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	CourseTitles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
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
2400606	**NRC**	**Employability Skills Development** (Common for All Programmes)	01	-	-	-	01	01
2400009	**NRC**	**Open Educational Resources** (FTS, CHE, CSE, EE, ME, ME (Auto), MIE, ELX, AIML, CRE, CACDDM, AE, CE, ELX (R), GT)	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

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
2400606	**NRC**	**Employability Skills Development** (Common for All Programmes)	25	-	-	-	-	-	25
2400009	**NRC**	**Open Educational Resources** (FTS, CHE, CSE, EE, ME, ME (Auto), MIE, ELX, AIML, CRE, CACDDM, AE, CE, ELX (R), GT)	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

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.

A) Course Code **: 2415601(T2415601/P2415601/S2415601)**

B) Course Title **:** Environmental Engineering

C) Pre-requisite Course(s) **:** Basic Chemistry

D) Rationale **:**

Today's era of globalization and urbanization have a great impact on the natural resources and infrastructures which has created threat to the environment. The goal of environmental engineering is to ensure that societal development and the use of water, land and air resources are sustainable. This goal is achieved by managing these resources so that environmental pollution and degradation is minimized.

The Civil engineer must be aware of the environmental effects of pollutants and should be able to address the issues related to the pollutants and their characteristics so as to manage systems in most effective and efficient way.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/industry.

After completion of the course, the students will be able to-

CO-1 Determine the physical, chemical and biological properties of a given sample of water.
CO-2 Undertake the purification of water using relevant method of water treatment processes.
CO-3 Propose the relevant method of water distribution system for the given locality.
CO-4 Describe the functional utility of the relevant components of drainage and sewerage system used in the given locality.
CO-5 Undertake the treatment of given sample of sewage based on its characteristics.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO- 1**	**PSO- 2**
CO-1	3	2	2	3	3	3	3	-	-
CO-2	3	2	2	2	2	3	2	-	-
CO-3	3	2	1	2	2	2	2	-	-
CO-4	3	2	1	2	3	2	2	-	-
CO-5	3	2	2	2	3	3	2	-	-

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional.

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415601	Environmental Engineering	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415601	Environmental Engineering	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: T2415601

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO1.a Identify the possible sources of water For a given locality. TSO1.b Justify the need of planned water Supply system for a given locality. TSO1.c Forecast the population at the end of specified decade for a given city using relevant method of estimation. TSO1.d Carryout the testing for the given Physical, chemical and biological properties of water.	**Unit 1.0: Sources, Demand and Water Quality Assessment:** 1.1 **Sources of water**: Surface and subsurface sources of water, Intake structures: Types, Purposes and its Location. 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. 1.3 **Population forecasting**: Design period, Methods of population forecasting, (Simple problems on population forecasting). 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 (D0), pH, Fluoride, Nitrogen(N) and its compounds. 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.	**CO1**
TSO2.a Explain the process of water treatment to make it potable. TSO2.b Use relevant type of filter in water purification process at given location. TSO2.c Suggest the relevant method of disinfection process for a given sample of water. TSO2d. Draw the flow diagram of conventional water treatment plant.	**Unit2.0: Purification of Water** 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. 2 . 2 **Filtration**: Theory, Purposes and Types of Filters, Construction, Mechanism and Operation of Slow Sand, Rapid Sand and Pressure Filter. 2.3 **Disinfection**: Methods of Disinfection, Kinetics of disinfection, Chlorination and Practices of Chlorination, Calculation of Doses of chlorine. 2.4 **Water treatment Plant**: Purpose, Construction and its flow diagram.	**CO2**
TSO 3a. Select a relevant type of pipe material for the conveyance of water for the given locality. TSO 3b. Explain the relevant method of water distribution with labeled sketch. TSO 3c. Use Hardy cross method to determine the equivalent size of pipe for the given distribution system.	**Unit-3.0: Distribution and Conveyance of Water** 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. 3.2 **Distribution System**: Need, Purposes and Advantages, Methods of Distribution-Gravity, Pumping (Pressure)and Combined System. 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. 3.4 **Pipe network Analysis**: Hardy-Cross method,	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
	equivalent pipe method, Appurtenances in the distribution system.	
TSO 4a. Explain the need and importance of sanitation for the given building. *TSO 4b.* Select the relevant type of pipe for a given sewerage system. *TSO 4c.* Suggest the relevant type of sanitary fittings suiting for the given location in a building. *TSO 4d.* Suggest the relevant type of sewers for a given sewerage system. *TSO 4e.* Carryout testing and maintenance for a given sewerage system.	**Unit-4.0: Domestic Sewages and Sewerage System:** 4.1 **Building Sanitation**: Need and importance of sanitation, Definitions-Sewage, Sullage, Types of sewage, Definition of the terms related to building sanitation. 4.2 **Pipes for sewerage system**: Soil pipe, Sullage pipe, Vent pipe. 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. 4.4 **System of Sewerage and Sewer appurtenances**: Types of Sewers, System and Layout of sewerage, self-cleansing velocity and non-scouring velocity, Laying. 4.5 **Testing and Maintenance of sewers**: Inspection chambers and Manholes-component parts, location and spacing; Sewer Inlets, Street Inlets.	**CO4**
TSO 5a. Determine BOD and COD of a given sample of sewage water. *TSO 5b.* Explain sewage treatment processes. *TSO 5c.* Describe various component of sewage disposal process. *TSO 5d.* Explain the sludge treatment process. *TSO 5e.* Explain the various activities involved In solid waste disposal process. *TSO 5f.* Design a septic tank for the given building project with labeled sketch (Plan and Elevation).	**Unit-5.0: Sewage Treatment and Waste Management-** 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, Objectiveofsewagetreatmentandflowdiagramof conventionalsewagetreatmentplant. 5.2 **Treatment of Sewage**: Screening, Types of Screens, Grit removal, Skimming, Sedimentation of sewage, Aerobic and Anaerobic process, Sludge digestion, Trickling filters. 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. 5.4 **Solid waste disposal:** composting, incineration, Introduction to sanitary landfill.	**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)
LSO1.1 Determine pH value of given water sample.	1.	Determine pH value of given sample of water.	CO1
LSO2.1 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.

2. Self-Learning Topics:
    - Select relevant method of disinfection for treatment of given sample of water.
    - Classify different types of pipes used for conveyance of water for the given situations.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	25%	30%	25%	20%	30%	35%
CO-2	20%	20%	20%	20%	20%	20%	20%
CO-3	20%	20%	20%	15%	15%	15%	15%
CO-4	20%	20%	20%	20%	25%	10%	10%
CO-5	15%	15%	10%	20%	20%	25%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Sources, Demand and Water Quality Assessment.	12	CO1	18	5	6	7
Unit-2.0 Purification of Water.	10	CO2	14	4	4	6
Unit-3.0 Distribution and conveyance of water.	10	CO3	14	4	4	6
Unit-4.0 Domestic Sewages And Sewage system.	10	CO4	14	4	4	6
Unit-5.0 Sewage Treatment and Waste Management	6	CO5	10	3	3	4
Total	**48**	-	**70**	**20**	**21**	**29**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine pH value of given sample of water.	CO1	60	30	10
2.	Determine the turbidity of the given sample of water.	CO1	70	20	10
3.	Determine suspended, dissolved solids and total solids of given sample of water.	CO1	60	30	10
4.	Determine the dissolved oxygen in a sample of water.	CO1	70	20	10
5.	Determine residual chlorine in a given sample of water.	CO2	60	30	10
5.	Determine the dissolved oxygen in a sample of water.	CO1	70	20	10
6.	Determine the optimum dose of coagulant in a given raw water sample by jar test.	CO2	60	30	10
7.	Prepare a report of field visit to nearby water treatment plant.	CO2	30	60	10
8.	Draw sketches of various valves used in water supply pipe line.	CO3	30	60	10
9.	Prepare a report on plumbing system by site visit of nearby newly constructed building.	CO4	40	50	10
10.	Draw a flow diagram of conventional sewage treatment plant.	CO5	40	50	10
11.	Determine BOD of given sample of sewage water using BOD apparatus.	CO5	60	30	10
12.	Determine COD of given sample of sewage water using COD apparatus.	CO5	60	30	10
12.	Prepare a report on septic tank with labeled sketch	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Digital pH meter	1.Measurement Type Using pH electrode with BNC end cable 2. Range pH -2.0 to 16 3. Accuracy ± 0.02 Ph 4. Resolution 0.01 pH 5. Operating temperature 0-45°C 6. Temperature compensation Automatic or manual Min 2 points automatic or manual 7. pH calibration with buffer solution for min 2 calibration 8. Power Battery operated/with suitable AC adaptor for 220V/SOHz	1
2.	Digital Turbidity Meter	Range- 0 – 1000 NTU (in 4 Ranges)0 – 2, 20, 200,1000 NTU **Resolution-** 0.01 NTU **Accuracy-** ± 3% FS, ± 1Digit	2
3.	B.O.D Apparatus	Range: 0-700mg/l (Minimum) BOD. This can be of single selectable range or different range. Power supply: 230V AC, 50 Hz Resolution: 1mg/L BOD or better Accuracy: ±1 or better Operating temperature: 20 Deg. C. Storage Temperature: 0 to 40 Deg. C. (Minimum) Dimensions: Should be of standard dimension & should fit into our incubator of volume approx. 30 cm x 35 cm x 35 cm (L x B x H)	11
4.	C.O.D Digestion Apparatus	Dimension(L*W*H) 280X165X70 Millimeter (mm) Power 220/230, 50Hz Volt (v) Voltage 220-230 Volt (v) Heat Temperature 150 Degree C	12
5.	Suspended solids, dissolved solids, and total solids measuring apparatus.	Balance, Beaker, Measuring cylinder**,** Filter paper/ or Gooch Crucible, Funnel, Dropper	3

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Water Supply Engineering -Vol.I	Santosh kumar Garg	Khanna Publishers, New Delhi ,35th edition (1 January 1977) 1. ISBN-10**:** 9788174091208 2. ISBN-13: 978-8174091208
2.	Environmental Engineering, vol.I and II	Dr. B.C Punmia	Laxmi Publishers, New Delhi,2nd Edition, September 1995 1. ISBN-10**:** 9788131807033 2. ISBN-13: 978-8131807033
3.	Environmental Engineering	NN Basak	Mc Graw Hill Publishers, Noida,1st Edition (1 July 2017) 1. ISBN-10: 0070494630 2. ISBN-13: 978-0070494633
4.	Environmental Engineering	S.C Sharma	Khanna Publishing House, New Delhi, 1st edition (28 December 2020) 1. ISBN-10: 9386173573 2. ISBN-13: 978-9386173577

5.	Water Supply and Sanitary Engineering	Birdie, G.S. and Birdie	Dhanpat Rai, New Delhi,9th Edition (2011) 1. ISBN-10: 8187433795 2. ISBN-13: 978-8187433798
6.	I.S.10500:2012, Drinking Water Standards,2012.	-	I.S.10500:2012

(b) Online Educational Resources:

1. https://www.youtube.com/watch?v=wI7uvQThX8A&list=PL1BFC82F3A63B4172&index=5 (NPTEL)
2. https://www.youtube.com/watch?v=PVstxkDkcQY&list=PLLy2iUCG87AZvtaiuD3r4HATrBKhb90P&index=2 (IIT Roorkee)
3. https://www.youtube.com/watch?v=JOBeeWvludU&list=PLLy2iUCG87AZvtaiuD3r4HATrBKhb90P&index=14 (IIT Roorkee)
4. https://www.youtube.com/watch?v=Tke_kbdmup0&list=PLLy2iUCG87AZvtaiuD3r4HATrBKhb90P&index=15 (IIT Roorkee)
5. https://online-learning.tudelft.nl/courses/introduction-to-treatment-of-urban-sewage/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. IS10500:2012- DrinkingWaterStandards,2012.
2. IS2065:1983- Code of Practice for Water Supply In Buildings.
3. IS1172:1993 - Code of Basic Requirements For Water Supply, Drainage And Sanitation

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A) Course Code **: 2415602(T2415602/S2415602)**

B) Course Title **:** Steel Structure

C) Pre-requisite Course(s) **:** Engineering Mechanics, Strength of Materials

D) Rationale **:**

The steel used for construction of steel structures are called structural steel. Nowadays, the use of structural steel has increased due to its properties such as strength, durability, flexibility, high load-carrying capacity etc. It is available in variety of sizes and shapes and very useful for speedy construction. The steel structure is one of the core subjects of civil engineering which deals with the planning and designing of structural components, proportioning of members of the structure to carry the load in the most economical manner, and considerations for the erection of the structure at the site. The course consist design of steel connection, tension member, compression member, and steel beam using limit state method as per IS 800:2007. The knowledge of this course will help the students to plan and design steel structures and to supervise the erection of steel structures at the site.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/industry.

After completion of the course, the students will be able to-

CO-1 Select suitable type of steel section for a given steel structural member in accordance with IS 808:1989.

CO-2 Design suitable joint for connecting various steel structural members using specified data.

CO-3 Design suitable tension member for a given steel structure using specified data.

CO-4 Design suitable compression member for a given steel structure using specified data.

CO-5 Design suitable beam section for a given steel structure using specified data.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO- 1**	**PSO- 2**
CO-1	3	2	3	1	1	-	1		
CO-2	2	2	3	1	1	-	1		
CO-3	2	2	3	1	1	-	1		
CO-4	2	2	3	1	1	-	1		
CO-5	2	2	3	1	1	-	1		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional.

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415602	Steel Structure	02	01	-	02	05	04

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)	
2415602	Steel Structure	30	70	20	30	-	-	150

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: T2415602

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
loaded tension member of a given steel structure. TSO 3d. Compute strength ofa given axially loaded tension member using specified data. TSO 3e. Design a tension member for a given steel structure using specified data.	net area for angles. 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. 3.3 Analysis and Design of axially loaded single and double angle tension members with bolted and welded connection as per IS: 800-2007. 3.4 Introduction to gusset plate, lug angle and tension splice (meaning and purpose only).	
TSO 4a. Identify suitable steel section for a compression member of a given steel structure. TSO 4b. Explain codal provisions for effective length and slenderness ratio. TSO 4c. Compute strength of a given axially loaded compression member using specified data. TSO 4d. Design a compression member for a given steel structure using specified data. TSO 4e. Explain the purpose of lacing and battening system with neat labeled diagrams.	**Unit-4.0 Design of Compression Member (Limit State Method)** 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. 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. 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)	**CO4**
TSO 5a. Identify suitable steel section for a beam of a given steel structure. TSO 5b. Classify cross section of a steel beam based on yielding behavior. TSO 5c. Differentiate between laterally supported and unsupported beam. TSO 5d. Compute bending strength of a given steel beam using specified data. TSO 5e. Design a steel beam section using specified data. TSO 5f. Identify various elements of a given steel roof truss.	**Unit-5.0 Design of Steel Beams (Limit State Method)** 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. 5.2 Bending strength of laterally supported beam and laterally unsupported beam, Shear strength of beam as per IS: 800-2007. 5.3 Analysis and design of laterally supported and unsupported beams (rolled I-sections only)with relevant checks as per IS: 800-2007. 5.4 Introduction to element of the steel roof truss, built-up beam, plate girder and gantry girder (meaning and purpose only).	**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.

