Curriculum of Diploma Programme

in

Construction Technology and Management

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

State Board of Technical Education
(SBTE), Bihar

Semester – V
Teaching & Learning Scheme

Course Codes	Category of Course	CourseTitles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2415501	**PCC**	**Hydraulics**	03	-	04	02	09	06
2415502	**PCC**	**RCC Structure**	03	-	04	02	09	06
2415503	**PCC**	**Estimating, Costing & Contracts**	02	01	-	02	05	04
2400504	**OEC**	**Open Electives*/ COE** (Basic - Any One)	03	-	04	02	09	06
2400505	**NRC**	**Entrepreneurship Development & Start-ups** (Common for All Programmes)	-	-	04	02	06	03
2415506	**PSI**	**Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes)	-	-	02	04	06	03
2415507	**PSI**	**Minor Project** (Common for all programmes)	-	-	02	02	04	02
Total			**11**	**1**	**20**	**16**	**48**	**30**

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

Legend:

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

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

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

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

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

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

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

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

Semester - V
Assessment Scheme

Course Codes	Category of Course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment(LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415501	**PCC**	**Hydraulics**	30	70	20	30	20	30	200
2415502	**PCC**	**RCC Structure**	30	70	20	30	20	30	200
2415503	**PCC**	**Estimating, Costing & Contracts**	30	70	20	30	-	-	150
2400504	**OEC**	**Open Electives*/ COE** (Basic - Any One)	30	70	20	30	20	30	200
2400505	**NRC**	**Entrepreneurship Development & Start-ups** (Common for All Programmes)	-	-	20	30	20	30	100
2415506	**PSI**	**Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes)	-	-	20	30	20	30	100
2415507	**PSI**	**Minor Project** (Common for all programmes)	-	-	10	15	10	15	50
Total			**120**	**280**	**130**	**195**	**110**	**165**	**1000**

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

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.
*: 3D Printing & Design /Artificial Intelligence (AI)/ Drone Technology/ Electric Vehicle / Industrial Automation & Control/ IOT/ Robotics/Transformer Manufacturing and Repairing/Optical Fiber and 5G Communication

Note:

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

A) Course Code : 2415501(T2415501/P2415501/S2415501)

B) Course Title : Hydraulics

C) Pre-requisite Course(s) :

D) Rationale :

It is necessary for civil, environmental and transportation engineers to understand the behavior of fluid flow in different conditions in pipes, channels, canals, notches, weirs etc. In the field these conditions are very common and diploma passouts has to solve problems related to water seepage and discharge.

The basic knowledge about hydraulics and fluid mechanics is useful in subjects like Irrigation, Water Resources Management and Public Health Engineering and in day to day activity of the human being. In this course, basics of hydraulics and its application oriented content has been kept with a focus that students should be able to solve practical problems. Competencies developed by this course would therefore be useful for students while performing his/her job in the field of Water resources / Irrigation/PHE and Environment Engineering.

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 Measure the pressure acting on the given type of fluid in the given situation.

CO-2 Apply the Bernoulli's equation along with continuity eqaition for the fluid flow through closed conduits.

CO-3 Apply the Darcy Weisbach Equation to determine head loss of fluid flow through pipes.

CO-4 Design the most economical section of the given type of channel using Chezy's and Manning's formulae for the given data.

CO-5 Calculate the discharge through notches and weirs.

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	3	-	1		
CO-2	3	-	-	2	2	-	2		
CO-3	3	3	2	3	3	2	2		
CO-4	3	2	2	2	2	2	1		
CO-5	3	-	1	3	3	3	2		

Legend: High (3), Medium (2), Low (1) and Nomapping (-)

***** 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				
2415501	Hydraulics	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.

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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)	
2415501	Hydraulics	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:

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- 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: T2415501

