OER – Benefits to Students - Access to Quality Education</p> <p>1.4 OER - Benefits to Faculty - Use, Improve and Share, Network and collaborate with peers, Lower Cost, Improve access to information</p> <p>1.5 Challenges of Using OER – Subject Availability, Format and Material type availability, Time and Support availability</p> <p>1.6 Evaluating OER – a) Clarity, Comprehensibility, and Readability, b) Content and Technical Accuracy, c) Adaptability and Modularity, d) Appropriateness and Fit, e) Accessibility</p> <p>1.7 Finding Open Content - OER Search Scenario Filter by Usage Rights in Google, Repositories and Search Tools, Subject-specific Repositories</p>	CO1
<p><i>TSO 2a.</i> Explain benefits of copyright protection for creator</p> <p><i>TSO 2b.</i> Explain exceptions and limitations to copyright law</p> <p><i>TSO 2c.</i> List rights granted to copyright holders.</p> <p><i>TSO 2d.</i> Explain Exceptions and limitations to copyright law</p> <p><i>TSO 2e.</i> Explain Fair use/fair dealing apply to copyright</p> <p><i>TSO 2f.</i> Elaborate Public domain and how does it relate to copyright</p> <p><i>TSO 2g.</i> Elaborate penalties for copyright infringement.</p> <p><i>TSO 2h.</i> Explain copyright for digital content and the internet.</p> <p><i>TSO 2i.</i> Explain use of copyrighted works in education</p> <p><i>TSO 2j.</i> Explain the use of free licenses</p>	<p>Unit-2.0 Copyright and Open Licensing</p> <p>2.1 Copyright and what it does protect, benefits of copyright protection for creators, duration of copyright protection last, rights granted to copyright holders.</p> <p>2.2 Exceptions and limitations to copyright law, fair use/fair dealing apply to copyright</p> <p>2.3 Public domain and its relation to copyright.</p> <p>2.4 Penalties for copyright infringement</p> <p>2.5 Apply copyright to digital content and the internet</p> <p>2.6 Use of copyrighted works in education.</p> <p>2.7 Open Licenses – GNU – Free Documentation license, Free Art License</p> <p>2.8 Why Free Licenses – Retain, Reuse, Revise, Remix, Redistribute</p>	CO2
<p><i>TSO 3a.</i> Describe the four different Creative Commons License components.</p> <p><i>TSO 3b.</i> Explain the reason some CC-licensed content might not be considered OER.</p> <p><i>TSO 3c.</i> Explain the Strength and weakness of four Open CC Licenses</p> <p><i>TSO 3d.</i> Choose the right Creative Commons license for work.</p> <p><i>TSO 3e.</i> Apply a Creative Commons license to existing work.</p> <p><i>TSO 3f.</i> Use of Creative Commons licenses for commercial purposes.</p>	<p>Unit-3.0 Creative Common Licenses</p> <p>3.1 Alternatives to copyright as Creative Commons licenses.</p> <p>3.2 Four components of creative common Licenses – Attribution, Share- Alike, Non – commercial, No Derivatives</p> <p>3.3 Choosing a Creative common licenses – Wiley's 5 Rs and Creative Common Licenses</p> <p>3.4 Four Open CC Licenses and Their Strengths and Weaknesses – (a) CC BY (b) CC BY SA (c) CC BY NC (d) CC BY NC SA</p> <p>3.5 Attribution Vs Citation - Creative Commons licensed work without giving attribution</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 3g.</i> Modify a work licensed under Creative Commons.</p> <p><i>TSO 3h.</i> Revoke a Creative Commons license, combine works with different Creative Commons licenses</p> <p><i>TSO 3i.</i> Differentiate between Attribution and Citation</p>	<p>3.6 Apply a CC License - choose the right Creative Commons license for work, apply a Creative Commons license to existing work, Creative Commons licenses be used for commercial purposes, modify a work licensed under Creative Commons, revoke a Creative Commons license, combine works with different Creative Commons licenses</p>	

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:

Related to Open Educational Resources – CO1

- i. OER help to reduce the cost of education for students. Justify?
- ii. Explain why it is necessary to assess an OER's adaptability?
- iii. Identify four search tools for finding open educational resources?
- iv. Identify at least two search tools for finding openly licensed media?

Related to Copyright – CO2

- i. Explain copyright and what does it protect
- ii. Explain the rights granted to copyright holders
- iii. Describe the exceptions and limitations to copyright law
- iv. Elaborate the way fair use/fair dealing apply to copyright?
- v. Describe the public domain and its relationship with copyright
- vi. Elaborate the penalties for copyright infringement?
- vii. Explain copyright apply to digital content and the internet
- viii. Explain the way copyright law address the use of copyrighted works in education

Related to Creative Common Licenses – CO3

- i. Explain various Creative Commons licenses
- ii. Describe, how can you apply a Creative Commons license to your existing work?
- iii. Explain the benefits of using Creative Commons licenses?
- iv. Elaborate, how you can modify a work licensed under Creative Commons?
- v. Are Creative Commons licenses valid worldwide?
- vi. Elaborate how Creative Commons license can be revoked, once it has been applied to your work?
- vii. Explain, how anyone use a Creative Commons licensed work without giving attribution?
- viii. Explain the limitations/restrictions while using works with Creative Commons licenses?

b. Micro Projects:

1. Collect information on the impact of OER on cost savings and student engagement.
2. Search at least four OER related to topic of your Engineering Discipline over Internet. Evaluate the material based on the relevance, accuracy and usability.
3. Explore the different types of resources under creative Commons licenses (e.g., CC BY, CC BY-SA, CC BY-NC, etc.) and their specific permissions and restrictions.
4. Create a comparative analysis chart or infographic that visually represents the key characteristics of each license.