1. Describe the method of lap and butt joint in bolted connection with neat and clean labeled sketch.
2. Design the joint with suitable pitch dimensions for the given type of bolt to connect two flats (Fe 410 Grade Steel) of each 210 mm × 8 mm using 20 mm diameter of 4.6 grade bolts and for factored load of 250 kN.
3. Design a weld to transmit load equal to the design strength of the member with following data;
4. A tie member consisting of an ISA 80 mm × 50 mm × 8 mm (Fe 410 grade steel) is to be welded to a 12 mm thick gusset plate at site.
5. Write the design procedure of axially loaded tension member as per the provisions of IS 800:2007.
6. Design a rectangular bar of standard structural steel of grade Fe 410 with following data; A tension member 0.95 m long is to resist a service dead load of 20 kN and a service live load of 60 kN. Assume that the member is connected by one line of 16 mm diameter bolts of grade 4.6.
7. Write the design procedure of axially loaded compression member as per the provisions of IS 800:2007.
8. Design a column section to be used in a public building. Column is 4.80 m long with both of its ends restrained in direction and position. The column is to support a factored load of 2500 kN.
9. Write the design procedure of laterally supported steel beam as per the provisions of IS 800:2007.
10. Write the design procedure of laterally unsupported steel beam as per the provisions of IS 800:2007.
11. Design an appropriate section using steel of grade Fe 410 with following data; A simply supported steel joist of 4.0 m effective span is laterally supported throughout. It carries a total uniformly distributed load of 40 kN (inclusive of self-weight).

b. Micro Projects:

1. Draw labeled sketch of any five standard rolled steel sections with the help of steel table.
2. Draw labeled sketch of any five built-up steel sections with the help of steel table.
3. Undertake the internet survey to collect the information of various rolled steel sections used in construction of steel structures.
4. Write any five IS clauses related to dead load, live load and wind load from IS 875:1987 Part I to IV.
5. Name any five computer aided techniques for analysis of steel structure with detail elaboration of any-one of it.
6. Specify the different grades of stainless steel (SS) used in fabrication along with its specific utility.
7. Draw the labeled sketch of types of bolts and types of bolted joints.
8. Draw the labeled sketch of types of welds and types of welded joints.
9. Design a connection with given data and verify the theoretical value with the value obtained from connection design using open-source software in accordance with IS 800:2007.
10. Design a tension member form given data and draw labeled sketch of member.
11. Design a compression member form given data and draw labeled sketch of member.
12. Write the provisions of IS 800:2007 for the effective length of compression member having different end condition with its significance.
13. Design a steel beam form given data with labeled sketch.
14. Draw the labeled sketch single and double laced built-up columns and battened built-up columns.
15. Prepare a model of two steel plates joined with bolted connections as tension/compression member from the given data.
16. Prepare a model of two steel plates joined with welded connections as tension/compression member from the given data.
17. Prepare a model of angle section joined to gusset plate with bolted connections from the given data.
18. Prepare an excel program for analysis and design of given connections, given tension and compression members from the given data.
19. Analyze and design connections or steel members from given data using open-source software and compare design data with theoretical design data.

c. Other Activities:

1. Seminar Topics:
   - Quality of structural steel and its control.
   - Salient features of the world best steel structures.
   - Manufacturing process of structural steel.
   - Structural steel buildings.
   - Failure of steel structures.
   - Software for analysis of steel structures.
   - Design philosophy for design of steel structure.

2. Visits: Visit to under construction site to collect detailed information about steel sections, types of connections, design and drawings of steel structure.

3. Self-Learning Topics:
   - Computer aided technique for analysis of steel structures.
   - Analysis and design of plate girder.
   - Analysis and design of steel roof truss.
   - Types of column bases for steel column.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work& Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	15%	15%	15%	20%	-	-
CO-2	30%	25%	25%	25%	25%	-	-
CO-3	20%	20%	20%	25%	20%	-	-
CO-4	20%	20%	20%	20%	20%	-	-
CO-5	20%	20%	20%	15%	15%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**-**	**-**
			50				

Legend:
*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.
**: Mentioned under point- (N)
#: Mentioned under point-(O)

Note:
- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA(Marks)		
				Remember (R)	Understanding(U)	Application &above(A)
Unit-1.0 Basics of Steel Structure	04	CO1	08	04	04	-
Unit-2.0 Design of Connections (Limit State Method)	14	CO2	20	04	08	08
Unit-3.0 Design of Tension Member (Limit State Method)	10	CO3	14	04	04	06
Unit-4.0 Design of Compression Member (Limit State Method)	10	CO4	14	04	04	06
Unit-5.0 Design of Steel Beams (Limit State Method)	10	CO5	14	04	04	06
Total	**48**	**-**	**70**	**20**	**24**	**26**

Note: Similar table can also be used to design class/mid-term/internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical): (Not Applicable)

P) Suggested Instructional /Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/ outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Limit State Design of Steel Structures	Duggal, S. K.	McGraw-Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2019, ISBN-13: 9789353164874, ISBN-10: 9353164877
2.	Steel Structures Design and Practice	Subramanian, N.	Oxford University Press Publisher, New Delhi,1st Edition, 2011, ISBN-13:9780198068815, ISBN-10: 0198068816
3.	Limit State Design in Structural Steel	Shiyekar, M.R.	Prentice Hall India Private Limited, Delhi, 3rd Edition, 2013, ISBN-13:9788120353503, ISBN-10: 8120353501
4.	Design of Steel Structures	Dayaratnam, P.	S. Chand Limited, New Delhi, 2nd Edition, 2012, ISBN-13:9788121923200, ISBN-10: 8121923204
5.	Design Of Steel Structures (By Limit State Method as Per IS: 800 2007)	Bhavikatti, S.S.	I.K. International Publishing House Pvt. Limited, New Delhi, 5th Edition, 2019, ISBN-13:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
			9789389307054, ISBN-10: 9389307058
6.	Limit State Design of Steel Structures	Shah, V. L., and Gore, V	Structures Publications, Pune, 3rd Edition, 2013, ISBN 13: 9788190371754
7.	Design of Steel Structures	Sairam, K.S.	Pearson Education India, 2nd Edition, 2015, ISBN-13: 9789332542105, ISBN-10: 9332542105

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc19_ce25/preview
2. https://archive.nptel.ac.in/courses/105/105/105105162/
3. https://youtube.com/playlist?list=PLPYKd0KLmzo5e4g4-DGlGGYQugyWBeYMn
4. https://ia800407.us.archive.org/6/items/gov.in.is.800.2007/is.800.2007.pdf
5. https://ia801405.us.archive.org/17/items/gov.law.is.875.1.1987/is.875.1.1987.pdf
6. https://archive.org/details/gov.law.is.875.2.1987
7. https://ia600401.us.archive.org/28/items/gov.in.is.875.3.1987/is.875.3.1987.pdf
8. https://law.resource.org/pub/in/bis/S03/is.875.4.1987.pdf
9. https://ia800906.us.archive.org/0/items/gov.in.is.808.1989/is.808.1989.pdf
10. https://law.resource.org/pub/in/bis/S03/is.sp.6.1.1964.pdf

(c) Others:

1. IS: 800: 2007 - Code of Practice for general construction in Steel
2. IS 808: 1989- Dimensions for hot rolled steel beam, column, channel and angle sections.
3. IS 875(Part 1):1987-Code of practice for design loads (other than earthquake) for buildings and structures Part 1 Dead loads – Unit weights of building material and stored materials (second revision).
4. IS 875(Part 2):1987-Code of practice for design loads (other than earthquake) for buildings and structures: Part 2 Imposed loads (second revision).
5. IS 875(Part 3):1987- Code of practice for design loads (other than earthquake) for buildings and structures: Part 3 Wind loads (second revision).
6. IS 875(Part 4):1987- Code of practice for design loads (other than earthquake) for buildings and structures Part 4 Snow loads (second revision)
7. IS 875(Part 5):1987- Code of practice for design loads (other than earthquake) for buildings and structures Part 5 Special loads and load combinations (second revision)

******

A) Course Code **: 2415603A(T2415603A/P2415603A/S2415603A)**

B) Course Title **:** Pre-Stress and Precast Concrete

C) Pre-requisite Course(s) **:** Strength of Material, Design of R.C.C

D) Rationale **:**

Pre-stressed concrete is used in a wide range of building and civil structures where its improved performance can allow for longer spans, reduced structural thickness and material savings compared with simple reinforced concrete. It has uses in forming siding, foundations, driveways and columns. Its versatility including possible reflectivity and its relative low cost are the reasons why this construction component has become popular. Therefore knowledge regarding precast and pre-stressed concrete is the vital needs for the diploma engineers.

Pre-stressed concrete is used in a wide range of building and Civil Engineering Structures where its improved performance can allow for longer spans, reduced structural thickness and material savings compared with simple reinforced concrete. It has uses in construction of siding, foundations, driveways and columns. Its popularity is attributed to its versatility, including potential reflectivity, and it's relatively low cost. Therefore, a comprehensive understanding of precast and pre-stressed concrete is imperative for diploma engineers due to its pivotal role in contemporary construction practices.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/industry.

After completion of the course, the students will be able to-

- **CO-1** Explain the need of pre-stressed concrete in construction.
- **CO-2** Select the relevant methods / systems of pre-stressing for the given structural element of the civil structure.
- **CO-3** Design a pre-stressed concrete beam for the given condition of loading.
- **CO-4** Select the relevant precast concrete element for the given type of construction.
- **CO-5** Use the relevant components for the given prefabricated structure.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Program Outcomes (POs)							Program Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO- 1**	**PSO- 2**
CO-1	3	1	-	-	1	-	1		
CO-2	3	2	-	1	1	-	1		
CO-3	3	3	2	-	-	-	1		
CO-4	3	2	-	2	1	-	1		
CO-5	3	2	-	2	2	-	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional.

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415603A	Pre-Stress and Precast Concrete	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work& Self Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415603A	Pre-Stress and precast Concrete	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 re01forms 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: T2415603A

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a. Explain the principles of pre-stressing used in the given structural component. TSO1b.Describe the applications of pre-stressed concrete elements in the given situation. TSO1c. Describe the utility of PSC in the given situation. TSO1d.Justify the need of high strength construction materials for PSC. TSO1e.Select the relevant type of pre-stressing materials for the given loading condition.	**Unit-1.0: Introduction to Pre-stressed Concrete (PSC)** 1.1 Principles of pre-stressed concrete and basic terminology. 1.2 Applications, advantages and disadvantages of pre-stressed concrete. 1.3 Materials used and their properties, Necessity of high-grade materials, Admixtures for concrete. 1.4 Types of Pre-stressing steel -Wire, Cable, tendon, Merits-demerits and application.	**CO1**
*TSO*2a.Select the relevant method of pre-stressing for a given structural element. TSO2b.Differentiate the systems of pre-tensioning and post-tensioning with their merits/demerits. TSO2c.Explain Hoyer system of pre-tensioning with diagram. TSO2d. Explain relevant procedure of post-tensioning based on the given criteria with diagram. TSO2e. Identify the reasons for loss of pre-stress in the given element. TSO2f. Explain the BIS recommendations for percentage loss in the given pre-stressing method.	**Unit-2.0: Methods and Systems of Pre-Stressing** 2.1 Methods of Pre-stressing – Internal and External pre-stressing, Pre and Post tensioning- applications. 2.2 Systems for pre-tensioning – process, applications, merits and demerits. 2.3 Systems for post-tensioning - process, applications, merits and demerits 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. 2.5 BIS recommendation for percentage loss in case of pre and post tensioning.	**CO2**
TSO 3a. Explain the assumptions made in the analysis of PSC beams. TSO3b.Explain the effect of given cable profile on fiber stresses. TSO3c.Calculate maximum stresses induced in the given beam for a given cable profile.	**Unit-3.0: Design and Analysis of Pre-Stressed Rectangular Beam Section** 3.1 Basic assumptions in analysis of pre-stressed concrete beams. 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. 3.3 Numerical problems on determination of maximum stresses at mid span with linear (concentric and eccentric) cable profiles only.	**CO3**
TSO4a.Explain the advantages and disadvantages of precast concrete. TSO4b.Select the relevant structural/ Non-structural precast concrete element in the given situation. TSO4c.Explain the application of precast concrete elements in different construction works. TSO4d.Explain the testing procedure for precast components.	**Unit-4.0: Precast Concrete Elements** 4.1 Advantages and disadvantages of precast concrete members. 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. 4.3 Structural Precast elements – Canal lining, Box culvert, bridge panels, foundation 4.4 Testing of Precast components as per BIS standards.	**CO4**

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

L) **Suggested Term Work and Self Learning**: **S2415603A** Some sample suggested assignments, micro projects and other activities are mentioned here for reference.

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

b. **Micro Projects:**

1. Collect pictorial information related to procedures adopted in pre-stressing.
2. Collect data of pre-stressed components used in the nearby vicinity.
3. Write a detailed report of visit to any one prefabricated unit.
4. Prepare a report of the construction site where prefabricated building component have been used.

c. **Other Activities**:

1. Seminar Topics:
   - Prepare a power point presentation on systems of pre-stressing.
   - Present a seminar on testing of precast units.
   - Salient features of at least five precast elements from your area.
   - Prepare a report on comparison of cast in situ and precast elements with respect to time required, quality and cost.

2. Self-Learning Topics:
   - Identify different precast components used on construction sites.
   - Classify different types of precast members on the basis of their manufacturing.
   - Visit site/design office to collect the reinforcement details for different types of precast beams under given loading.
   - Search the software on the course content and prepare the report stating their applications.

M) **Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and term work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate CO attainment.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/ Mid Sem Test	End Theory Assessment (ETA)	Term Work& Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	15%	15%	30%	15%	10%	20%
CO-2	25%	25%	20%	-	15%	10%	20%
CO-3	20%	25%	25%	-	30%	10%	20%
CO-4	15%	15%	20%	35%	30%	60%	20%
CO-5	15%	20%	20%	35%	10%	10%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.
**: Mentioned under point- (N)
#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Pre-Stressed Concrete	08	CO1	12	4	4	4
Unit-2.0 Methods and Systems of Pre-Stressing	12	CO2	17	5	6	6
Unit-3.0 Analysis and Design of Pre-stressed Rectangular Beam Section	12	CO3	16	4	6	6
Unit-4.0 Precast Concrete Elements	06	CO4	10	3	3	4
Unit-5.0: Prefabricated Building	10	CO5	15	4	5	6
Total	**48**	-	**70**	**20**	**24**	**26**

Note: Similar table can also be used to design class/mid-term/internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Prepare the report and collect the samples of various types of pre-stressing wires/cables/strands.	CO1	50	40	10
2	Compare the various losses occurring in the pre tensioning and post tensioning of members with their respective percentage.	CO2	50	40	10
3	Prepare the report and compare stress distribution for different types of cable profiles.	CO3	50	40	10
4	Determine the compressive strength of given solid precast block.	CO4	50	40	10
5	Determine the compressive strength of given hollow precast block.	CO4	50	40	10
6	Determine the compressive strength of given hollow precast block.	CO4	50	40	10
7	Perform load test on a given manhole cover as per IS 12592:2002 Annex c.	CO4	50	40	10
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	50	40	10
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	CO4	50	40	10

	chajjas, staircase elements with reference to the manufacturing process).				
10	Determine the flexural strength on given wall panels on site.	CO5	60	30	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional /Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/ outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
1.	Universal Testing Machine	Universal Testing Machine: Capacity – 1000 kN. Type: Mechanical type / digital, electrically	10
2.	Compression Testing Machine	Digital display manual control compression testing; machine; Max. Capacity (KN): 2000	4,5,6,7

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Pre-stressed Concrete	N Krishna Raju	Mcgraw Hill, 6th Edition ISBN-13 978-9387886209 ISBN-10 9387886204
2.	Pre-stressed Concrete : Analysis And Design Members	Karuna Moy Ghosh	Prentice-Hall of India Pvt.Ltd ISBN 9788120348431
3	Pre-stressed Concrete Analysis And Design	Dr. Y.R.M. Rao, J.P. Annie & P. Easwary	S.K. Kataria& Sons ISBN 9789350146354
4	IS 12592 Precast concrete manhole cover and frame	BIS NEW DELHI	BIS NEW DELHI
5	IS 15658 Precast and concrete block for paving-code of practice	BIS NEW DELHI	BIS, NEW DELHI

(b) Online Educational Resources:

1. https://www.youtube.com/watch?v=4KYPltsNAWs&list=PLB50EF6A79D1F8C14 (NPTEL)
2. https://archive.nptel.ac.in/courses/105/106/105106118/ (NPTEL)
3. https://nptel.ac.in/courses/105106117 (NPTEL)

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

A) Course Code **: 2415603B(T2415603B/P2415603B/S2415603B)**

B) Course Title **:** Traffic Engineering and Pavement Design

C) Pre- requisite Course(s) **:** Transportation Engineering

D) Rationale **:**

Traffic engineering is an important aspect of all modes of transportation. Due to the abundant growth in population and infrastructure development, there is urgent need to pay the immediate attention to the certain issues like designing traffic control device installations and modifications, including traffic signals, signs, and pavement markings. Also, it is important for safety of vehicle users as well as pedestrians. This course is expected to develop knowledge of performing various traffic surveys, analyze and interpret the data and provide the solutions in the form of traffic controlling devices. The civil engineering diploma holders have to do the related construction and maintenance activities of the structures made for guiding the traffic. Development of roads infrastructure required sound knowledge and competency of various road design aspects so that required type of pavements/road can be design. At diploma level, students are expected to study about different aspects of pavement design so as to develop their understanding in order to apply their knowledge in construction industry.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Analyse traffic characteristics of the given road section.
CO-2 Carryout relevant type of Traffic survey for the given road section.
CO-3 Suggest the relevant road traffic signs and markings for a given location.
CO-4 Supervise the construction & maintenance work of rigid & flexible pavement.
CO-5 Analyse the stresses induced in the given type of pavement.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	-	1	-	-	2	-	-
CO-2	3	1	2	2	-	-	-	-	-
CO-3	3	3	-	2	3	-	-	-	-
CO-4	3	3	2	2	-	-	-	-	-
CO-5	3	-	3	3	-	3	2	-	-