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO1a.Explain the terms, "Hydrostatics, Hydro-kinematics, Hydro-Dynamics, Ideal Fluid and Real Fluid". TSO1b.Explain the properties and its importance of the given liquid. TSO1c. Measure the pressure acting on the given fluid using relevant method of measurement. TSO 1d. Explain the Relationship between pressure and depth of liquid with its significance. TSO 1e. Compute total Pressure and Centre of pressure in the given situation. TSO 1f. Convert absolute pressure into gauge pressure for the given situation and vice versa. TSO 1g. Convert pressure head in mm of a liquid to that of another liquid from the given data. TSO 1h. Draw the pressure diagram for a given situation.	**Unit – 1.0 Introduction, Hydrostatic Pressure and Pressure Measurement** 1.1 Introduction, need and importance of hydraulics in civil engineering. Technical terms used in Hydraulics – Fluid Mechanics, Hydrostatics, Hydro-kinematics, Hydro-Dynamics-Ideal and Real Fluid. 1.2 Properties of liquid – Viscosity-Density-Specific Gravity-Surface Tension-Capillarity Vapour Pressure-Elasticity. 1.3 Various types of pressure – Atmospheric Pressure, Gauge Pressure, Absolute Pressure, Vacuum Pressure and Separation Pressure. 1.4 Measurement of pressure by different methods. 1.5 Measurement of difference of pressure using "U" tube Manometer and inverted "U" tube Manometer. 1.6 Relationship between pressure and depth of liquid. 1.7 Pressure diagram for different conditions. 1.8 Total pressure and center of pressure. 1.9 Computation of Total Pressure and depth of centre of pressure.	**CO-1**
TSO 2a. Explain the given type of fluid flow. TSO 2b. Interpret the type of flow using Reynold's number. TSO 2c. Derive the Continuity Equation with sketch. TSO 2d. Explain the terms, "Potential energy and Kinetic energy". TSO 2e. Apply Bernoulli's theorem to measure the given parameters in the given situation.	**Unit – 2.0 Fluid Flow Parameters** 2.1 Types of flow :- Laminar, Turbulent, Uniform, Non-uniform, Steady, Un-steady, Rotational, irrotational, One, Two and Three Dimensional flow. 2.2 Determine types of flow using Reynold's number. 2.3 Continuity Equation of flow. 2.4 Types of Energy of flowing liquid: Potential energy and kinetic energy. 2.5 Bernoulli's Equation, assumptions and its applications. 2.6 Momentum Equation based simple numerical.	**CO-2**
TSO 3a. Draw Hydraulic Gradient Line (HGL) and Total Energy Line (TEL)for the given data. TSO 3b. Explain the Energy (Head) losses that occurs in the given pipe flow. TSO 3c. Use Darcy Weisbach equation to find out the head loss due to friction in the given situation. TSO 3d. Compute the discharge in the given network (Parallel or series) of pipes. TSO 3e. Use nomogram to find diameter of pipe from given data. TSO 3f. Find the diameter of a pipe using Moody's diagramfrom given data. TSO 3g. Calculate discharge in a pipe for the given	**Unit – 3.0 Flow through Pipes** 3.1 Characteristics of flow through pipes. 3.2 Major head loss in pipe: Frctional loss and its computation by Darcy Weisbach equation. Practical examples of head loss for resdential building. 3.3 Major and Minor Energy (Head) losses in pipe Flow- frictional loss, loss of head at entry , exit, Sudden enlargement and contraction and at bend. 3.4 Computation of major head by Darcy Weisbach Equation. 3.5 Hydraulic Gradient Line (HGL) and Total Energy Line (TEL). 3.6 Design of Pipeline-using formula & Nomogram.	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
data using venturimeter. TSO 3h. Design the Pipeline network using formula and nomogram TSO 3i. Compute different Hydraulic Coefficient for different types of orifice.	3.7 Water hammer in pipes : causes and Remedial measures. 3.8 Use ofMoody's Diagram and Nomograms for calculating diameter of pipe from the given data. 3.9 Discharge measuring device for pipe flow: Venturimeter-construction and working. 3.10Definition and types of orifice.Various Hydraulic Coefficient and its relation - Coefficient of Contraction, Velocity, Discharge. 3.11Discharge measuring for a tank: using Orifice, Hydraulic Coefficients of Orifice.	
TSO4a. Describe the geometrical properties of the given channel. TSO 4b. Determine discharge through the given channel using relevant formulae for the given data. TSO 4c. Design the most economical channel section from the given conditions. TSO 4d. Analyse the uniform flowfor the given situation. TSO 4e. Draw the Specific Energy Diagram for the given situation. TSO 4f. Describe Procedure formeasuring Velocity and discharge using the given flow measuring device.	**Unit – 4.0 Flow through Open Channel** 4.1 Characteristics of open channel flow. 4.2 Comparison of pipe flow and channel flow. 4.3 Field examples of open channel ,Analyse uniform flow' 4.4 Froud's number,Hydraulic mean depth- concept & computation. 4.5 Use of Chezy's and Manning's formulae 4.6 Most economical sections of channel Rectangular, Trapezoidal and circular shapes. 4.7 Specific Energy DiagramRiver Gauging, Measurement of mean velocity using surface float, velocity rod and current meter	**CO-4**
TSO 5a. Classify the types of Notches and the weirs. TSO 5b. Calculate discharge flowing through notches and weirs. TSO 5c. Calculate the coefficient of discharge, contraction and velosity in the given situation. TSO 5d. Establish the relationship between coefficient of discharge, contraction and velosity in the given situation.	**Unit – 5.0 Notches and Weirs** 5.1 Types of notches and weirs. 5.2 Computation of discharge through Rectangular Notch and V -Notch. 5.3 Computation of discharge through weirs. 5.4 Discharge through narrow crested and broad Crested weir and Discharge through Cipolletti weir.	**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: P2415501

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO1.1 Determine the viscosity of given fluid using viscometer.	1.	Determine the viscosity of given fluid using viscometer.	CO-1
LSO2.1. Measure the pressure of water in the given pipe.	2.	Measure the pressure of water in the given pipe using (a) Piezometer (b) Different types of manometers.	CO-1, CO-2
LSO3.1. Determine discharge passing through pipes.	3.	Determine discharge passing through the given pipe usingventurimeter.	CO-3
LSO4.1. Determine coefficient such as Cc, Cv, and Cd.	4.	Determine coefficient such as Cc, Cv, and Cd for given types of orifices.	CO-2, C0-3