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415603B	Traffic Engineering and Pavement Design	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work& Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415603B	Traffic Engineering and Pavement Design	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: T2415603B

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4c. Describe the given type of pavement. *TSO 4d.* Describe various construction & maintenance aspects of flexible & rigid pavements. *TSO 4e.* Explain the process involved in the structural evaluation of flexible and rigid pavements	4.2 Types of Pavements: Flexible Pavement and Rigid Pavement. 4.3 Pavement components: Sub-grade, Sub-base, Base Course and wearing course. 4.4 Construction and maintenance of flexible and rigid pavements. 4.5 Structural evaluation of flexible and rigid pavements.	
TSO 5a. Explain the factors affecting design of given type of Pavement. *TSO 5b.* Calculate design wheel load for at least three types of traffic loads. *TSO 5c.* Explain stresses and joints of rigid pavement.	**Unit-5.0 Introduction to Pavement Design:** 5.1 Factors affecting design of pavements. 5.2 Flexible Pavement- Tyre pressure, Equivalent Single Wheel Load (ESWL), Terminologies used in flexible pavement design. 5.3 Rigid Pavement- Wheel load stresses, temperature stresses and critical combination of stresses. 5.4 Types of Joints of rigid pavement.	**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)
LSO 1.1. Explain Carry flow chart of Traffic engineering organization.	1.	Draw flow chart of Traffic engineering organization in transportation department of city.	CO1
LSO 2.1. 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
LSO 3.1. Draw various traffic signs for a given traffic location.	3.	Study the various traffic sign for given traffic location.	CO3
LSO 4.1. Draw the various type of Road marking.	4.	Study the various types of road marking.	CO3
LSO 5.1. Prepare the spot speed diagram for given traffic condition.	5.	Draw the spot speed diagrams.	CO3
LSO 6.1. Plan a seminar by a town planner/engineer.	6.	Seminar on any aspect of the traffic engineering.	CO2, CO3, CO4, CO5
LSO 7.1. Typical C/S of different types of roads. LSO 7.2. Types of Joint in Rigid Pavement.	7.	Study the types of pavement in your city.	CO4, CO5
LSO 8.1. Calculate wheel road stresses in given road.	8.	Study the wheel road stresses in given road.	CO4, CO5
LSO 9.1. 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

L) **Suggested Term Work and Self Learning: S2415603B** 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. Depute students to help traffic police for control of traffic movements at an intersection.
2. Ask students to perform traffic survey of busy parts of city in groups and to suggest measures for improvement.
3. Road accident survey for particular areas/section of traffic.
4. Visit to a road construction site, and prepare a technical report.
5. Prepare models of flexible and rigid pavement.
6. Refer and study the pavement related codes.

c. Other Activities:

1. Seminar Topics:
    - Design Considerations for Roadside Safety.
    - Evaluation of Highway Materials and Design Performance.
    - Flexible Pavement.
    - Highway Safety.
    - Mixed Traffic Control & Behavior.
    - GIS and Its Applications in traffic engineering.
7. Visits: Visit to a road construction site, and prepare a technical report.

2. Self-Learning Topics:
    - Numerical on Design of Flexible Pavements for Highway
    - Numerical on Design of joints of Rigid Pavements For Highway
    - Demonstration of following tests 1. Plate Bearing Test. 2. Field CBR Test.

M) **Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work& Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	15%	-	-	20%	20%
CO-2	10%	10%	10%	25%	-	10%	20%
CO-3	15%	15%	15%	25%	33%	15%	20%
CO-4	30%	30%	30%	25%	33%	15%	20%
CO-5	30%	30%	30%	25%	34%	40%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Fundamentals of traffic Engineering	8	CO1	10	3	3	4
Unit-2.0 Traffic Studies	8	CO1, CO2	8	2	2	4
Unit-3.0 Traffic Signs and Pavement Markings	8	CO3	10	3	3	4
Unit-4.0 Pavement and its Components	10	CO4	21	6	6	9
Unit-5.0 Introduction to Pavement Design	8	CO5	21	6	6	9
Total	**48**	**-**	**70**	**20**	**20**	**30**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested AssessmentTable for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Draw flow chart of Traffic engineering organization in transportation department of city.	CO1	30	60	10
2.	Methods of collection of traffic volume count data and O-D survey for given area.	CO2	40	50	10
3.	Study the various traffic sign for given traffic location.	CO3	30	60	10
4.	Study the various types of road marking.	CO3	30	60	10
5.	Draw the spot speed diagrams.	CO3	30	60	10
6.	Seminar on any aspect of the traffic engineering.	CO2, CO3, CO4, CO5	30	60	10
7.	Study the types of pavement in your city.	CO4, CO5	30	60	10
8.	Study the wheel road stresses in given road.	CO4, CO5	40	50	10
9.	Seminar on relevant topics	CO2, CO3, CO4, CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course

teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer system	As per manufacturers specification	All
2.	Drawing board with accessories	As per manufacturers specification	1, 3, 4, 5, 6
4.	Measuring Tape	As per manufacturers specification	3, 4, 5, 6
5.	Line dori, white wash, brush	As per manufacturers specification	3, 4, 5, 6
6.	Stopwatch and Enoscope	As per manufacturers specification	2, 5
7.	Speedometer and Camera	As per manufacturers specification	2, 5

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Highway Engineering	S.K. Khanna & C. J. Justo	Nemchand& Bros., 7th Edition (2000).
2.	Principles and Practices of Highway Engineering	Dr.L.R.Kadiyali& Dr. N. B. Lal	Khanna publishers (2003).
3.	Principles of pavement design	Yoder & wit zorac	Jhonwilley& Sons.

(b) Online Educational Resources:

1. https://nptel.ac.in/courses/105104098
2. https://archive.nptel.ac.in/courses/105/105/105105215/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. IRC code

****

A) Course Code : **2415603C(T2415603C/P2415603C/S2415603C)**

B) Course Title : Green Building and Sustainability

C) Pre-requisite Course(s) : Construction Materials

D) Rationale :

Green practices are rapidly expanding in the construction industry, with an increasing number of builders incorporating them into buildings to diminish the carbon footprint.

Green building is an innovative construction approach that focuses on sustainable practices to minimize the environmental impact of a structure. Its objective is to create high-quality, durable buildings without compromising the surrounding **environment**. It encompasses the use of sustainable materials, efficient energy systems, green roofs, and other **eco-friendly** features. Therefore, application of **green practices** is important for Diploma Engineers.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Explain the concepts and objectives of **green building** design.
CO-2 Propose cost effective materials in green building construction.
CO-3 Suggest the measures to **reduce energy** demand for a given building.
CO-4 Explain the components of heating, ventilation, and air conditioning (HVAC) System.
CO-5 Select Green Building rating assessment using IGBC, LEED, GRIHA guidelines.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO- 1**	**PSO- 2**
CO-1	3	-	-	-	2	-	1		
CO-2	3	1	1	-	2	1	1		
CO-3	3	1	1	2	2	1	1		
CO-4	3	-	-	-	1	-	1		
CO-5	2	-	-	1	1	-	-		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415603C	Green Building and Sustainability	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work& Self Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415603C	Green Building and Sustainability	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: T2415603C

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a. Explain the principles of green building. TSO 1b. Explain the benefits of a green building design. TSO 1c. Identify the salient features of a green building.	**Unit 1.0: Introduction to Green Building and Sustainability.** 1.1 Definition-Green Building, Benefits of Green Buildings, Concept of Green building and sustainable development. 1.2 Objectives, Principles and Benefits of Green building design. 1.3 Green building features and environmental design strategies.	**CO1**
TSO 2a. Suggest the relevant materials to be used in the construction of a given green building. TSO2b.Explain the relevance of reinforced polymer composite as green building material. TSO2c.Identify the relevant recyclable materials to be used in the construction of a given green building.	**Unit 2.0: Concept of Cost-Effective Construction Materials–** 2.1 Uses of different types of materials and their availability-Stone and Laterite blocks, Burned Bricks, Concrete Blocks, Stabilized Mud Blocks, Lime Pozzolana Cement, Gypsum Board, Light Weight Beams, Fiber Reinforced Cement Components- Fiber 2.2 Availability of different materials:- Reinforced Polymer Composites, Bamboo, Jute fiber, sisal fiber etc. 2.3 Recycling of building materials – Brick- Concrete- Steel- Plastics	**CO2**
TSO3a.Explain the measures taken to reduce the energy demand for a building. TSO3b.Suggest the onsite sources and sink of energy available in environment. TSO3c.Use the given Source of renewable energy for the conservation of energy.	**Unit-3.0: Overview of Relevant Design Aspects for Green Building** 3.1 Introduction, Reduction in Energy Demand, Onsite Sources and Sinks, Maximize System Efficiency. 3.2 Steps to Reduce Energy Demand and Use Onsite Sources and Sinks. 3.3 Use of Renewable Energy Sources. Ecofriendly captive power generation for factories and Buildings.	**CO3**
TSO4a.Explain the relevance of HVAC unit in the green building. TSO4b.Explain the functions of the components of HVAC unit in the given type of green building.	**Unit-4.0: Heating, Ventilation, and Air Conditioning (HVAC) System** 4.1 Design philosophy, Design interventions, Energy modeling, heating, ventilation, and air conditioning (HVAC) System. 4.2 Components of heating, ventilation, and air conditioning (HVAC) System.	**CO4**
TSO5a.Select the rating system for the assessment of the given green building.	**Unit-5: Rating system for Green Buildings.** 5.1 Introduction to rating system, Different rating	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO5b.Explain the provisions of IGBC, LEED and GRIHA rating system for a given building. TSO5c.Compare the various rating systems for energy assessment adopted in our country.	agencies in India and worldwide. 5.2 Indian Green Building Council (IGBC). 5.3 Leadership in energy and environmental design (LEED). 5.4Green Rating for integrated habitat assessment (GRIHA).	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2415603C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment /Practical Titles	Relevant Cos Number(s)
LSO1.1 Compare cost calculation of various recyclable and non-recyclable materials used in green building.	1	Prepare a detailed report on various cost effective and recyclable construction materials used in green buildings.	CO2
LSO2.1 Explain the energy generation process by solar power plant.	2	Prepare a detailed report based on your observations on the generation of energy after visiting the nearby Solar power plant with relevant sketches.	CO3
LSO 3.1 Suggest various modifications as per the requirements of a green building.	3	Inspect your Institute building and prepare action plan for converting it into green building.	CO4
LSO 4.1. Identify the various components of HVAC unit.	4	Visit the site of green building to identify the component of HVAC and submit the report.	CO4
LSO 5.1 Explain the various parameters of IGBC rating system for a given green building.	5	Assess a green building with relevant rating system (IGBC) and submit the report.	CO5
LSO 6.1 Explain the various parameters of LEED rating system for a given green building.	6	Assess a green building with relevant rating system (LEED) and submit the report.	CO5
LSO 7.1 Explain the various parameters of GRIHA rating system for a given green building.	7	Assess a green building with relevant rating system (GRIHA) and submit the report.	CO5

L) Suggested Term Work and Self Learning: **S2415603C** 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 the utility of Green Buildings and their efficiency in water consumption.
2. Suggest various solutions to reduce electricity consumption in the given building.
3. Collect the relevant information regarding recent technologies used in green building construction and prepare a report on it.
4. Prepare a report while comparing various rating system of green building.

c. Other Activities:

1. Seminar Topics:
   - Prepare a power point presentation on the use of green materials for sustainable buildings.
   - Present a seminar on green buildings and indoor air quality.
   - **Green buildings** impact on the environment.

- Use of Renewable Energy Sources.
- Eco-friendly captive power generation.

2. Self-Learning Topics:
   - Identify different components of green building on actual sites.
   - Recycling of building materials – Brick- Concrete- Steel- Plastics.
   - Visit to a green building site to collect information regarding HVAC system used in it.
   - Identify the software related to |Green Building and prepare the report stating their applications.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate CO attainment.

Cos	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/ Mid Sem Test	End Theory Assessment (ETA)	Term Work& Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	20%	20%	20%	20%	-	20%
CO-2	25%	22%	20%	20%	20%	15%	20%
CO-3	20%	22%	20%	20%	40%	15%	20%
CO-4	15%	14%	20%	15%	20%	30%	20%
CO-5	15%	22%	20%	25%	-	40%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.
**: Mentioned under point- (N)
#: Mentioned under point-(O)

Note:
- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA(Marks)		
				Remember (R)	Understanding (U)	Application & above(A)
Unit-1.0 Introduction to Green Building and Sustainability	10	CO1	15	4	5	6
Unit-2.0 Concept of Cost-Effective Construction Materials	10	CO2	15	3	6	6
Unit-3.0 Overview of Relevant Design Aspects for Green Building	10	CO3	15	5	5	5
Unit-4.0 Heating, Ventilation, and Air Conditioning (HVAC) System	8	CO4	10	4	2	4
Unit-5.0 Rating System for Green Buildings	10	CO5	15	4	5	6
Total Marks	**48**	**-**	**70**	**20**	**23**	**27**

Note: Similar table can also be used to design class / mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Prepare a detailed report on various **cost** effective and recyclable construction materials used in green buildings.	CO2	50	40	10
2.	Prepare a detailed report based on your observations on the generation of energy after visiting the nearby Solar power plant with relevant sketches.	CO3	50	40	10
3.	Inspect your Institute building and prepare action plan for converting it into green building.	CO4	50	40	10
4.	Visit the site of green building to identify the component of HVAC and submit the report.	CO4	60	30	10
5.	Assess a green building with relevant rating system (IGBC) and submit the report.	CO5	50	40	10
6.	Assess a green building with relevant rating system (LEED) and submit the report.	CO5	50	40	10
7.	Assess a green building with relevant rating system (GRIHA) and submit the report.	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical . Rubrics need to be prepared by the course teacher for each experiment / practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio-Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blend or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Green Building Fundamentals	HarharaIyer G	Notion Press ISBN-13: 979-8886416091
2.	Green Building: Principles & Practices	Dr. Adv. HarshulSavla,	Notion Press (28 October 2021) ISBN-10: 1685866042 ISBN-13: 978-1685866044
3	Handbook on Green Practices		Indian Society of Heating Refrigerating and Air conditioning Engineers 2009
4	Sustainable Construction: Green Building Design and Delivery	Charles J. Kibert	Wiley; 1st edition (1 March 2005) ISBN-10 0470114215 ISBN-13 978-0470114216
5	Alternative Building Materials and Technologies	Jagadish, K.S.Reddy, B.V. Venkatarama ,Rao, K.S. Nanjunda	Publisher: New Age International ISBN: 9789385923876, 9385923870

(b) Online Educational Resources:

1) https://www.youtube.com/watch?v=DRO_rIkywxQ
2) https://www.youtube.com/watch?v=pojRTvI23EA&list=PLp6ek2hDcoND9o3oVRI_p_xqvg6PRuIw6 (IIT Delhi)
3) https://www.youtube.com/watch?v=oRt0zRuFKC4&list=PLLy_2iUCG87CfjAcR9lGNrJ16Fe6OqXzr (IIT Roorkee)
4) https://www.youtube.com/watch?v=2NEluSrn6fY&list=PLyqSpQzTE6M_PO9gmUEE6ILnJ9cGqqWk2 (NPTEL)

(c) Others: -

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A) Course Code : **2415603D(T2415603D/P2415603D/S2415603D)**

B) Course Title **:** Water and Waste Water Management

C) Pre-requisite Course(s) **:** Environment Engineering

D) Rationale **:**

Water plays a vital role in the life of every living creatures and plants. Since we need safe drinking water for good health, we should always conserve water as there is limited source of fresh and drinkable water. With time, the demand of fresh water is increasing rapidly and at the same time, source of fresh water is declining due to urbanization and improper management of water supply. Further Water sources are contaminated as it gets mixed with the waste water originating from domestic and industrial waste. As confirmed in the NITI Aayog's report titled "Composite **Water Management** Index (CWMI), 70% of India's water supply is contaminated as80% of waste water gets disposed off without any treatment in the river or lake. This poses a grave risk to living health and the environment across the globe. Therefore, it is necessary to remove the contaminants from the water and waste water through relevant treatment techniques to ensure the sustainability of the water resources. This course will develop the required awareness among the students to manage the water and waste water to ensure the environmental sustainability and reinforce towards achievement of sustainable development goal 3 (Good Health and Well-being) and sustainable development goal 6 (Clean Water and Sanitation)

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/industry.

After completion of the course, the students will be able to-

CO-1 Justify the need of water and **wastewater management.**

CO-2 Undertake Preliminary, Primary, and Secondary Treatment for the given sample of water.

CO-3 Select the relevant technique of domestic wastewater treatment based on the characteristics of wastewater.

CO-4 Suggest the relevant method of treatment of Industrial wastewater.

CO-5 Apply Advanced technique for treating the given sample of water and wastewater.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO- 1**	**PSO- 2**
CO-1	3	1	-	1	1	1	2	--	--
CO-2	3	3	1	2	2	1	1	--	--
CO-3	3	3	2	2	3	2	1	--	--
CO-4	3	2	2	2	3	2	1	--	--
CO-5	2	2	3	3	2	2	2	--	--

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional.

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415603D	Water and Waste Water Management	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415603D	Water and Waste Water Management	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: 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.aExplainthecomponentsofwatercycle. 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)
TSO4.d Suggest the relevant natural method of waste water disposal as per provisions of relevant IS code. TSO4.e Describe the factors that affect the self-purification capacity of given stream/river. TSO 4.f Identify the use of treated industrial waste water for the given situation.	removal, Primary and Secondary Settling Tank, Aeration. 4.3 Biological Treatment by microorganism in Aerobic and Anaerobic condition. 4.4 Natural method of waste water disposal –By Land treatment and by Dilution, Indian Standards for disposal of waste water. 4.5 Self-purification capacity of stream/River –Self-purification zones, Factors affecting self-purification capacity of stream. 4.6 Managementofeffluentaftertreatmentwithinandoutsideindustry-Cooling Tower, Boiler feed water, Irrigation, Land scape watering.	
TSO5.a Carry out the relevant technique to treat the given sample of water. TSO5.b Select the relevant method of treatment for given sample wastewater. TSO5.c State the advantages of IoT based smart water supply monitoring system.	**Unit-5.0 Advanced Water and Waste Water Treatment Technique** 5.1 Water Treatment Technique-Reverse Osmosis; Membrane Filtration; Electrodialysis. 5.2 Waste Water Treatment Technique – Phytorid technology; Enhanced Biological Phosphorous Removal; Air Stripping; Electro flocculation treatment; Activated Carbon Adsorption; SBR technique; Rotating Biological Contractor. 5.3 Smart Water Supply and monitoring system – Purposes and advantages, IoT based smart water supply monitoring system and water Quality monitoring system.	**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.	PrepareareportofvisittoRainwaterharvestingimplementedonResidentialorPublicbuildingwithneatlabeledsketch, 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.	Prepareavisitreportonreuseandrecyclingofwastewateradoptedinaresidential 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 Phytorid technology technique used in treatment of waste water.	11.	Prepare a site visit report to waste water treatment plant implementing Phytorid 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.
   - Phytorid 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.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	8%	10%	15%	-	-	20%	20%
CO-2	25%	25%	15%	20%	10%	10%	20%
CO-3	22%	20%	15%	30%	15%	15%	20%
CO-4	30%	30%	35%	20%	25%	15%	20%
CO-5	15%	15%	20%	30%	50%	40%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Water and Waste Water	4	CO1	07	3	2	2
Unit-2.0 Water Management and Treatment	12	CO2	18	4	6	8
Unit-3.0 Domestic Waste Water	10	CO3	15	4	4	7
Unit-4.0 Industrial Waste Water	14	CO4	20	5	7	8
Unit-5.0 Advanced Water and Waste Water Treatment Technique	8	CO5	10	4	3	3
Total	**48**	-	**70**	**20**	**22**	**28**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Determine the water quality index based on the given data of BOD, TSS, DO, Conductivity and Temperature.	CO1	60	30	10
2	Prepare a detailed report on the type of pollutants present in the nearby pond/river and measures to control it.	CO1	45	45	10
3	Prepare a detailed report on water conservation project with relevant information of literature, collection of posters, images video clippings, etc.	CO2	45	45	10
4	PrepareareportofvisittoRainwaterharvestingimplementedonResidentialorPublicbuildingwithneat Labeled sketch, design parameter, required calculation, etc.	CO2	45	45	10
5	Prepare a report on different methods of ground water recharge assessing the impact of ground water recharge on ground water quality.	CO2	45	45	10
6	Find out the optimum dose of coagulant required to treat given sample of turbid water.	CO3	60	30	10
7	Find out the amount of residual chlorine present in given Sample of treated water.	CO3	60	30	10
8	Prepare a visit report on reuse and recycling of waste water adopted in a residential colony.	CO3	45	45	10
9	Drawalabeledsketchofthewastewatertreatmentplantwithabriefreportonits working.	CO4	45	45	10
10	Prepare a summary report on IS Recommendations used for wastewater disposal using dilution method.	CO4	45	45	10
11	Prepareasitevisitreporttowastewatertreatmentplantimplementing Phytoridtechnologyfortreatmentofwaste water.	CO5	45	45	10
12	Draw the Layout of an IoT based smart water monitoring system.	CO5	45	45	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specification	Relevant Experiment / Practical Number
1.	Digital Turbidity Meter	Range- 0 to 4000 NTU (Nephelo metric Turbidity Unit),Accuracy-(±2% -±5%),Response time- Less than 15 sec.	6
2.	Digital Chlorimeter	ME 953 C 5 Filter, Range: 400 nm to 700 nm, Accuracy: ±0.02 O.D.	7
3.	Hot Air Oven	Range-5˚Cto250˚C	6,7
4.	Digital weighing Machine	Capacity-60 Kg	6,7
5.	Measuring cylinder	As per requirements	6,7

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Water Supply Engineering	Santosh Kumar Garg	Khanna Publishers ISBN978-8174091208
2.	Water Supply and Sanitary Engineering	Rangwala	Charotar Publication ISBN:978-9385039201
3.	Industrial Water Treatment	H. M. Raghunath	New Age International ISBN978-8120353329
4.	Industrial Waste Water Treatment	A.D. Patwardhan	PHI Learning ISBN978-8120353329
5.	Waste Treatment Technologies	Dr. Mahendra Pal	NIIR Project Consultancy Service ISBN978-9381039670
6.	Waste Water Engineering– Treatment and Reuse	Metcalf and Eddy Inc.	TMH Publication ISBN978-0070495395

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ce25/preview
2. https://www.classcentral.com/course/hwts-1721
3. https://online-learning.tudelft.nl/topic/water-treatment-courses/
4. https://alison.com/course/advanced-diploma-in-wastewater-treatment-and-recycling
5. https://jalshakti-ddws.gov.in/en/cpheeo-manual-water-supply-and-treatment
6. https://www.classcentral.com/course/edx-environmental-engineering-drinking-water-treatment-19001

(c) Others:

- IS10500:2012–Drinking Water Standards
- IS1172:1993–Code of Basic Requirements for Water Supply, Drainage and Sanitation
- IS 3025 (Part 58): 2006 – Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water
- IS 2490 (Part 2): 1974 – Indian Standards Tolerance limits for Industrial effluents discharged into Inland Surface water

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

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A) Course Code : 2400604B(T2400604B/P2400604B/S2400604B)

B) Course Title : Artificial Intelligence (Advanced)

C) Pre- requisite Course(s) : Artificial Intelligence (Basic)

D) Rationale :

In Artificial Intelligence (Basic) course, students have learned the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This Artificial Intelligence (Advanced) course offers the students the comprehension of Machine learning which is a subset of artificial intelligence in the field of computer. The course also exposes students to Tens or flow a Python-based open source library for numerical computation used in machine learning and developing neural networks. After completing the course students will be able to implement various techniques used in machine learning and neural networks using open source tools.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensurethe accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Elaborate the use of Machine learning in Artificial Intelligence.

CO-2 Implement various supervised and unsupervised learning models and methods.

CO-3 Illustrate Artificial neural networks and its applications.

CO-4 Implement various Neural network models and Learning Methods.

CO-5 Solve machine learning and artificial neural network problems using Tens or flow.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainabilityand Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	-	2	2	-	-	-	1		
CO-2	3	3	3	3	-	-	2		
CO-3	-	3	3	3	-	-	2		
CO-4	3	1	3	3	-	-	2		
CO-5	3	3	3	3	-	-	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***:** PSOs will be developed by respective programme Coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credit (C)
		L	T				
2400604B	Artificial intelligence (Advanced)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604B	Artificial Intelligence (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: T2400604B

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
TSO 1a. Describe the basic terminology of Machine learning TSO 1b. Explain the concept of dataset and ways to handle them TSO 1c. illustrate the process of dataset division TSO 1d. Explain process involved in machine learning	**Unit – 1.0: Introduction to Machine Learning** Concept of Machine Learning, Define Learning, Learn the Network, Evaluate the Network, datasets and ways to handle them, Feature sets, Dataset division: test, train and validation sets, cross validation. Applications of Machine Learning, processes involved in Machine Learning	**CO-1**
TSO 2a. Identify the category or class of a particular dataset using KNN algorithm TSO 2b. Use Linear regression for predictive analysis TSO 2c. Predict the categorical dependent variable using Logistic Regression TSO 2d. Use SVM for classification problems in Machine Learning TSO 2e. determine the performance of the classification models TSO 2f. evaluate the performance of the classification model using ROC-curve TSO 2g Explain characteristics of Unsupervised learning. TSO 2h. Explain different clustering methods TSO 2i. Implement K-means clustering algorithm to group the unlabeled dataset	**Unit 2.0: Supervised and Unsupervised Learning** **Supervised Learning:** Introduction to Supervised Learning, K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: confusion matrix, precision, precision and recall, ROC-Curve (Receiver Operating Characteristic curve) **Unsupervised Learning:** Introduction to Unsupervised Learning, Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering. Expectation-Maximization (EM) Algorithm	**CO-2**
TSO 3a. Explain Structure and working of Biological Neural Network. TSO 3b. differentiate between Artificial Neural Network and Biological Neural Network TSO 3c. State key historical points in development of ANN TSO 3d. Explain the architecture of an artificial neural network	**Unit 3.0: Introduction to Neural Networks** Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.	**CO-3**
TSO 4a. Use neuron McCulloch – Pitts model in designing logical operations TSO 4b. Apply Rosenblatt's Perceptron to solve linear classification problems TSO 4c. Implement Adaptive Linear Neuron (Adaline) training algorithm in neural network TSO 4d. Use Backpropagation neural training algorithm TSO 4e. Use ART (Adaptive Resonance Theory) learning model TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network	**Unit 4.0: Neural Networks Models and Learning Methods** Models of neuron McCulloch – Pitts model, Rosenblatt's Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, Adaptive Resonance Theory (ART), Associative memories, BAM.	**CO-4**
TSO 5a. Illustrate the features of Tens or flow TSO 5b. Manipulate tensors TSO 5c. Explain features of Tens or Board visualization TSO 5d Explain the concept and features of Tens or flow playground	**Unit-5.0: Tensor flow** features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension and two-dimension tensor, Tensor handling and manipulations, Tensor board	**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 SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	CO-2
LSO 3.1 Perform clustering operations using k-means algorithm	3	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2
LSO 4.1 Perform clustering operations using EM algorithm	4	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2
LSO 5.1 Build artificial neural network LSO 5.2 Test artificial neural network	5	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4
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 SessionOutcomes (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.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment(ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	30%	20%	30%	--	--
CO-2	10%	25%	20%	20%	20%	30%	33%
CO-3	30%	25%	30%	20%	20%	--	--
CO-4	20%	20%	20%	20%	30%	30%	33%
CO-5	20%	15%	10%	20%	--	40%	34%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

* : Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

** : Mentioned under point- (N)

: Mentioned under point- (O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to Machine Learning	8	CO1	11	5	4	2
Unit-2.0. Supervised and Unsupervised Learning	10	CO2	18	5	6	7
Unit-3.0. Introduction to Neural Networks	10	CO3	17	5	7	5
Unit-4.0. Neural Networks Models and Learning Methods	10	CO4	14	3	3	8
Unit-5.0. Tensor Flow	10	CO5	10	2	6	2
Total Marks	**48**		**70**	**20**	**26**	**24**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Write a program to implement k-Nearest Neighbor 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	-	90	10
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	CO-2	-	90	10
3.	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2	20	70	10
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	-	90	10
5.	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4	10	80	10
6.	Implement the perceptron algorithm from scratch in python.	CO-4	10	80	10
7.	Write a programme to implement two dimension and three-dimension Tensor.	CO-5	-	90	10
8.	Write a programme to add and multiply two 4x4 matrix, you can Import “tens or flow” and “numpy”.	CO-5	-	90	10
9.	Solve a classification problem on the Tens or flow playground.	CO-5	20	70	10
10.	Implement algorithm for linear regression in tens or flow	CO-2, CO-5	10	80	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Group Discussion, Portfolio Based Learning, Live Demonstrations in Classrooms, Lab, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer Systems	Desktop Computers with i3 processor, 16 GB RAM, 512 GBHDD	S. No. 1 to 10
2.	Online Python IDE	https://www.online-python.com/	S. No. 1 to 10
3.	Jupyter Notebook	Download from https://jupyter.org/	S. No. 1 to 10

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
4.	Pip Python package manager	Download Pip 22.3 From https://pypi.org/project/pip/	S. No. 1 to 10
5.	Google colab	https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/quickstart/beginner.ipynb#scrollTo=DUNzJc4jTj6G	S. No. 1 to 10
6.	Various modules, Libraries and Packages	Tens or flow, NumPy, Pandas, package	S. No. 1 to 10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Machine Learning using Python	Manaranjan Pradhan, U Dinesh Kumar	Wiley, ISBN-10: 8126579900 ISBN-13: 978-8126579907
2.	Introduction to Machine Learning	Jeeva Jose	Khanna Book Publishing Co. (P) ltd, 2020. ISBN-10: 9389139066 ISBN-13: 978-9389139068
3.	Machine Learning for Dummies	John Paul Mueller and Luca Massaron, For Dummies,	For Dummies; 2nd edition, ISBN-10: 1119724015 ISBN-13: 978-1119724018
4.	Machine Learning	Rajeev Chopra	Khanna Book Publishing Co., 2021 ISBN-10: 9789386173423 ISBN-13: 978-9386173423
5.	Learn TensorFlow 2.0: Implement Machine Learning and Deep Learning Models with Python	Pramod Singh, Avinash manure	Apress, 978-1484255605 ISBN-10: 1484255607 ISBN-13: 978-1484255605
6.	Artificial Intelligence: Concepts, Techniques and Applications	Alexis Keller	States Academic Press, 2022 ISBN-9781649649245
7.	Artificial Intelligence: An Introduction	Jacob Pearson	Willford Press 2022 ISBN 9781682860911
8.	Fundamentals of Machine Learning	Mia Williams	Willford Press 2022 ISBN 9781682860920
9.	Artificial Intelligence: A Modern Approach	Emilia Stones	Larsen and Keller Education 2022 ISBN 9781641728525

(b) Online Educational Resources:

1. NPTEL Course: Introduction to Machine Learning, Prof. Balaraman Ravindran, IIT Madras
2. https://www.tensorflow.org/resources/learn-ml
3. https://www.tutorialspoint.com/tensorflow/index.htm
4. https://www.javatpoint.com/tensorflow
5. https://developers.google.com/machine-learning/crash-course/exercises

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

Data Source:

- https://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/
- https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data
- https://www.kaggle.com/arshid/iris-flower-dataset
- https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset

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A) Course Code **: 2400604C(T2400604C/P2400604C/S2400604C)**

B) Course Title **:** Internet of Things (Advanced)

C) Pre- requisite Course(s) **:** IoT (Basics), Computer Networks

D) Rationale **:**

The rise and rise of IoT technologies is redefining business opportunities and process. This has led to a growing need to learn advance skills to remain competitive in the market. Put together, these are a potent combination of technologies that will dictate how our future is written, which is a strong indicator of rewarding job opportunities in those domains. Introduction of the Advanced IoT follows a rigorous curriculum which blends the academic excellence and industry-relevant applications.