LSO5.1. Compute coefficient of discharge for the given V notch.	5.	Compute coefficient of discharge for the given V notch using calibration graph for interpolation and extrapolation.	CO-5
LSO6.1. Compute coefficient of discharge for the given Rectangular notch.	6.	Compute coefficient of discharge for Rectangular notch and Preparation of calibration graph for interpolation and extrapolation.	CO-5
LSO7.1. Determine loss of head in various diameter of pipes.	7.	Determine the head loss in the given pipe of given diameter with the explanation of effect of pipe material on head loss.	CO-2, CO-3
LSO8.1. Application of Bernoulli's equation.	8.	Draw the total energy line for the fliud in close conduit of varying cross sections using Bernoulli's theorem.	CO-2
LSO9.1. Significanse of Reynold's number.	9.	Use the Reynold's apparatus to interpret the type of flow.	CO-2
LSO10.1. Use the Friction factor Apparatus.	10.	Use the Friction factor Apparatus to determine friction factor for the given pipe.	CO-3
LSO11.1 Measure minor losses in pipe fitting.	11.	Determine the minor losses in pipe fittings due to sudden contraction, sudden enlargement.	CO-3
LSO12.1 Design of most economical section in the given situation.	12.	Apply the Chezy's and Manning's formula in the given situation to determine the most economical section of channel.	CO-4

L) Suggested Term Work and Self Learning: S2415501 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. Student will visit nearby Canal Structure and Submit report consisting flow data, cross sections, hydraulic data etc. for the same.
2. Student will Survey an industry / Department for handling or using pressure measuring devices.
3. Student will carry out market survey for pipes of different materials.

c. Other Activities:

1. Use demonstration, video/animation films field/industry visit for explaining complex/abstract concepts of Hydraulics.
2. This course requires lot of practice on numerical. Students may be asked to solve the numerical during lecture periods and tutorial periods, in addition home assignments may be given. To avoid copying by students each problem must have different parameters for each student or at least there may be five to six sets of problems with different values., In other words each student will get same problem but with varied parameters. (Values of pressure, volume, flow, force, distance, speed etc may be different for each student.

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	20%	20%	20%	-	-	21%	21%
CO-2	20%	20%	20%	20%	-	20%	20%
CO-3	25%	25%	20%	30%	33%	25%	25%
CO-4	20%	20%	20%	20%	33%	10%	10%
CO-5	15%	15%	20%	30%	34%	24%	24%
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 Introduction, Hydrostatic Pressure and Pressure Measurement	9	CO1	14	3	5	6
Unit – 2.0 Fluid flow Parameters	9	CO2	14	4	4	6
Unit – 3.0 Flow through Pipes	12	CO3	18	5	5	8
Unit – 4.0 Flow through Open Channel	10	CO4	14	4	4	6
Unit – 5.0 Hydraulic coefficient, Notches and Weirs	8	CO5	10	4	2	4
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 Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine the viscosity of given fluid using viscometer.	CO-1	50	40	10
2.	Measure the pressure of water in the given pipe using (a) Piezometer (b) Different types of manometers.	CO-1, CO-2	60	30	10
3.	Determine discharge passing through the given pipe using venturimeter.	CO-3	50	40	10
4.	Determine coefficient such as Cc, Cv, and Cd for given types of orifices.	CO-2, CO-3	45	45	10
5.	Compute coefficient of discharge for the given V notch using calibration graph for interpolation and extrapolation.	CO-5	40	50	10
6.	Compute coefficient of discharge for Rectangular notch and Preparation of calibration graph for interpolation and extrapolation.	CO-5	60	30	10
7.	Determine the head loss in the given pipe of given diameter with the explanation of effect of pipe material on head loss.	CO-2, CO-3	50	40	10
8.	Draw the total energy line for the fliud in close conduit of varying cross sections using Bernoulli's theorem.	CO-2	30	60	10
9.	Use the Reynold's apparatus to interpret the type of flow.	CO-2	40	50	10
10.	Use the Friction factor Apparatus to determine friction factor for the given pipe.	CO-3	40	50	10
11.	Determine the minor losses in pipe fittings due to sudden contraction, sudden enlargement.	CO-3	50	40	10
12.	Apply the Chezy's and Manning's formula in the given situation to determine the most economical section of channel.	CO-4	30	60	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.List of Major Laboratory Equipment , Tools and Software:

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

<table>
<tr><th>S. No.</th><th>Name of Equipment, Tools and Software</th><th>Broad Specifications</th><th>Relevant Experiment/ Practical Number</th></tr>
<tr><td>1.</td><td>PRESSURE MEASURING EQUIPMENTS</td><td>1. Piezometer
2. Different types of manometers.</td><td>2</td></tr>
<tr><td>2.</td><td>VENTURI METER EXPERIMENT</td><td>The Venturimeter consists of three main parts :-
1. Convergent cone
2. A Cylindrical throat
3. Divergent cone</td><td>3</td></tr>
<tr><td>3.</td><td>ORIFICES EXPERIMENT</td><td>1) Measuring tank of Size 0.6 x 0.6 x 0.8 meter with overflow arrangement, gauge glass, scale arrangement and a drain valve.
2) Stop Watch.
3) Orifice meters fitted onto horizontal pipes of diameters 20mm, 25mm and 40mm with pressure tapping’s and gate valves to regulate flow rate.
4) Differential mercury manometer with wooden scale of 1m length and scale graduations of 1mm to measure the loss of head.
5) The orifice diameter corresponding to the pipe diameters are as follows:
<table>
<tr><th>Sr no</th><th>Pipe diameter(mm)</th><th>Orifice diameter(mm)</th></tr>
<tr><td>1</td><td>20</td><td>13.41</td></tr>
<tr><td>2</td><td>25</td><td>16.77</td></tr>
<tr><td>3</td><td>40</td><td>26.83</td></tr>
</table></td><td>4</td></tr>
<tr><td>4.</td><td>V- Notch</td><td>1. A Channel with V- Notch
2. Hook gauge
3. Collecting tank
4. Pizometer</td><td>5</td></tr>
<tr><td>5.</td><td>COEFFFICIENT OF DISCAHRGE OF A WEIR</td><td>1. A channel or flume to provide a flow passage.
2. A broad crested weir.
3. Hook-gauge to measure the head over the crest over the crest of weir.
4. A collecting tank to fit with a pyrometer, to the discharge over the weir and to find out actual discharge.
5. Stop watch to note the time of collection of water for a known rise of water level in the collecting tank.
6. Meter scale to measure the internal plan dimensions of the collecting tank.</td><td>6</td></tr>
<tr><td>6.</td><td>BERNOULLI’S EXPERIMENT</td><td>1) Apparatus for the verification of Bernoulli’s theorem.
2) Measuring tank
3) Stop watch setup for measuring the actual flow rate.</td><td>8</td></tr>
<tr><td>7.</td><td>REYNOLD’S EXPERIMENT</td><td>1. Reynolds Apparatus test rig
2. Stop watch</td><td>9</td></tr>
<tr><td>8.</td><td>DETERMINATION OF MINOR LOSSES IN PIPES</td><td>A flow circuit of G. I. pipes of different pipe fittings viz. Large bend, Small bend, Elbow, Sudden enlargement from 25 mm dia to 50 mm dia, Sudden contraction from 50 mm dia to 25 mm dia, Utube differential manometer, collecting tank.</td><td>11</td></tr>
</table>

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Hydraulics and Fluid Mechanics	Modi,P.N.and Seth, S.M.	Standard book house, Delhi ISBN: 13: 978-8189401269;
2	Hydraulics. Fluid Mechanics and Fluid Machines	Ramamrutham, and Narayan, R.	Dhanpat Rai Publishing Company New Delhi, ISBN:81874841
3	Hydraulics, Fluid Mechanics,Hydraulic machines	Khurmi,R.S.	S Chand Publishers, New Delhi ISBN: 9788121901628
4	Fluid Mechanics	Rajput, R.K.	S Chand, New Delhi ISBN: 9788121916677
5	Fluid Mechanics and Machinery	Ojha, C.S.P. and Berndtsson, R.	Oxford University Press, New Delhi, ISBN: 9780195699630

b) Online Educational Resources:

1) www.waterbouw.tudelft.nl/
2) www.learnrstv.com
3) www.shiksha.com
4) IIT, Roorkee
5) www.blackwellpublishing.com
6) www.hrpwa.org
7) www.creativeworld9.com
8) nptel.iitm.ac.in

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:

List of Major Equipment/Materials:

1. Piezometer
2. U-Tube Manometer
3. Ventutrimeter
4. V-notch
5. U-notch
6. Pipes- PVC, G.I.,
7. Measuring Tank
8. Stop Watch
9. Gauge
10. Mercury Or Hydraulic Bench equipped with all above equipments

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A) Course Code : 2415502(T2415502/P2415502/S2415502)

B) Course Title : RCC STRUCTURE

C) Pre-requisite Course(s) : Strength of Material, Theory of Structure, concrete technology

D) Rationale :

The infrastructure sector plays a pivotal role in propelling the nation's economy. An understanding of designing and detailing of reinforced concrete structures is crucial to ensure the safety, serviceability, and durability of constructions. This expertise can be applied in various segments of infrastructural development which includes buildings, bridges, roads, and other critical projects.

A Civil Engineer must have knowledge of design concepts and the behavior of structural components. It will enable them to design safe and economical structures and to ensure quality in supervision and effective on-site execution. Hence, it is crucial for diploma engineers to acquire knowledge and understanding of precast and pre-stressed concrete for practical application in the field.

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 Design singly reinforced rectangular beam sections using the relevant method of design under different loading conditions.

CO-2 Design doubly reinforced rectangular beam sections using Limit State Method subjected to different loading conditions.

CO-3 Design shear reinforcement for a given beam section based on the provisions of IS 456-2000.

CO-4 Design a given slab using IS code method & under given loading conditions.

CO-5 Design axially loaded short column and isolated square footing as per IS code 456-2000 provisions.

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	-	1	-	1		
CO-2	3	3	2	-	1	-	1		
CO-3	3	2	2	-	1	-	1		
CO-4	3	3	2	-	1	-	1		
CO-5	3	3	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				
2415502	RCC Structure	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)	
2415502	RCC Structure	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: T2415502