This course will be exposed to a breadth of skills which will help students to become multi-faceted software engineers with a deeper understanding of these modern technologies, their applications, and interdependence.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

- **CO-1** Use basic Python features in Programming.
- **CO-2** Use advance Python features in Programming.
- **CO-3** Explain features of Cloud and IoT data storage on it.
- **CO-4** Explain IoT Networking and its application.
- **CO-5** Develop IoT App for the given problem

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	3	2	2	-	2	-		
CO-2	3	3	2	2	-	2	-		
CO-3	1	-	3	2	2	2	2		
CO-4	1	-	2	3	-	2	2		
CO-5	3	3	3	2	2	3	3		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400604C	IoT (Advanced)	03	-	04	02	09	06

Legend:

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

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

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

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

SL: Self Learning, MOOCS, spoken tutorials, Online educational resources etc.

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604C	IoT (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: T2400604C

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5. 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:

1. Deeper knowledge in Python features
2. Network devices and its capabilities
3. Advantages of IoT implementations

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	20%	--	33%	10%	20%
CO-2	15%	10%	20%	--	33%	15%	20%
CO-3	30%	30%	20%	--	34%	15%	20%
CO-4	20%	30%	20%	50%	--	30%	20%
CO-5	25%	20%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
***:** Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.
******: Mentioned under point- (N)
#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Python basics	5	CO1	7	2	2	3
Unit-2.0 Python Advance	5	Co1, CO2	7	2	2	3
Unit-3.0 Cloud features	14	CO3	21	8	8	5
Unit-4.0 Networking and Application	14	CO4, C03	21	5	7	9
Unit-5.0 IoT Applications	10	CO5, CO3 and CO4	14	3	6	5
Total Marks	**48**		**70**	**20**	**25**	**25**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Install given version of Python the computer system.	CO-1	70	20	10
2.	Prepare a python program using print() function and run it.	CO-1	60	30	10
3.	Access given value from the tuple	CO-1	60	30	10
4.	Print the given value of key from the dict.	CO-1	60	30	10
5.	Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes	CO-1	60	30	10
6.	Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array.	CO-1	60	30	10
7.	Write a python program to check whether person is eligible for voting or not. (accept age from the user)	CO-1	60	30	10
8.	Write a python program to check whether the entered number is even or odd.	CO-1	60	30	10
9.	Write a python program to check whether entered number is divisible by another entered number.	CO-1	60	30	10
10.	Write a python program to display “Yes” is entered number is divisible by 5 otherwise display “No”	CO-1	60	30	10
11.	Prepare a python program which can print first 10 even and odd numbers using while statement	CO-2	60	30	10
12.	Write a python program which can print first 10 integers and its square using while/for loop.	CO-2	60	30	10
13.	Write a python program which can print sum of first 10 natural numbers using while/for loop.	CO-2	60	30	10
14.	Write a python program which can identify the prime number between the range given using while/for loop.	CO-2	60	30	10
15.	Consider a situation where you want to iterate over a string and want to print all the characters until a letter ‘e’ or ‘s’ is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
16.	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.	CO-2	60	30	10
17.	Create a Class with instance attributes	CO-2	60	30	10
18.	Create a Vehicle class without any variables and methods	CO-2	60	30	10
19.	Write a Python function to find the Max of three numbers.	CO-2	60	30	10
20.	Write a Python program to reverse a string.	CO-2	60	30	10
21.	Create a free cloud account	CO-3	70	20	10
22.	Store data on cloud and retrieve it.	CO-3	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
23.	Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.	CO-4	70	20	10
24.	Connect the computers in Local Area Network	CO-4	70	20	10
25.	Connect 2 or more devices using Bluetooth	CO-4	70	20	10
26.	Connect 2 or more devices using infrared	CO-4	70	20	10
27.	Connect 2 more machine using m2m	CO-4	70	20	10
28.	Connect 2 or more different devices using access point	CO-4	70	20	10
29.	Connect 2 devices suing LPWAN (Smart Meter)	CO-4	70	20	10
30.	Connect 2 or more devices using RFID	CO-4	70	20	10
31.	Identify a problem and develop an app	CO-5	70	20	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/ Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1	Python software	Openly available as per instruction	As mentioned above list
2	Cables connecters and crimping tools	Cat 6e cable, RJ-45 connectors and Crimping Tool	
3	Bluetooth and infrared devices	Any mobile and wireless keyboard and mouse	
4	IoT free cloud	Free available	
5	Smart devices	Like meters, bulbs etc.	
6	Wireless access point	Wireless router or access point	-
7	Arduino development board	Arduino Uno and Arduino Nano.	-
8	Raspberry Pi	Raspberry Pi 4/ Raspberry Pi 3/ Raspberry Pi 2	-

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Let Us Python	Kanetkar Yashavant	BPB Publications ISBN: 9789388511568, 9789388511568
2	IOT (Internet of things) and Its Application	P K Pandey	T Balaji Publication (1 January 2020) ISBN-10: 8194136385 ISBN-13: 978-8194136385
3	Raspberry Pi Cookbook: Software and Hardware Problems and Solutions	Simon Monk	Shroff/O'Reilly; Third edition (4 October 2019) ISBN-10: 9352139267 ISBN-13: 978-9352139262
4	Raspberry Pi Cookbook: Software and Hardware Problems and Solutions,	Simon Monk	Shroff/O'Reilly; Third edition (4 October 2019) ISBN-10: 9352139267 ISBN-13: 978-9352139262
5	Cloud Computing: Concepts, Technology & Architecture	Erl	Pearson Education India; 1st edition (1 January 2014), ISBN-10: 9332535922 ISBN-13: 978-9332535923
6	Fundamentals of Internet of Things	Eden Scott	States Academic Press 2023 ISBN 9781649649235
7	Internet of Things	Alaina Wilson	Murphy & Moore Publishing 2023 ISBN 9781649872731
8	Principles of Internet of Things	Hallie Parker	Larsen and Keller Education 2023 ISBN 9781641728312 (b)

(b) Online Educational Resources:

1. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
2. en.wikipedia.org/wiki/Shear_and_moment_diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
6. https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/
7. https://wiki.python.org/moin/TimeComplexity
8. www.engineerstudent.co.uk/stress_and_strain.html
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf

Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work. https://github.com/OpenRCE/sulley

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

A) Course Code : **2400604D(T2400604D/P2400604D/S2400604D)**

B) Course Title : Drone Technology (Advanced)

C) Pre- requisite Course(s) : Drone Technology (Basics)

D) Rationale :

In previous semester, a course in drone technology broadly discussed about basic principles, functions and interface of different components and design simple drone structure. In order to understand the successive development of drones / UAVs in terms of their geometric structure, working methodology and navigation control etc., so it is important to study the advanced course on Drone Technology. This course includes the study of Static and dynamic force analysis on drone, advance flying features, navigation control, maintenance and advance applications of different types of drone.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Apply the concept of engineering mechanics for stability of drone.

CO-2 Design the structure of drone using GPS module and thermal Image camera.

CO-3 Operate drone using advance flight controller board.

CO-4 Perform drone maintenance and assembly.

CO-5 Use drone in advance applications like precision agriculture, security, IoT, etc.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	-	-	-	-		
CO-2	2	2	-	3	3	-	-		
CO-3	2	2	3	3	-	-	-		
CO-4	3	-	-	3	-	-	-		
CO-5	-	2	2	-	-	3	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Legend:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400604D	Drone Technology (Advanced)	03	-	04	02	09	06

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)	
2400604D	Drone Technology (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 (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	**Unit-1.0 Engineering mechanics for Drone Technology** 1.1 Drone Mechanics • Free body diagram of drone • Method of finding resultant of force system • Equilibrium of coplanar force system 1.2 Center of Gravity • Centroid of plane figure • Center of gravity of solid bodies 1.3 Force analysis in drone • Force analysis in drone • Forces of flight • Principle axes and rotation of aerial systems 1.4 Dynamics of machine • Static and dynamic force analysis • Gyroscopic motions	**CO-1**
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	**Unit-2.0 Drone Frame and Components** 2.1 Drone frame design • Calculation principle for drome frame sizes • Quadcopter frame design • Smart materials for UAV frame • Green material uses in drone 2.2 Advance Drones component • GPS, Interfacing of GPS hardware • Thermal and chemical sensor • Tilt and LiDAR sensor 2.3 RF transmitter and receiver • RF blocks • RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	**CO-2**
TSO 3a. Identify features and specifications of FCB use in different application 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 • Software installation 3.3 Radio Communication with FCB • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC 3.7 GPS interface with FCB	**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 • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling	**CO-4**
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	**Unit-5.0 Advance Drone Application** 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in • Military • Precision Agriculture	**CO-5**

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

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

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

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 5.2Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	CO-2
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identity different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	CO-3
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator. LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.	12.	Measure various electric parameters in drone hardware	CO-4
LSO 13.1 Inspect drone as per the given checklist LSO 13.2 Diagnose drone problems after flying of 50 and 100hrs	13.	Perform preventive maintenance of drone components	CO-4
LSO 14.1 Perform dismantle process of drone. LSO 14.2 perform services need for operation LSO 14.3 Check and Install different parts of the drone system. LSO 14.4 Assemble drone component.	14.	Dismantle and service of different parts of drone system	CO-4

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

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

b. Micro Projects:

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

c. Other Activities:

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

d. Self-Learning Topics:

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

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	20%	20%	20%	25%	25%
CO-2	20%	20%	20%	20%	20%	25%	25%
CO-3	25%	25%	20%	20%	20%	25%	25%
CO-4	25%	25%	20%	20%	20%	25%	25%
CO-5	15%	15%	20%	20%	20%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.
****:** Mentioned under point- (N)
#: Mentioned under point-(O)

Note:
- The percentage given are approximate

- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit 1.0 Engineering mechanics for Drone Technology	8	CO-1	12	04	04	04
Unit 2.0 Drone frame and components	10	CO-2	14	04	04	06
Unit 3.0 Advance Flight Controller Board	12	CO-3	16	04	06	06
Unit 4.0 Maintenance and assembling of drone	10	CO-4	16	04	06	06
Unit 5.0 Advance Drone Application	8	CO-5	12	04	04	04
Total Marks	**48**		**70**	**20**	**24**	**26**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine Centre of gravity of different done structure.	CO-1	50	40	10
2.	Demonstrate gyroscopic effect on a drone model	CO-1	40	50	10
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	50	40	10
4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2	50	40	10
5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3	50	40	10
6.	Test HD and thermal Image camera and their characteristics.	CO-2	50	40	10
7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2	60	30	10
8.	Programming and configuration of parameters in flight control board (FCB).	CO-3	60	30	10
9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2	60	30	10
10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2	60	30	10
11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
12.	Measure various electric parameters in drone hardware	CO-4	40	50	10
13.	Perform preventive maintenance of drone components	CO-4	60	30	10
14.	Dismantle and service of different parts of drone system	CO-4	60	30	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Drone Frame	Tricopter/Quadcopter/Hexacopter	1-15
2.	Propellers	15 X 5.5 CW/Others	1-15
3.	GPS module	M8N Series	1-15
4.	Drone Camera	15-20 Megapixel	1-15
5.	Camera Gimble	3 Axis feature, 360 Degree movement	1-15
6.	Tilt Sensor	8-30 volt	1-15
7.	LiDER sensor	Range 75m to 200m	1-15
8.	Battery	Lithium Polymer Battery,8000 to 10000 mAh	1-15
9.	Motor	BLDC, 370kv	1-15
10.	Electronic speed Controller (ESC)	40 Amp	1-15
11.	Flight Controller Board	CC3D/Pixhawk/Others	1-15
12.	Transmitter and Receiver for radio signal	10 Channels and more, 2.4 GHz & 5.8 GHz	1-15
13.	Embedded system for AI application on UAV	Open Source Jetson Baseboard /Others	1-15

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Make: DIY Drone and Quadcopter Projects: A Collection of Drone-Based Essays, Tutorials, and Projects	Editors of Make	Shroff/Maker Media, First edition 2016, ISBN-978-9352133994
2.	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Terry Kilby & Belinda Kilby	Shroff/Maker Media, First edition 2016, ISBN-978-9352133147
3.	Agricultural Drones: A Peaceful Pursuit	K R Krishna	Apple Academic Press,1st edition 2018, ISBN-978-1771885959
4.	Building Multicopter Video Drones: Build and fly multicopter drones to gather breathtaking video footage	Ty Audronis	Packt Publishing Limited; Illustrated edition,2014, ISBN-978-1782175438
5.	The Complete Guide to Drones	Adam Juniper	Ilex Press, Extended 2nd Edition,2018 ISBN-9781781575383
6.	Unmanned Aircraft Systems - UAVS Design, Development and Deployment (Aerospace Series)	R Austin	John Wiley & Sons Inc, 1st edition, 2010, ISBN-978-0470058190
7.	Drone Technology	Miranda Hall	NY Research Press 2023 ISBN 9781632389574
8.	Introduction to UAV Systems	Rupert Baker	Willford Press 2023 ISBN 9781682860890
9.	Theory, Design, and Applications of Unmanned Aerial Vehicles	Tyler Wood	Larsen and Keller Education 2023 ISBN 9781641728338

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/101/104/101104083/
2. https://onlinecourses.nptel.ac.in/noc21_ae14/preview
3. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
4. https://fusion.engineering/
5. https://robocraze.com/blogs/post/best-flight-controller-for-drone
6. https://www.youtube.com/watch?v=lrkFG7GilPQ
7. https://www.youtube.com/watch?v=KjG6FKCNCbM
8. https://ardupilot.org/
9. https://px4.io/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Development of an Autonomous IoT-Based Drone for Campus Security, Abdelrahman Mahmoud Gaber, Rozeha A. Rashid, Nazri Nasir, Ruzairi Abdul Rahim, M. Adib Sarijari, A. Shahidan Abdullah, Omar A. Aziz, Siti Zaleha A. Hamid, Samura Ali,2021
2. IoT based UAV platform for emergency services; S. K. Datta, J. L. Dugelay, & C. Bonnet, 2018
3. Development of an Autonomous Drone for Surveillance Application; M. A. Dinesh, S. Santhosh Kumar, J. Sanath, K. N. Akarsh & K. M. Manoj Gowda,2018
4. Autonomous cloud-based drone system for disaster response and mitigation; C. Alex & A. Vijaychandra,2016
5. https://www.geeetech.com/Documents/CC3D%20flight%20control%20board.pdf
6. https://www.bhphotovideo.com/lit_files/201146.pdf
7. http://tricopter.hu/docs/cc3d_manual.pdf

******

A) Course Code : 2400604E(T2400604E/P2400604E/S2400604E)

B) Course Title : 3D Printing and Design (Advanced)

C) Pre- requisite Course(s) : 3D Printing and Design (Basic)

D) Rationale :

This advanced course on 3D Printing tries to develop understanding of the process of making real complex objects from digital models in the students using various 3D printing processes and materials (Plastics, Ceramics and Metals). It also covers the post processing required and details about various printing process and parameters to make a quality 3D printed component. This course can only be taken up after completing 3D Printing and Design (Basic) course offered in previous semester.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Select newer 3D Printing material for various applications.
CO-2 Use solid based 3D Printing processes to develop products.
CO-3 Use liquid-based 3D Printing processes to develop products.
CO-4 Use powder-based 3D Printing processes to develop products.
CO-5 Apply post processing techniques and quality checks on 3D printed components.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	-	2	-	2		
CO-2	3	-	2	2	-	-	2		
CO-3	3	-	2	2	-	-	2		
CO-4	3	-	2	2	-	-	2		
CO-5	3	2	-	3	2	-	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Legend: CI:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400604E	3D Printing and Design (Advanced)	03	-	04	02	09	06

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.

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604E	3D Printing and Design(Advanced)	30	70	20	30	20	30	200

Legend:

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

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

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Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain various forms of 3D printing raw material. *TSO 1b.* Select material for the given popular 3D printing processes with justification. *TSO 1c.* Select various Polymer based 3D printing raw materials with justification.	**Unit-1.0 3D Printing Materials** 1.1 Various forms of 3D printing raw material- Liquid, Solid, Wire, Powder. 1.2 Popular FDM, SLA, SLS, Binder Jetting, Material Jetting and Direct Energy deposition 3D printing materials.	**CO1**

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

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

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

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

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

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

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

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

b. Micro Projects:

1. Prepare a list of solid, liquid and powder form 3D printing raw materials stating their cost, colour opacity, flexibility and weight per unit volume.
2. Download 5 videos of 3D printing of different components using FDM, SLA and SLS each. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
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

(Microstructure testing). Watch them and write a report to detail out the steps involved and equipment used.

c. Other Activities:

1. Seminar Topics:
   - Newer 3D printing raw materials
   - Direct energy 3D printing process
   - Material jetting 3D printing process
   - Micro 3D printing process
   - Metal and Ceramic 3D printing
   - 3D printing of Jewelry
   - 3D printing of Bio implants
   - Printing of flexible plastic components

2. Visits: Visit nearby tool room/industry with 3D Printing facilities. Prepare report of visit with special comments of 3D printing technique used, material used, single component/batch production/mass production and cost of printed component.

3. Self-Learning Topics:
   - 3D printing of transparent, soft and flexible plastic components
   - 3D printing of metal components
   - 3D printing of ceramic components
   - 3D scanning process.
   - Chemical post processing techniques

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	15%	-	-	10%	20%
CO-2	20%	20%	20%	25%	25%	25%	20%
CO-3	20%	20%	20%	25%	25%	25%	20%
CO-4	20%	20%	20%	25%	25%	25%	20%
CO-5	25%	25%	25%	25%	25%	15%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

****:** Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 3D Printing Materials	6	CO1	10	3	2	5
Unit-2.0 Solid based 3D Printing Processes	10	CO1, CO2	14	4	5	5
Unit-3.0 Liquid based 3D Printing Processes	10	CO1, CO3	14	4	5	5
Unit-4.0 Powder based 3D Printing Processes	10	CO1, CO4	14	4	5	5
Unit-5.0 Post Processing and Quality	12	CO1, CO2, CO3, CO4, CO5	18	5	5	8
Total	**48**	**-**	**70**	**20**	**22**	**28**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	CO1, CO2	30	60	10
2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	CO1, CO3	30	60	10
3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	CO1, CO4	30	60	10
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	30	60	10
5.	Print one assembly on SLA/SLS based 3D Printer.	CO2/CO3/ CO4	30	60	10
6.	Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.	CO2, CO3, CO4	40	50	10
7.	Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.	CO5	40	50	10
8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	High end computers	Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10	All
2.	Parametric Computer Aided Design software	CATIA/Solid works/NX/Creo **OR** Available with CoE	1 to 5
3.	FDM based 3D printer	Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 **OR** Available with CoE	1,4,5,6
4.	SLA based 3D printer	Printing Technology: SLA, 145 x 145 x 175mm build volume, Common layer thickness 25–100 µm, Dimensional Accuracy ± 0.5% (lower limit: ±0.10 mm), cure time of only 1-3s per layer, Material type: UV-sensitive liquid resin, Curing unit.	2,4,5,6
5.	SLS based 3D printer	Printing Technology: SLS., Build Volume: 130 x 130 x 180 mm, Recommended min. wall thickness: 0.8 mm, Powder Diameter: 60 Microns, Material Type: Nylon, TPU, Light Source: Laser Diode	3,4,5,6
6.	3D Printing Material	ABS/PLA, Resin based Photosensitive material, Polymer/metal/ceramic powder **OR** Available with CoE	1,2,3,4,5,6
7.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE	1 to 6
8.	3D Scanner and Processing software	Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software **OR** Available with CoE	6
9.	Post processing equipments and tools	Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper, Chemicals, Etching agents etc.	7
10.	Inspection and Testing devices	• Visual inspection, Devices related to: • 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 strenght • Metallography (Microstructure testing)	8

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing	Lan Gibson, David W. Rosen, Brent Stucker	Springer, 2010 ISBN: 9781493921133
2.	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074
3.	3D Printing and Design	Sabrie Soloman	Khanna Publishing House, Delhi ISBN: 9789386173768
4.	3D Printing and Rapid Prototyping- Principles and Applications	C.K. Chua, Kah Fai Leong	World Scientific, 2017 ISBN: 9789813146754
5.	Getting Started with 3D Printing: A Hands-on Guide to the Hardware, Software, and Services Behind the New Manufacturing Revolution	Liza Wallach Kloski, Nick Kloski	Make Community, LLC; 2nd edition, 2021 ISBN: 9781680450200
6.	Laser-Induced Materials and Processes for Rapid Prototyping	L. Lu, J. Fuh, Y.S. Wong	Kulwer Academic Press, 2001 ISBN: 9781461514695
7.	3D Printing: A Practical Guide	Clay Martin	Larsen and Keller Education 2023 ISBN 9781641728323
8.	Fundamentals of 3D Printing	Elizah Brooks	Clanrye International 2023 ISBN 9781647290943
9.	Principles of 3D Printing	Brady Hunter	NY Research Press 2023 ISBN 9781632389549

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://archive.nptel.ac.in/courses/112/104/112104265/
3. https://bigrep.com/post-processing/
4. https://www.mdpi.com/2227-7080/9/3/61
5. https://all3dp.com/2/best-3d-printing-books/
6. https://www.youtube.com/watch?v=TQY2lF-sFaI
7. https://www.youtube.com/watch?v=Oz0PoS5LPxg
8. https://www.youtube.com/watch?v=6ejjh0GdyDc

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. https://www.improprecision.com/inspection-method-for-3d-printed-parts/
4. 3D Printer Users' Guide
5. 3D Printer Material Handbook
6. Lab Manuals

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A) Course Code : **2400604F(T2400604F/P2400604F/S2400604F)**

B) Course Title : Industrial Automation (Advanced)

C) Pre- requisite Course(s) : Industrial automation (Basic), Digital Electronics and Basic programming skills

D) Rationale :

This course on Advanced industrial automation offers students a hands-on approach to implement industrial control using modern controllers like Programmable Logic Controller (PLC), Distributed Control System (DCS)Supervisory Control and Data Acquisition (SCADA). Students will learn to identify and connect field inputs and outputs; communicate with, and program microprocessor-based controllers. Students will also connect, communicate with, and develop displays for computer-based operator interfaces. Process manufacturers typically employ Distributed Control System (DCS) Supervisory Control and Data Acquisition (SCADA) technologies to monitor and control the operations in their facilities. DCS and SCADA systems are now doing much more than simply monitoring and controlling. The course will enable the students to use of basic instructions and addressing, advanced PLC instructions in Ladder Logic and to identify and troubleshoot the faults in PLC system and do PLC maintenance. This course also introduces the students to industrial automation communications, PLC maintenance and troubleshooting also to become a successful automation engineer.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1. Apply the principles of communication for industrial automation.

CO-2. Test the output of the PLC ladder logic programs for the given application

CO-3. Maintain PLC systems

CO-4. Use SCADA for supervisory control and for acquiring data from the field.

CO-5. Develop simple automation systems

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Developmen tof Solutions	**PO-4** EngineeringTools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Managem ent	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	2	2	2	-	2		
CO-2	3	3	3	3	-	-	2		
CO-3	3	3	3	3	2	2	2		
CO-4	3	2	2	2	2	2	2		
CO-5	3	2	2	3	2	2	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400604F	Industrial Automation (Advanced)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604F	Industrial Automation (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: T2400604F

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

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

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

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

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

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

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

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

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

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

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

b. Micro Projects:

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

c. Other Activities:

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

a. Software Development- Download any open source software for PLC and install on your laptop/PC and carry out basic PLC programming
6. Also download any open source software for SCADA and install on your laptop/PC and carry out basic SCADA HMI programming
7. Surveys – Carry out a internet based survey to compare SCADA and DCS

d. Self-Learning Topics:

- Basic concepts of working of robot
- Automated material handling.
- Instrumentation systems for inspection and testing for quality of the product
- Use of robots in different applications
- Intelligent Transportation Systems
- Communication standards and protocols used in PLC
- Use of PLC for different industrial applications
- Use of SCADA for different industrial applications
- Interfacing of PLC

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	20%	20%	--	33%	10%	20%
CO-2	15%	25%	20%	--	33%	15%	20%
CO-3	15%	20%	20%	--	34%	15%	20%
CO-4	30%	20%	20%	50%	--	30%	20%
CO-5	30%	15%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
***:** Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.
****:** Mentioned under point- (N)
#: Mentioned under point- (O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-.1.0 Industrial automation Communication and Interfacing	9	CO1	14	5	4	5

Unit-.2.0 PLC Programming	12	CO2	17	5	6	6
Unit-.3.0 Installation and maintenance of PLC systems	10	CO3	14	4	5	5
Unit-.4.0 SCADA and DCS	9	CO4	14	4	5	5
Unit-.5.0 Applications of Industrial Automation	8	CO5	11	2	4	5
Total Marks	**48**		**70**	**20**	**24**	**26**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Transfer the control data from PLC to PC and vice versa	CO1	50	40	10
2.	Transfer the control data from PLC to PLC	CO1	50	40	10
3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1	50	40	10
4.	Interface the given PLC with a PC or a Laptop	CO1	50	40	10
5.	Identify Different parts and front panel indicators of a PLC	CO2	50	40	10
6.	Develop Ladder logic program for different arithmetic operations	CO2	50	40	10
7.	Develop Ladder logic program for different logical operations	CO2	50	40	10
8.	Program Latch and Unlatch circuit in a PLC for motor operation	CO2	50	40	10
9.	Create delay in operation using on delay, off delay and retentive timer function in a given PLC	CO2	50	40	10
10.	Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	CO2	50	40	10
11.	Program PLC using ladder logic to control a LED/Lamp	CO2	50	40	10
12.	Program PLC using ladder logic to control a simple traffic light system	CO2	50	40	10
13.	Use hygrometer to measure the humidity inside the panel	CO3	50	40	10
14.	Use thermometer to measure ambient temperature inside the panel	CO3	50	40	10
15.	Use tester to determine the voltage fluctuation at the power supply terminals is within specifications	CO3	50	40	10
16.	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	CO3	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
17.	Investigate the cause of Noise in the given PLC	CO3	50	40	10
18.	PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.	CO3	50	40	10
19.	Troubleshoot the corrupted PLC memory.	CO3	50	40	10
20.	Replace CPU and power supply fuses in a given PLC system	CO3	50	40	10
21.	Download any open source SCADA software and install the same.	CO4	50	40	10
22.	Interpret the available components in symbol factory in SCADA software	CO4	50	40	10
23.	Create simple SCADA HMI applications and apply dynamic properties **(Any Three).** 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.	CO4	50	40	10
24.	Create historical and real time trends for the given automation	CO4	50	40	10
25.	**Select any three of the following: -** 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. ii. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application iii. 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. iv. Develop a Automation system to Open and close the door in the shop v. Develop a line following robot with RFID sensor for supplying materials and automating workflow. vi. 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. vii. Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.	CO5	60	30	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	SCADA software (reputed make like Allen Bradley, Siemens etc.,)	Ready-to-use symbol library, React and respond in real-time, Real time monitoring, Friendly, manageable, secure, extensible, Easy-to-use, easy to implement, Easy configuration, simplified maintenance, Communication with PLC, easy and flexible alarm definition, data collection and analysis for new and existing systems, easy-to-use for report generation, open access to historical data, different packages available with input/output structure. Open source software SCADA software: like Ellipse/FTVSE/Wonderware/ open SCADA can also be used	14
2.	Universal PLC Training System with HMI (Of reputed make such as Allen bradely, Siemens, etc.,) Compatible with SCADA software	Human Machine Interface (HMI) display, PLC with 16 digital inputs, 16 digital outputs with RS232 communication facility. Open platform to explore wide PLC and HMI applications. Industrial look & feel. Toggle Switches, push to ON Switch, proximity sensor, visual indicator, audio indicator, and DC motor. Experiments configurable through patch board. Powerful instruction sets. Several sample ladder and HMI programs. PC based ladder and HMI programming. Extremely easy and student friendly software to develop different programs. Easy downloading of programs. Practice troubleshooting skills. Compact tabletop ergonomic design. Robust construction. PLC gateway for cloud connectivity. Open source software like Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools can also be used	1 to 12
3.	Safety gears	Gloves, Safety goggles, Ear protection, Dust masks and respirators.	13
4.	Power tools	Power drills, Orbital sanders, Circular saws, Impact wrenches.	13
5.	Hand tools	Screwdrivers, Hammers, Hand saws, Hex Key Allen Wrench Set Inch and Metric, relay puller, Multi-Tool Wire Stripper/Crimper/Cutter	13
6.	Electrical tools	Wire and cable strippers, Multimeters- Volts, Ohms, and Amps, Crimpers- Side Cutter Crimping, Wire Crimp Connector Kit, Digital Multimeter Clamp Meter with Amp, Volt, and Ohm, Non-Contact Voltage Tester	13
7.	Spare parts	PLC Programming Cables, SD Card Reader Compact flash, Wire Nut Set, Fuses- Class J 30, 35, 60, and 100-amp fuses, Class CC 2, 3, 5, 10 ,15, 20, and 30-amp fuses, 5mm x 20mm 0.032 (for 4-20mA circuits), 0.5, 1, 2, 5, 10, and 15 amps, Cube Relays, Resistor Kit, batteries, LED Indicators PLC Processor (CPU), Input/ output module	13
8.	Thermo-hygrometer	Measuring range Temp.: -30 ... 60°C / -22 ... 140°F Measuring range rel. Humidity: 0 ... 100% rh, Measurement protocol as PDF, Data export possible as CSV, Readable without software, data sets of measured values can be stored.	13
9.	Digital Hygrometer	maximum humidity measurement- 100%RH, temperature measurement resolution -0.1egree centigrade, humidity measurement resolution -0.1%RH, minimum operating	13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		temperature - -10 to -20-degree centigrade, Maximum operating temperature +45 to +50 degree centigrade	

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Programmable Logic Controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005, ISBN 13: 9781401884260
2.	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386
3.	Programmable Logic Controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003, ISBN: 9780130607188
4.	Industrial automation and Process control	Stenerson Jon	PHI Learning, New Delhi, 2003, ISBN: 9780130618900
5.	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN: 9788174092281
6.	Programmable Logic Controllers and Industrial Automation - An introduction,	Mitra, Madhuchandra; Sengupta, Samarjit,	Penram International Publication, 2015, ISBN: 9788187972174
7.	Control System	Nagrath & Gopal	New Age International Pvt Ltd, ISBN: 9789386070111, 9789386070111
8.	Linear Control Systems with MATLAB Applications, Publisher:	Manke, B. S.	Khanna Publishers, ISBN: 9788174093103, 9788174093103
9.	Supervisory Control and Data Acquisition	Boyar, S. A.	ISA Publication, USA, ISBN: 978-1936007097
10.	Practical SCADA for industry,	Bailey David; Wright Edwin	Newnes (an imprint of Elsevier), UK 2003, ISBN:0750658053
11.	Industrial Automation: Systems and Engineering	Geoffrey Williamson	States Academic Press , 2022 ISBN 9781649649270
12.	Industrial Automation Technologies	Jane Taylor	States Academic Press 2023 ISBN 9781649649255
13.	Introduction to Industrial Automation	Kian Pearson	Willford Press 2023, ISBN 9781682860864

(b) Online Educational Resources:

1. Software: - www.fossee.com
2. Software: - www.logixpro.com
3. Software: - www.plctutor.com
4. Software; - www.ellipse.com
5. PLC lecture: - https://www.youtube.com/watch?v=pPiXEfBO2qo
6. PLC tutorial: http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API_I_C3_3_ST.pdf
7. https://www.youtube.com/watch?v=277wwYWolpw-PLC system troubleshooting and repair. Industrial control panel. PLC system repair.
8. https://www.youtube.com/watch?v=5Jmtvrch5Jg
9. https://www.youtube.com/watch?v=peyV9bwEaLY
10. https://www.youtube.com/watch?v=QdJhRmtKpxk&list=RDCMUCke36Liq-w5fboMHkq1APZw&index=3
11. https://www.youtube.com/watch?v=ygrrRwaJz3M

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

*****

A) Course Code : 2400604G(T2400604G/P2400604G/S2400604G)

B) Course Title : Electric Vehicle (Advanced)

C) Prerequisite Course(s) : Electric Vehicle (Basics)

D) Rationale :

The automobile manufacturing sector in India is rapidly switching over to electric vehicles used for the public as well as private transport. The Govt. of India has launched the FAME-II Scheme (Faster Adoption and Manufacturing of Hybrid & Plug-in Electric Vehicles) to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles and to create demand for Electric Vehicles in the country. The technology is being evolved to enhance the vehicle's efficiency and running mileage by controlling the manufacturing, maintenance and recurring costs of such vehicles. Due to the rapid increase in EV demand, industries will also require skilled manpower in this area. This advanced course on electric vehicles is included as an open elective for all the diploma programmes to provide a sound knowledge of EVs to engineering diploma students and develop skills related to testing and maintenance of various electrical, electronic and mechanical systems in EVs.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the learners' accomplishment of the following course outcomes. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the student will be able to-

CO-1 Compute various parameters affecting Vehicle movement.