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a. Explain the significance of steel as reinforcing material in the given RCC structure. TSO 1b. Draw the stress strain curve for mild steel and concrete by notifying the critical points on the curve. TSO 1c. Compare Working stress and Limit stress method of design of the given RCC beam. TSO 1d. Analyze the given singly reinforced beam using LSM & WSM of design. TSO 1e. Analyze the given singly reinforced beam using a given Method TSO 1f. Calculate Moment of resistance of a given RCC Beam using LSM or WSM. TSO 1g. Compare the area of steel obtained from the design of the given singly reinforced beam from LSM or WSM. TSO 1h. Identify the given section as Under reinforced, over reinforced, or balanced section. TSO 1i. Draw the reinforcement detailing of the given element as per IS specifications.	**Unit –1.0: Introduction to Reinforced Cement Concrete (R.C.C.) & Methods of Design** 1.1 Introduction to Reinforced Cement Concrete, use of steel as Reinforcing material, grades of steel and concrete, stress strain curve for concrete and mild steel. 1.2 Working Stress Method (WSM) of design: Assumptions, Stress block diagram, Permissible stresses, Concept of Equivalent sections. 1.3 Analysis of singly reinforced beam using WSM, Concept of under reinforced, over reinforced and balanced section. 1.4 Limit state and its types, Limit State Method (LSM) of design: Assumptions , Stress block diagram. 1.5 Analysis of singly reinforced beam using LSM, Concept of under reinforced, over reinforced and balanced section. 1.6 Simple numerical problems on ultimate moment of resistance and design of beam section (LSM & W SM)	**CO1**
TSO 2a. Explain the significance of providing doubly reinforced sections of the beam. TSO 2b. Design a doubly reinforced beam subjected to given loading using LSM. TSO2c. Calculate the ultimate moment of resistance for the given type of section. TSO2d.Explain the advantages of Flanged beams. TSO2e. Calculate the effective width of a given flanged beam as per IS code provisions.	**Unit–2.0: Doubly Reinforced Beam and Flanged Sections (LSM)** 2.1 Introduction to doubly reinforced beam.It's necessity & importance. 2.2 Analysis of doubly reinforced section. 2.3 Simple numerical problems on finding moment of resistance and design of doubly reinforced sections. 2.4 Introduction to T & L section beams, advantages & uses, effective width as per IS 456-2000. 2.5 Analysis of singly reinforced T-Beam, strain diagram & stress diagram, depth of neutral axis, moment of resistance of T-beam section with neutral axis lying within the flange only. 2.6 Simple numerical problems on finding out effective width of flange & moment of resistance of T-beam section with N. A. lying within or upto the bottom of flange.	**CO2**
TSO3a.Describe various form of shear reinforcement used in RCC beams. TSO3b.Calculate "design shear strength" of the given beam for given loading condition. TSO3c.Compute the development length required for the given beam for given loading condition. TSO3d. Enumerate the various codal provisions related to anchorage/lapping of bars in a given beam. TSO3e. Check the adequacy of the given section	**Unit-3.0: Shear, Bond and Development length in Design of RCC member** 3.1 Nominal shear stress in RCC section, Design shear strength of concrete, Design of shear reinforcement, Minimum Shear Reinforcement, Provisions of IS 456, forms of shear reinforcement. 3.2 Types of bonds, Bond stress, check for bond stress, Determination of Development length in tension and compression members and check as per codal provisions, Anchorage value of 90-degree hook, Lapping of bars.	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
of a beam in resisting shear force. TSO3f.Draw the shear reinforcement detailing of the given element as per IS specifications.	3.3 Simple numerical problems on Shear reinforcement, Adequacy of section for resisting shear.	
TSO4a.Check the deflection of the given type of slab. TSO4b. Check the development length of the given type of slab. TSO4c. Design the given types of slab using the given parameters. TSO4d Draw the shear reinforcement detailing of the given slab as per IS specifications.	**Unit-4.0: Design of Slab (LSM)** 4.1 Design of simply supported one-way slab for flexure, shear and deflection. Also check the slab as per the provisions of IS 456-2000. 4.2 Design of one-way cantilever slab, for Flexure including checks for Development length and Shear stress. 4.3 Design of two-way simply supported slab(IS Code method).	**CO4**
TSO5a.Explain the assumptions made in the design of axially loaded column. TSO5b.Enumerate the various IS code provisions related to design of axially loaded column. TSO 5c. Calculate the load carrying capacity of the column in the given situation. TSO5e. Design the axially loaded short column for the given data. TSO5f. Suggest the given type of RCC footing for the given situations. TSO 5g. Design given type of footing for the given column loading. TSO5h.Draw the reinforcement detailing of the given column/footing for the given loading condition as per IS specifications.	**Unit-5.0: Design of Axially Loaded Column and Footing (LSM)** 5.1 Assumptions in limit state of collapse – compression 5.2 Definition and classification of columns, effective length of column. IS Code provisions for minimum reinforcement; cover, maximum reinforcement, number of bars in rectangular, square and circular sections, diameter and spacing of lateral ties. 5.3 Analysis and design of axially loaded short, square, rectangular and circular columns with lateral ties only; check for short column and check for minimum eccentricity. 5.4 Types of footing, Design of isolated square footing for flexure and shear. 5.5 Simple numerical problems on the design of axially loaded short columns and isolated square footing.	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2415502