CO-2 Test the operation of the different elements of the Automobile System.

CO-3 Test the battery and motor used for Power Transmission in EVs.

CO-4 Test electronic control unit system of EVs.

CO-5 Interpret the impact of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) during the charging cycle.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	1	2	-	-	1		
CO-2	3	2	2	3	1	-	-		
CO-3	2	2	2	3	3	1	3		
CO-4	2	3	-	2	2	-	2		
CO-5	3	2	-	2	3	1	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400604G	Electric Vehicle (Advanced)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604G	Electric Vehicle (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 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 • 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. 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.	Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. **3.5** Battery Assembly and Dismantling. **3.6** Gear and Differential Assembly **3.7** Safe disposal of used battery	
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.	**Unit- 4.0 Vehicle Control Unit (VCU)** 4.1 **Electronic Control Unit**: Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	**CO4**
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.	**Unit- 5.0 EV Charging Technologies** 5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	**CO5**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	• Testing of Control Disc Braking system and Control Regenerative Braking system.	CO2
LSO 2.3 Test the performance of different types of propulsion motors.	2.	• Testing of Motors	
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	• Testing of the automotive wiring system.	
LSO 3.1 Test the performance of a new set of batteries and aged batteries.	4.	• 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. LSO 3.6 Test the following speed-controlled performance characteristics of the given motor; a. Motor voltage over time b. Motor current over time. c. Speed and torque over time. d. Torque over speed. e. Current over speed. f. Electrical input power and the mechanical input power over speed	5.	• Speed control of Electrical Motors	
LSO 4.1 Connect the components of the EC Units with EV subsystems. LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.	6.	• Connection of Electronic Control Unit components • Troubleshooting of electronic control unit	CO4
LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	• Impacts of G2V and V2G	CO 5
LSO 5.2 Prepare a layout of a charging station	8.	• Demonstration of Charging stations	

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

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

b. Micro Projects:

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

c. Other Activities:

1. **Seminar Topics**:
   - Safe disposal process of Used Batteries.
   - Charging Technologies used for charging the EV.
   - EV power transmission systems.
2. **Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.
3. **Self-Learning Topics:**
   - Impact of fleet charging of EVs on Power Systems.
   - Energy Management in EV.
   - Fuel Cell powered bus.
   - EV Battery disposal and recycling.
   - Mobility and connectors.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use the appropriate assessment strategy and its weightage, in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment.**

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	20%	--	--	--	--
CO-2	20%	20%	20%	--	--	35%	25%
CO-3	20%	30%	20%	70%	40%	40%	25%
CO-4	20%	25%	20%	30%	20%	10%	25%
CO-5	20%	10%	20%	--	40%	15%	25%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point- (O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of the cognitive domain of the full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Vehicle Dynamics	8	CO1	12	4	5	3
Unit-2.0 Elements of Automobile.	10	CO2	15	5	6	4

Unit-3.0 EV Power Transmission System.	14	CO3	20	4	10	6
Unit-4.0 Vehicle Control Unit (VCU)	10	CO4	15	4	6	5
Unit-5.0 Charging Technologies	6	CO5	8	3	3	2
Total Marks	**48**		**70**	**20**	**30**	**20**

Note: Similar table can also be used to design class/mid-term/ internal question papers for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. N.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Testing of Control Disc Braking system and Control Regenerative Braking system.	CO2	60	30	10
2	Testing of Motors.				
3.	Testing of automotive wiring system.				
4.	Testing of Batteries used in EVs	CO2, CO3	60	30	10
5.	Speed control of Electrical Motors		60	30	10
6.	Connection of Electronic Control Unit components	CO4	60	30	10
7.	Troubleshooting of electronic control unit				
8.	Impacts of G2V and V2G	CO 5	30	60	10
9.	Demonstration of Charging stations		70	20	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both the end semester as well as progressive assessment of practicals. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student's performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Disc Braking and Regenerative braking system test rig	Test rig equipment for Demonstration of Disc Braking and Regenerative Braking system operation.	1
2.	Disc Braking System	Test rig / Software for testing the performance of the disc braking system in Half step and Full step braking mode.	1
3.	Induction motor	Induction motor For EV applications with testing kit	2,5
4.	Switched reluctance motor	Switched reluctance motor for EV applications with testing kit	2,5
5.	Permanent magnet (PM) DC motors	Permanent magnet (PM) DC motors for EV applications with testing kit	2,5
6.	Automotive wiring system	Testing facility of automotive wiring system using software /actual EV systems	3
7.	Lithium Ion and Lead-acid Batteries	12V, 7Ah with testing setup.	4
8.	Nickel-based batteries (metal hydride and cadmium battery).	12V, 7Ah with testing setup.	4
9.	Battery tester	For testing battery parameters	4
10.	Battery charger	Battery charger for EV	4
11.	Battery Management System	Training kit or simulation for BMS	4
12.	DC-DC Converter	48V to 12V bidirectional DC-DC Converter	4
13.	Power Analyser	To observe the impacts of G2V and V2G	5
14.	BMS setup	For Demonstration & training	4
15.	DC power supply	0-32V	5
16.	Charging Station Simulator	For Demonstration & training purposes.	5
17.	EC Unit with EV subsystems	Electronic Control Unit Hardware parts/ software for demonstrating the Connection of Electronic Control Unit components with EV subsystems.	6,7
18.	Facility to demonstrate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	-	7

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electric Vehicles: And the End of the ICE age	Anupam Singh	Kindle Edition ASIN: B07R3WFR28
2.	Wireless Power Transfer Technologies for Electric Vehicles (Key Technologies on New Energy Vehicles)	Xi Zhang, Chong Zhu, Haitao Song	Springer Verlag, Singapore; 1st ed. 2022 edition (23 January 2022) ISBN-13: 978-9811683473
3.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles	EHSANI	CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465
4.	Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles	John G. Hayes, G. Abas Goodarzi	Wiley; 1st edition (26 January 2018) ISBN-13: 978-1119063643
5.	New Perspectives on Electric Vehicles	Marian Găiceanu (Editor)	IntechOpen (30 March 2022) ISBN-13: 978-1839696145
6.	Electric and Hybrid Vehicles,	Tom Denton, Taylor & Francis	2nd Edition (2020) ISBN- 9780429296109
7.	Hybrid Electric Vehicles: Energy Management Strategies	S. Onori, L. Serrao and G. Rizzoni	Springer (2016) ISBN: 978-1-4471-6781-5
8.	Electric & Hybrid Vehicles	A.K. Babu	Khanna Publishing House, New Delhi, 1st Edition (2018) ISBN: 9789386173713, 9386173719
9.	Power Electronics: Circuits, Devices and Applications,	Rashid, M. H.	Pearson, 3rd edition, (2013) ASIN: B07HB3BM1W
10.	Electric Vehicle Engineering	Liana Walker	lanrye International2023, ISBN-978164729097
11.	Electric Vehicles: Current Progress & Technologies	Vanessa Jones	Murphy & Moore Publishing 2023, ISBN 9781649872746
12.	Electric and Hybrid Vehicles: Principles, Design and Technology	Mary Murphy	Larsen and Keller Education 2023 ISBN 9781641728520

(b) Online Educational Resources:

1. https://www.energy.gov/eere/fuelcells/fuel-cell-systems
2. https://powermin.gov.in/en/content/electric-vehicle
3. https://www.iea.org/reports/electric-vehicles
4. https://www.oercommons.org/search?f.search=Electric+Vehicles
5. https://fame2.heavyindustries.gov.in/Index.aspx

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Learning Packages on EV
2. EV Users' Guide
3. EV Manufacturers' Manual
4. EV Lab Manuals

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A) Course Code : **2400604H(T2400604H/P2400604H/S2400604H)**

B) Course Title : Robotics (Advanced)

C) Pre- requisite Course(s) : Robotics (Basic)

D) Rationale :

Efficiency and quality are the demands of industry 4.0. Robotics is a constituent of Industry 4.0 which not only provides the former two but also is beneficial for hazardous and similar challenging situations. The use of robotic technology is developing at a very fast rate in all types of industries whether manufacturing, service or tertiary. Engineers should be competent to use the robotic technology for industry and society advantage. This course aims for the diploma engineers to have advanced skills in robotic applications and use in digital manufacturing.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Plan the use of robots in engineering applications.
CO-2 Elucidate the conceptual place of the robotic components for engineering processes.
CO-3 Use robots for small automatic robotic applications.
CO-4 Compute the economics associated with use of robots in industries.
CO-5 Select appropriate robot for industrial requirements and other applications.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	-	-	3	-	2	-	2		
CO-2	-	2	3	2	-	-	-		
CO-3	3	2	3	-	-	-	2		
CO-4	3	-	-	2	-	-	-		
CO-5	3	2	-	-	2	-	-		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400604H	Robotics (Advanced)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
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: • 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 uutilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	**Unit–5.0 Applications in Non-manufacturing Environments** 5.1 Applications of Robots in • Healthcare and medicine • Construction industry • Underground coal mines • Utilities, military & firefighting operations • Undersea • Space • Logistics, • Retail and Hospitality • Smart Cities • Farming and Agriculture 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	**CO5**

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

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

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

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate CO attainment.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self- Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	23%	20%	10%	25%	10%	20%
CO-2	20 %	23%	20%	10%	25%	20%	20%
CO-3	15%	17%	20%	25%	25%	20%	20%
CO-4	20%	20%	20%	15%	25%	20%	20%
CO-5	20%	17%	20%	40%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

****:** Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Number and Title	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications	12	CO2, CO3	16	6	5	5
Unit– 2.0 Robot Drives, Control and Material Handling	10	CO2, CO3	16	4	8	4
Unit– 3.0 Robot Cell Design and Application	8	CO3	12	2	4	6
Unit– 4.0 Robot Programming and Economics of Robotization	10	CO1, CO4, CO5	14	4	4	6
Unit– 5.0 Applications in Non-manufacturing Environments	8	CO5	12	4	4	4
Total Marks	**48**		**70**	**20**	**25**	**25**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3	40	50	10
2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2	40	50	10
3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3	40	50	10
4.	Design a computer-controlled pick and place robot (wireless)	CO1, CO4	40	50	10
5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3	40	50	10
6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO3, CO4	40	50	10
7.	Design an unmanned arial photography system.	CO3, CO5	40	50	10
8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5	40	50	10
9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5	40	50	10
10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5	40	50	10
11.	Develop Obstacle avoidance robot Programming	CO1, CO5	40	50	10
12.	Program and simulate welding operation using robot simulation software.	CO1, CO5	40	50	10
13.	TPP / Offline program for drilling operation.	CO1, CO5	40	50	10
14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5	40	50	10
15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2, CO3	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number

1.	6 Axis Articulated Robot (Material Handling)- 1 No	• Articulated Type
		• Controlled axis: 6-axes (J1, J2, J3, J4, J5, J6)
		• Reach: 717 mm
		• Installation Floor, Upside-down (Angle mount)
		• Motion range (Maximum Speed)
		  • J1 Axis Rotation7.85 rad/s
		  • J2 Axis Rotation 6.63 rad/s
		  • J3 Axis Rotation 9.08 rad/s
		  • J4 Axis Rotation 9.60 rad/s
		  • J5 Axis Rotation 9.51 rad/s
		  • J6 Axis Rotation 17.45ras/s
		• Max. load capacity Wrist: 4Kg
		• Allowable Load moment 16.6 N-m at wrist J4 Axis, J5 Axis, J6 Axis
		• Allowable Load inertia).47 kg-m^2 at wrist J4 Axis J5 Axis, J6 Axis
		• Repeatability: +/- 0.05mm
		• Mass: 21 Kg Minimum
		• Installation environment: Ambient temperature: 0 – 45°C
		• Ambient humidity: Normally 75%RH or less. No dew, nor frost allowed.
		• Vibration Acceleration: 4.9 m/s2 (0.5G or less)
			1, 2, 3, 12

2.	6 Axis Articulated Robot (General Purpose-Welding, Assembly, Drilling) - 1 No	Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic Weight of robot: 50 Kg. Accuracy: ±0.3 Repeatability: ±0.2Tip Velocity range: 500 mm / minPay load capacity: 2 kg (including griper) J1 - Waist: ± 140°J2 - Shoulder: - 100 - 60°J3 - Elbow: - 70 + 10°J4 - Wrist rotate: ± 70°J5 - Wrist pitch: ± 35°J6 - Wrist roll: ± 180°External I/O8 Programmable digital inputs8 Programmable digital outputs	8, 9, 14
3.	A mounted vision system with software (Free open source Robot simulation software)	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from −40°C to 125°C (Analog Devices ADT7302)	3, 4, 5, 11
4.	6-axis Robotics Trainer	Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM	3, 4, 5, 13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		processors; Record and Play capability; Optional interfacing with PLC; Touch operated ON/OFF Switch; Auto set to home position; Applications can be developed; Data acquisition using USB	
5.	E-Yantra Firebird kit	• Fire Bird V 2560 Robot • Spark V Robot • Fire Bird V P89V51RD2 adapter card • Fire Bird V LPC2148 adapter card • LSM303 3 axis digital accelerometer and 3 axes magnetometers • L3G4200 3 axis digital gyroscope • Gyroscope, accelerometer and GPS interfacing module for the robot • GPS receiver • Zigbee Modules 100m range • Zigbee Modules Adapter • Metal-gear Servo Motors • Servo Motor Based Gripper kit for the Fire Bird V robot • Sharp infrared range sensor (10cm to 500cm) • Arduino Uno/Nano • Hexapod • 16 Programming Software (AVR studio, Keil, AVR Boot loader, Flash Magic)	1, 3, 5, 6, 7, 10
6.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	2, 8, 10
7.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc.	4
8.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4, 10
9.	Raspberry Pi kit	1.2GHz quad-core Broadcom BCM2837 CPU with 1GB DDR2 RAM with in-built Wi-Fi & Bluetooth Video Core IV 3D graphics core 40 pin extended pins - with 27 GPIO pins Micro SD slot Multiple ports: Four USB ports, full sized HDMI, four pole stereo output and composite video port, CSI camera port and DSI display port 10/100 BaseT Ethernet Micro-USB, power source 5V, 2A	7, 9

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Robotics Mechanics and Control	John Craig	Pearson Education 978-9356062191
2.	Robotics and controls	Mittal R.K., Nagrath I.J.	Tata McGraw Hill Education Pvt. Ltd.; 2017; **978**-0070482937
3.	Robotics and Image Processing: An Introduction	Janaki Raman. P. A	Tata McGraw Hill Publishing company Ltd., 1998; 978-0074621677

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
4.	Industrial Robotics -Technology, Programming and Applications	Nicholas Odrey, Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta	McGraw Hill Education; 2nd Edition; 978 -1259006210
5.	Robotic Engineering: an integrated approach	Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin	Prentice Hall of India, N. Delhi, 2009; 978-8120308428
6.	Industrial Robotics Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey	McGraw-Hill Education, Second Edition, 978-1259006210
7.	Robotics	Appuu Kuttan K. K.	Dreamtech Press, First Edition, 2020, 978-9389583281
8.	Introduction to Robotics: Analysis, Control, Applications	Saeed B. Niku	Wiley; Second Edition, 978-8126533121
9.	Essentials of Robotics Process Automation	S. Mukherjee	Khanna Publication, First Edition, 978-9386173751
10.	Robotics	R R Ghorpade, M M Bhoomkar	Nirali Prakashan 978-9388897020
11.	Mechatronics: Engineering Fundamentals	Allie Weaver	Murphy & Moore Publishing 2022 ISBN 9781649872758
12.	Elements of Robotics	Greg Scott	States Academic Press 2022 ISBN 9781649649261
13.	Robotics: Design, Construction and Applications	Allie Weaver	Willford Press 2022 ISBN 9781682860944
14.	Modern Robotics: Mechanics, Systems and Control	Julian Evans	Larsen and Keller Education 2022 ISBN 9781641728515
15.	Introduction to Mechatronics	Randy Dodd	Larsen and Keller Education 2022 ISBN 9781641728493
16.	Introduction to Robotics	Julian Evans	Larsen and Keller Education 2022 ISBN 9781641728503

(b) Online Educational Resources:

1. https://web.iitd.ac.in/~saha/ethiopia/appln.pdf
2. https://nptel.ac.in/courses/112105249
3. https://www.robotsscience.com/industrial/industrial-robots-types-applications-benefits-and-future/
4. https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL_APPLNS-converted.pdf
5. https://forcedesign.biz/blog/5-common-industrial-robot-applications
6. https://www.hitechnectar.com/blogs/top-industrial-robotics-applications-role-of-robots-in-manufacturing/ http://www.robotics.org/
7. https://en.wikipedia.org/wiki/Industrial_robot
8. https://www.youtube.com/watch?v=fH4VwTgfyrQ
9. https://www.youtube.com/watch?v=aW_BM_S0z4k
10. https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud
11. https://robots.ieee.org/robots/?t=all
12. https://www.youtube.com/watch?v=fc_Cynqr6jM

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

1. Learning Packages:

- https://www.edx.org/learn/robotics
- https://www.coursera.org/courses?query=robotics
- https://www.udemy.com/topic/robotics/
- https://library.e.abb.com/public/9a0dacfdec8aa03dc12578ca003bfd2a/Learn%20with%20ABB.%20Robotic%20package%20for%20education.pdf

2. Users' Guide:

- https://roboindia.com/store/DIY-do-it-your-self-educational-kits-robotics-embedded-system-electronics
- https://www.robomart.com/diy-robotic-kits
- https://www.scientechworld.com/robotics

3. Lab Manuals:

- http://www-cvr.ai.uiuc.edu/Teaching/ece470/docs/ROS_LabManual.pdf
- https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf

******

A) Course Code : 2415605(P2415605/S2415605)

B) Course Title : Major Project

C) Pre- requisite Course(s) :

D) Rationale :

Project work plays a very important role in engineering education in developing core technical skills, soft skills and higher level of cognitive, psychomotor and affective domain skills. Major Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in new situation or task to solve the problems of the industries/field agencies/etc.

Through major project work, students get direct exposure to the world of work in their relevant field. They are intrinsically motivated to explore new things, new methods, new design, many more ideas and also develop out of the box thinking abilities, creative and innovative capabilities. It also develops many soft skills like confidence, communication skills, creative ability, inquisitiveness, learning to learn skills, lifelong learning skills, problem solving skills, management skills, positive attitude, ethics etc.

Normally in a curriculum document, there is a mention of project work indifferent context. In situation one, project work is reflected as micro project under each and every course curricular detailing, in the form of Termwork mentioned under different semesters. These projects are normally related to the developing skills in respective course of the specific programme.

In the context of diploma programme in Bihar, minor project work will be carried out in Semester 5 with emphasis on project planning.

Major project work is reflected as a course in the total programme structure, normally at 6^{th}semester depending on the requirement of the programme. Through major project, students try to bring the industrial/real world problems in institutional setting, may be in collaboration/ networking with industries/field agencies/enterprises as per the requirement of different diploma programmes.

E) Course Outcomes: After completion of the major project work, students will be able to -

CO-1 Integrate the knowledge (K), skills (S), attitudes (A)developed, in a new task or problem identified in the form of project work.

CO-2 Develop higher level of cognitive, psychomotor and affective domain skills relevant to the course/programme.

CO-3 Solve the industrial/real world problems/tasks by Integrating the generic skills/soft skills/employable skills with relevanttechnical skills.

CO-4 Develop thecapabilities and skills of innovativeness, creativity, resourcefulness, time management, problem solving abilities, interpersonal skills, pro-activeness, cost effectiveness, environment consideration and sustainability.

CO-5 Prepare the project report.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Developmen tof Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	3	-	-	-	1		
CO-2	3	-	3	-	-	-	1		
CO-3	3	-	3	3	-	-	1		
CO-4	3	2	3	-	2	2	1		
CO-5	3	-	3	-	-	2	-		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2415605	Major Project	-	-	08	04	12	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415605	Major Project	-	-	20	30	50	100	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) Suggested Implementation of Major Project:

Under the minor project in fifth semester, project planning is almost over. The projects are identified and allocated to students. Teacher's role is important as they act as guide, facilitator, catalyser, motivator to promote brain storming, thinking, creativity, initiativeness and many other skills in the students. Teachers should help or guide continually to monitor whether the students are proceeding in the right direction as per outcomes to be attained.

It is also suggested that teachers are not supposed to guide and plan each and every step from the point of view of execution of the project, otherwise it will curb the creativity or thinking process of the students. Teachers have to see that he or she is able to create think tank for this fast-technological world of work for the growth of our country. Following points should be taken into consideration while implementing the major project work.

The following steps are undertaken under the major project-

1. Design, Development and Execution of the Major Project.
2. Quality of Project Report Writing and its Presentation.

1.0 Design, Development and Execution of Major Project:

Projects design, development, execution is done by the students under the guidance and feedback by respective teachers for attainment of courses specific outcomes, POs and PSOs.

Continual Monitoring, feedback and assessment mechanism on weekly progress/updates on action taken on different criteria and sub-criteria of the project work need to be planned for individual and team of students. Path breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

1.1 Unique Features of Major Project:

Following important characteristic features of project need to be given special emphasis during the implementation and evaluation of the major project work-

- Innovativeness
- Creativity
- Originality
- Pro-activeness
- Initiativeness
- Cost Effectiveness
- Resourcefulness
- Development of Soft Skills/Generic Skills
- Ethical Issues
- Environmental Considerations
- Simulated/Automated Industry's/Improvised Process
- Application or Utility in the World of Work.
- Relevance to the Curriculum

- Mapping of Outcomes of Project with Pos and PSOs (if applicable)
- Feasibility of Implementation of the Project

2.0 Quality of Project Report Writing and its Presentation:

Following points need to be taken care of during report writing, its implementation and evaluation-

- Report writing as per prescribed format
- Clarity of outcomes
- Innovativeness
- Presentation of Data
- Data Analysis, Interpretation and Result
- Quality of Product/Prototype

2.1 Project Report Writing:

The suggested format of the project report is mentioned below for teacher's and students' reference:

i. Problem Statement/ Project Title
ii. Abstract
iii. Literature Review
iv. Outcomes of the Project
v. Project Planning, Design and Development
vi. Methodology
vii. Implementation and Testing
viii. Result and its Interpretation
ix. Summary
x. References / Bibliography

2.2 Presentation & Discussion:

Quality of presentation of data need to be ensured using the following criteria -

- Clarity in Communication and Presentation
- Voice Audibility
- Use of Media and Methods
- Satisfying the Queries of Audience
- Attainment of Outcomes

2.3 Project's Potential:

Futuristic scope and recommendation for further studies related to project may be assessed from the following criteria -

- Papers Published or Award Received
- Exhibition or Display or Showcase of Project in Competition or Exhibition or Tech Fest
- Evaluation of Working/Testing of Projects or Prototype
- Relevance and Applications in the World of Work
- Recognition in any Form
- Related Areas/Sub Areas for Further Studies

J) Assessment of the Major Project:

For objective, valid and reliable assessment, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared. Even the students may been courage to adopt self-assessment techniques using the assessment rubrics.

The students need to be assessed continuously based on the suggested below mentioned assessment criteria at project planning stage. The project guide must prepare detailed rubric(s) for each criteria to have more valid and reliable assessment. Criteria of assessment of major project work are mentioned below.

Assessment Scheme for Major Project

S. No.	Suggested Assessment Criteria	Suggested Weightage (%)
1.	**Project Planning during Minor Project Work** 1.1 Identification of Area/Problem Statement 1.2 Literature Survey 1.3 Formulation of Project Title 1.4 Clarity in Formulation of Outcomes of The Project 1.5 Preparation of Synopsis 1.6 Presentation of Synopsis	30
2.	**Design, Development and Execution of the Project**. 2.1 Unique Features of Major Project	45
3.	**Quality of Report Writing and Presentation**. 3.1 Report Writing 3.2 Presentation & Discussion 3.3 Project's Potential	25
	TOTAL	100

******

A) Course Code : 2400606(T2400606)

B) Course Title : Employability Skills Development (Common for all Programmes)

C) Pre- requisite Course(s) :

D) Rationale :

Education may only be enough to qualify for a job, but employability skills are the major criteria to be considered for a job role. Employability skills are building blocks of any career and they equip one to carry out roles in the company to the best of their ability. Employers usually check these employability skills before hiring. These sets of job-readiness skills are behaviors that are necessary for every job and are essential attitudes that enable students to grow in their careers. Employers value employability skills because they regard these as indications of how their employees will get along with other team members and customers, and how efficiently they will be able to handle the job performance and career success. Employers like to hire a technical expert who also displays well-rounded employability skills.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Build resume and showcase portfolio for placement activity.
CO-2 Face interviews and participate effectively in Group Discussions.
CO-3 Apply engineering tools in work situations and societal processes.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Developmentof Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	3	-	-	2		
CO-2	3	-	-	-	2	2	3		
CO-3	3	-	-	3	3	2	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400606	Employability Skills Development	01	-	-	-	01	01

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)	
2400606	Employability Skills Development	25	--	--	--	--	--	25

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: T2400606

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

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

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

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

a. Assignments:

1 Build a resume for Placement Activity.

2 Prepare letters for job applications.

b. Micro Projects:

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

c. Other Activities:

1. Seminar Topics:
   - Emotional Intelligence.
   - 21st Century Skills.
   - Multitasking

2. Visits: Visit nearby Job Fairs, Career Guidance Fairs, etc.

3. Self-Learning Topics:

   - Use of social media.
   - Self-introduction.
   - Self-grooming.
   - QC Tools.
   - Lean Manufacturing,
   - Emotional Intelligence.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	30%	-	-	-	-	-	-
CO-2	40%	-	-	-	-	-	-
CO-3	30%	-	-	-	-	-	-
Total Marks	**25**	**-**	-	-	-	**-**	**-**
			-				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested Assessment Table for Laboratory (Practical): (Not Applicable)

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications
1.	Group Discussion Tables and chairs	Round Table with seating arrangement for 15 person
2..	Mock Interviews infrastructure	2 parallel mock interview set up with recording facility.
3.	Ear phones	Compatible with mobile phones
4	Headphones	Compatible with laptop/desk top
5	Blue tooth	Compatible with mobile phones.
7.	CC TV Camera	Compatible to record presentations and addresses.
8.	Podium	For presentations on stage.
9.	Public address system	For public meetings.
10.	Full Glass Mirrors	For monitoring Body Language

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Employability Skills Skills for Employability	Dr. M. Sen Gupta	Innovation Publication Pvt Ltd, 2020, ISBN: 978-81-933819-1-5
2.	Employability Skills	Dr. Nishith Rajaram Dubey, Anupam Singh	Indra Publishing House, 2023 ISBN - 978-93-93577-68-9
3.	Organizational Behavior	A. K. Chitale, Rajendra Prasad Mohanty and Dr Nishith Dubey	PHI Learning Pvt Ltd ISBN 978-81-203-4696-3
4.	Managerial Skills	Dr Nishith Dubey & Prof Gitanjali Shrivastava	Shiva Prakashan, Indore, India,2010, ISBN 81-7677-100-7,
5.	Body Language	Allan Pease	Pease International PTY. Ltd Australia
6.	Production and Operations Management Goods & Services approach	Dr S.V Deshmukh, Dr A. K. Chitale and Dr Nishith Dubey	Archers & Elevators publishing house, Bangalore, ISBN 9789386501197
7.	Emotional Intelligence	Daniel Goleman	Word Press.Com, 9789382563792
8.	How to win friends and influence people	Dale Carnegie	Srishti Publishers & Distributors, Delhi, India

(b) Online Educational Resources:

1. **4-Year Plan for Career Success:** https://eng.umd.edu/sites/clark.umd.edu/files/4%20Year%20Plan%20For%20Career%20Success_Categorized_1.pdf
2. **AREER DEVELOPMENT GUIDE** https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/career_development_guide_may_2014.pdf
3. **Tips for successful career planning** tips://www.aryacollege.in/tips-for-successful-career-planning-in-2021/
4. **Career Planning –** Complete Guidehttps://www.mygreatlearning.com/blog/what-is-career-planning/
5. **Build Resume:** https://www.themuse.com/advice/how-to-make-a-resume-examples
6. **Build Resume** https://resumegenius.com/blog/resume-help/how-to-write-a-resume
7. **Body Language**: https://ubiquity.acm.org/article.cfm?id=3447263
8. **Group Discussions:** https://brightspeaking.com/en/how-to-effectively-participate-in-a-group-discussion/
9. **Carrier planning & goal setting**: https://www.hays.com.au/career-advice/career-development/setting-career-goals
10. **Carrier planning & goal setting:** https://www.thebalancemoney.com/step-by-step-guide-to-setting-career-goals-2059883
11. **Collaboration & teamwork:** https://www.indeed.com/career-advice/career-development/teamwork-and-collaboration
12. **Interview skills:** https://www.youtube.com/watch?v=lKCTS9dY4h4

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others: -

******

A) Course Code : **2400009(T2400009)**

B) Course Title : Open Educational Resources (OER)
(FTS, CHE, CSE, EE, ME, ME (Auto), MIE, ELX, AIML, CRE, CACDDM, FPP, GT)

C) Pre- requisite Course(s) :

D) Rationale :

Open educational resources (OER) are openly-licensed, freely available educational materials that can be modified and redistributed by users. Learning about Open Educational Resources (OER), copyright, and Creative Commons licenses is a valuable endeavor for content creators, users, and anyone interested in sharing knowledge and creative works. Creative Commons licenses, offer a standardized way to grant permissions for the use and sharing of creative works. Learning about OER, copyright, and Creative Commons licenses is an ongoing process. As these fields evolve, it's important to stay informed and continue exploring new resources and practices.

After going through this course, students will at first place have reasonable idea to explore and use various OERs useful for their course of study and secondly, be motivated for fair use of resources available to them on various platform by understanding the restrictions and legal issues related to copyright and other licensing policies.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Use Open Educational Resources (OER) after their evaluation
CO-2 Use copyright material appropriately.
CO-3 Implement suitable Creative Common License.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Developmentof Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	-	2	-	-	3	-	3		
CO-2	-	2	-	-	3	-	3		
CO-3	-	3	-	-	3	-	3		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)				
		Classroom Instruction (CI)		Notional Hours (TW/ Activities+ SL)	Total Hours (CI+TW/ Activities)	Total Credits (C)
		L	T			
2400009	Open Educational Resources	01	-	-	01	01

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) 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)	
2400009	Open Educational Resources	25	-	-	-	-	-	25

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: T2400009

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3g. Modify a work licensed under Creative Commons. *TSO 3h.* Revoke a Creative Commons license, combine works with different Creative Commons licenses *TSO 3i.* Differentiate between Attribution and Citation	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	

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.

5. Select minimum 5 real-world examples from different domains (such as music, art, literature, or education) where creators have used Creative Commons licenses.

c. Other Activities:

1. Seminar Topics:
   - OER Quality Assurance
   - OER Repositories and Platforms
   - Creative Commons and Digital Media
   - Creative Commons in the Visual Arts
   - Examine the legal implications of using Creative Commons licenses, including the obligations and responsibilities of both creators and users and present it.

2. Self-Learning Topics:
   - Open Licensing and Copyright: Understanding the Legal Framework for OER
   - Creative Commons and the future of Copyright
   - Copyright and Open Access Publishing
   - Copyright and Software

K) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

L) List of Major Laboratory Equipment, Tools and Software: (If Any)

S. No.	Name of Equipment, Tools and Software	Broad Specifications
1.	Computers	Desktop computer with word processing and presentation facility
2.	Internet	Internet Connectivity

M) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	The OER Starter Kit.	Abbey Elder - 2019	IA: Iowa State University Digital Press, available under a Creative Commons Attribution 4.0 International License. Retrieved from iastate.pressbooks.pub/oerstarterkit
2.	A Brief History of Open Educational Resources	Bliss, T J and Smith, M. - 2017	In: Jhangiani, R S and Biswas-Diener, R. (Eds.) Open: The Philosophy and Practices that are Revolutionizing Education and Science (pp. 9–27). London: Ubiquity Press. DOI: https://doi.org/10.5334/bbc.b.

Note: Above listed books are available in soft form and can be downloaded as given respective link

(b) Online Educational Resources:

1. OER for Empowering Teachers Instructional Material by P. Malliga is licensed under a Creative Commons Attribution 4.0 International License.
2. William & Flore Hewlett Foundation. (n.d.). OER defined. Retrieved from https://hewlett.org/strategy/open-educational-resources/
3. Free Software Foundation. (2008). GNU Free Documentation License. Retrieved from https://www.gnu.org/licenses/fdl.html
4. Copyleft Attitude. (2007). Free Art License 1.3. Retrieved from http://artlibre.org/licence/lal/en/
5. Free Software Foundation. (n.d.). What is copyleft? Retrieved from https://www.gnu.org/copyleft/copyleft.html

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

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