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment /Practical Titles	Relevant COs Number(s)
LSO1.1. Draw stress and strain diagram for a given singly reinforced beam	1.	Draw cross section, strain diagram & stress diagram for singly reinforced section	CO1
LSO2.1. Draw stress and strain diagram for a given doubly reinforced beam.	2.	Draw cross section, strain diagram & stress diagram for doubly reinforced section	CO2
*LSO3.1*Show the shear reinforcement detailing of a given beam.	3.	Design beam section for shear as per IS 456:2000 provisions.	CO3
LSO 4.1 Design of reinforcement in a given cantilever slab.	4.	Design a cantilever slab from the given data.	CO4
LSO5.1. Design of reinforcement in a given one way simply supported slab.	5.	Design a one way simply supported slab from the given data.	CO4
LSO6.1. Design of reinforcement in a given two way simply supported slab.	6.	Design a two way simply supported slab from the given data.	CO4
LSO7.1. Show the reinforcement detailing for given cantilever slab, one way simply supported	7.	Draw the reinforcement detail for cantilever slab, one way simply supported slab and two	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment /Practical Titles	Relevant COs Number(s)
slab and two way simply supported slab.		way simply supported slab designed in serial no. 4,5 & 6	
LSO8.1. Design of reinforcement for given axially loaded short column	8.	Design an axially loaded short column from the given data.	CO5
LSO9.1. Identify different types of column footings.	9.	Draw sketches of different types of column footings.	CO5

L) **Suggested Term Work and Self Learning**: **S2415502** 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. Enlist various softwares used for design of RCC structures. Give details of any one.
2. Procure working drawings of any structural design and write a report after checking the actual execution at the site.
3. Collect details of safety norms followed during RCC construction.
4. Identify various human errors occurred while placing the reinforcement and suggests remedial measures.
5. Write a report on activities during removal of formworks and precautions to be taken.

c. Other Activities:

1. Seminar Topics:
   (a) A new composite element for fiber reinforced polymer concrete.
   (b) Low cost earthquake resistant design.
   (c) Behavior of composite beams of steel reinforced recycled concrete.
   (d) Structural health monitoring.

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%	25%	20%	20%	25%	20%
CO-2	20%	20%	20%	20%	25%	40%	20%
CO-3	20%	15%	15%	20%	-	10%	20%
CO-4	20%	20%	20%	20%	30%	10%	20%
CO-5	15%	25%	20%	20%	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: Introduction to R.C.C. & Methods of design.	10	CO1	14	4	4	6
Unit- 2.0: Doubly reinforced and Flanged sections (L.S.M.)	9	CO2	14	4	4	6
Unit- 3.0: Shear, Bond and Development length in Design of RCC Member.	7	CO3	11	3	4	4
Unit- 4.0: Design of slab (L.S.M.)	10	CO4	14	4	4	6
Unit- 5.0: Design of Axially Loaded Column and Footing (LSM)	12	CO5	17	5	6	6
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.	Draw cross section, strain diagram & stress diagram for singly reinforced section.	CO1	30	60	10
2.	Draw cross section, strain diagram & stress diagram for doubly reinforced section	CO2	30	60	10
3.	Design beam section for shear as per IS 456:2000 provisions.	CO3	60	30	10
4.	Design a cantilever slab from the given data.	CO4	60	30	10
5.	Design a one way simply supported slab from the given data.	CO4	60	30	10
6.	Design a two way simply supported slab from the given data.	CO4	60	30	10
7.	Draw the reinforcement detail for cantilever slab, one way simply supported slab and two way simply supported slab	CO4	40	50	10
8.	Design an axially loaded short column from the given data.	CO5	60	30	10
9.	Draw sketches of different types of column footings.	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.	Drawing boards, sheets, scales, pencils, IS codes	As per requirements	All

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	REINFORCED CONCRETE DESIGN	S Unnikrishna Pillai Devdas Menon	Mc Graw Hill Publication (4th edition), 1. ISBN-13: 978-0070141100 2. ISBN-10:007014110X
2.	Design of reinforced concrete structures	M.L.Gambhir	PHI publication- ISBN-13 : - 9788120331938
3.	Design of reinforced concrete structures	N.Krishna Raju	CBS publication; 3rd edition ISBN-10 : 8123909896, ISBN-13 : 978-8123909899
4.	Reinforced concrete limit state design	Ashok k jain	Nem Chand & Brothers publication Roorkee; 7thedition, ISBN-10 : 9788185240664 ISBN-13 : 978-9788185240664
5.	Design of reinforced concrete structures	N. Subramanian	Oxford publication (Illustrated Edition) ISBN-10 : 0198086946 ISBN-13 : 978-0198086949

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/105/105/105105105/
2. https://youtu.be/AfHmpWlcqq4 (nptelhrd)
3. https://youtu.be/PDJPcQq3PZE (nptelhrd)
4. https://youtu.be/pIdaC_I6H_M (nptelhrd)
5. https://youtu.be/zVKf6hZfrhA (nptelhrd)
6. https://youtu.be/3Do2cZMUGYc (nptelhrd)

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. IS 456:2000
2. SP 16 design aids for reinforced concrete to IS 456:2000
3. SP 24 explanatory handbooks on IS 456:2000
4. IS 875:1987 for loading standards

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A) Course Code : **2415503(T2415503/S2415503)**

B) Course Title : Estimating, Costing and Contracts

C) Pre-requisite Course(s) : Basic Civil Engineering Concept & Knowledge

D) Rationale :

Estimating and costing of any civil engineering construction project is the process of forecasting its value. However, final project cost is only known once the project is completed in all respect. There are various types of processes to carry out estimation and costing of any given construction project. A good estimate helps in proper planning and sanction/utilization of budget of the project. Purpose of an estimate has a different meaning to each stakeholder involved in the project. To the owner, it provides a reasonable, accurate idea of the cost. This will help him or her decide whether the work can be undertaken as proposed, needs to be modified, or should be abandoned. To the contractor, it helps in getting the cost of materials, labour, project cost and the profit involved. The estimator must understand the type of construction, the project schedule, availability skilled workers and materials etc. to prepare an accurate estimate. A contract is an agreement between two or more parties mutually agreed by both parties for smooth functioning of the project.

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 Estimate the quantities of materials for the given civil work using relevant method of estimation.

CO-2 Carry out rate analysis for the given item of work of a construction projects.

CO-3 Prepare contract documents for the given civil construction work.

CO-4 Carry out tendering process for the given civil construction work.

CO-5 Apply the relevant method of valuation to decide the cost of the given project.

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	2	-	2	1	-	1	-	-
CO-2	3	2	1	1	1	-	2	-	-
CO-3	3	2	-	-	2	-	1	-	-
CO-4	3	3	-	-	1	1	1	-	-
CO-5	3	2	1	2	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				
2415503	Estimating, Costing and Contracts	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 = (1x CI hours) + (0.5x LI hours) + (0.5x 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)	
2415503	Estimating, Costing and Contracts	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: T2415503

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO1a. Explain the necessity of preparing the estimate for the given work. TSO1b. Prepare the estimate based on the given data for a construction project using the relevant method of estimation. TSO1c. Explain various types of estimates used in construction work. TSO1d. Calculate the quantities of items of work using various estimation methods. TSO 1e. Explain the term, "Plinth area and Carpet area. TSO 1f. Explain the duties and responsibility of a quantity surveyor.	**Unit-1.0 Fundamentals of Estimating and Costing** 1.1 Introduction: Need and importance of estimating and costing, Definitions of estimating and costing, Plinth area, Carpet area, administrative approval, technical sanction, Budget sanction. 1.2 Units of measurement: Different type of estimates: Preliminary, Approximate, Abstract, Rough Cost Estimate, Plinth Area Estimate, Cube Rate Estimate, Quantity Method Estimate, Detailed Estimate or Item Rate Estimate, Supplementary Estimate, Revised Estimate, Annual Repair or Maintenance Estimate (A. R. or A. M. Estimate) 1.3 Estimation methods: Long wall – short wall method, Centre line method, partly centerline and short wall method, Rules for deductions. Duties of quantity surveyor, measurement of items, entry in the measurement book, calculation of various quantities, preparation of bill. CO1	**CO1**
TSO2a. Explain the purpose rate analysis. TSO 2b. Perform the rate analysis for the given item of construction activity. TSO 2c. Calculate the cost of a given construction project using schedule of rates (SOR). TSO2d. Describe the steps involved in controlling the cost of the construction project.	**Unit-2.0 Rate Analysis** 2.1 Definition and purpose of rate analysis Rate analysis procedure, task work and factors affecting it, labour required for different works and labour rates, market rate of construction materials. 2.2 Schedule of rates (SOR), State PWD schedule of rates, CPWD DSR, CPWD Works manual, rate analysis for earthwork in excavation, cement concrete work, brick masonry work, RCC work, plastering and flooring work. 2.3 Material requirement for different works, bricks, cement, sand, aggregate, water, steel reinforcement, flooring material and painting material. 2.4 Costing, benefits of cost estimation and Cost control.	**CO2**
TSO 3a. Explain the importance of contract in a given civil construction project.	**Unit-3.0 Contracts** 3.1 Definition of contract, role of contractor. 3.2 Types of contracts: Lump Sum contract, Schedule	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3b. Explain various types of contracts applicable in civil construction projects. Unit-3.0 Contracts *TSO 3d.* Explain the importance of measurement book (MB). *TSO 3e.* Justify the need of arbitration and legislation in civil construction contracts.	rate contract, Labor contract, Target contract, Material supply contract, Piece work agreement; advantage and Disadvantage of various types of contracts. Elements of contract and contract documents. 3.3 Measurement book (MB) and nominal muster roll Arbitration and Legislation and its importance, penalty clause of contract.	
TSO4a. Explainthe need and importance of item specifications in a civil construction projects. *TSO 4b.* Write the detailed specification for earthwork in excavation for a given type of foundation. *TSO 4c.* Prepare tender document with required specifications for a civil construction project. *TSO 4d.* Differentiate between earnest money deposit and Security money deposit. *TSO4e.* Explain the procedure of-tendering.	**Unit-4.0 Specifications and Tenders** 4.1 Specification and need of specification. Factors governing specification. Classification of specification. General specification of different type of residential buildings. Detailed Specification for earthwork excavation for foundation. 4.2 Tender, Procedure for inviting tender. Types of Tenders. Details to be mentioned in notice inviting tenders. Technical terms related to tender: Earnest money deposit, Security money deposit, receiving and opening of tender. E-tender procedure and its limitations.	**CO4**
TSO5a. Explain importance and purpose of valuation. TSO5b. Differentiate between the terms cost price and value. TSO5c. Explain the steps involved in the process of valuation of a property (land, building farm, etc.) TSO5d. Explain the terms capitalized value, scrap value and salvage value. TSO 5e. Describe the procedure of fixing the standard rent of a given property.	**Unit-5.0 Valuation** 5.1 Purpose of valuation, factors consideration for valuation; cost, price, and value. Important terms: Municipal tax, capital cost, capitalized value, year of purchase, gross income, outgoings taxes and repair, scrap value, salvage value, market value, and book value. 5.2 Method of valuation: depreciation method of valuation, valuation based on cost, valuation based on profit, fixation of rent; method of calculation of depreciation.	**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: S2415503 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. Prepare an approximate estimate of a building project with a total plinth area of all building is 80 sq.m and from the following data. Plinth area rate Rs. 40000 per sq.m Cost of water supply @7½% of cost of building. Cost of Sanitary and Electrical installations each @ 7½% of cost of building. Cost of architectural features @1% of building cost. Cost of roads and lawns @5% of building cost. Cost of P.S. and contingencies @4% of building cost. Determine the total cost of building project.
2. Estimate the quantities of brickwork and plastering required in a wall 4 m long, 3 m high and 30 cm

thick. Calculate also the cost if the rate of brickwork is Rs.320.00 per cumec and of plastering is Rs.8.50 per sq.m.

3. Estimate the quantities of cement, sand, aggregate, water, and steel reinforcement of RCC slab of size 4mx3m and thickness of slab 100mm.
4. Prepare a draft of notice inviting tender (NIT).
5. Explain the factors consideration for valuation of given structure.
6. Prepare approximate estimate of given type of building such as nearby school, hospital, auditorium, hostel etc.
7. Prepare detailed estimate of any load-bearing single room structure.
8. Prepare rate analysis of RCC of given type of column as per specification.

b. Micro Projects:

1. Estimate the quantities of brick and cement for a given wall.
2. Download any two estimating and costing software and check their compatibility with your computer.
3. Prepare detailed estimate of PMGSY road of 100m length.
4. Prepare detailed estimate of a given slab.
5. Prepare detailed estimate of all beams and columns used in your classroom.
6. Prepare the approximate estimate for earthwork for a given building plan.
7. As per the latest scheduled of rate (SOR) of Bihar, find out the valuation of a given single storey load-bearing structure.
8. Calculate the scrap value of an abandoned nearby building as per the straight-line depreciation method.

C. Other Activities:

1. Seminar Topics:

   - Estimation of quantities of brickwork laid in a given building.
   - Properties of estimating software.
   - Estimation and costing of low-cost building under Pradhan Mantri Gramin Awas Yojna.
   - Rate analysis of Indira Awash Yojna.

2. Visits: Visit nearby under construction site. Prepare the report of visit with special comment on quantities and cost of materials of materials used.

3. Self-Learning Topics:

   - Create abstract of cost in excel.
   - COCOMO (Constructive Cost Model) Software.
   - Method of calculation of depreciation of building.
   - Software used for estimation and costing.
   - Open-source learning using internet

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%	20%	15%	50%	40%	-	-
CO-2	15%	16%	10%	-	30%	-	-
CO-3	15%	14%	15%	-	-	-	-
CO-4	25%	28%	30%	-	-	-	-
CO-5	30%	22 %	30%	50%	30%	-	-
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 (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Fundamentals of Estimation	10	CO1	14	4	5	5
Unit-2.0 Rate Analysis	8	CO2	12	3	4	5
Unit-3.0 Contracts	6	CO3	10	3	3	4
Unit-4.0 Specifications and Tenders	14	CO4	20	6	6	8
Unit-5.0 Valuation	10	CO5	14	4	4	6
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): (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 the mare 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: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Estimating and Costing in Civil engineering	Datta,B.N.	UBS Publishers Pvt. Ltd. New Delhi.ISBN:9788174767295
2.	Estimating and Costing	Rangawala, S.C.	Charotar Publishing House PVT. LTD., Anand (Gujrat)Reprint-2011 ISBN-10-9385039059
3.	Construction Management and Contract Practices	Raina, V. K.	Shroff Publishers & Distributers Pvt. Ltd. New Delhi, ISBN:9788184047875,
4.	Explanation of Indian Contract Act	Mullaand Sanjeeva Rao, B.D.Virmani, B.T.Gajaria	Lexis, Nexis ISBN:9789391211370
5.	Civil Engineering Contracts and Estimates	Patil, B.S.	Orien Longman, Mumbai, Ed.2010 ISBN:9788173715594,8173715599

(b) Online Educational Resources:

1. https://state.bihar.gov.in/rcd/CitizenHome.htmlhttps://www.youtube.com/watch?v=ZHoVWbGKpPQ&t=3shttps://onlinecourses.swayam2.ac.in/nou21_ce06/previewhttp://cpwd.gov.in/cpwdetender.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. State Schedule of rate, Government of Bihar
2. RS Means Estimating Handbook,- RSMeans-ISBN-13:978-0876292730
3. Handbook of Measuring Units and Conversions- Kachru R .P,Singh G , JainA.K - ISBN-13:978-8126102129

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A) Course Code : 2400504B(T2400504B/P2400504B/S2400504B)

B) Course Title : Artificial Intelligence (Basic)

C) Pre- requisite Course(s) :

D) Rationale :

Artificial intelligence is the theory and development of computer systems able to perform tasks such as, visual perception, speech recognition, decision-making etc. normally requiring human intelligence. Data analytics gives the basis of developing any artificial intelligence system.

The Python programming language is one of the most accessible programming languages, has several modules to write programs to solve Artificial Intelligence, Machine Learning, Data Analysis problems. Moreover, it has simplified syntax and versatile data structures and functionsto speed up the code writing efficiently.

This course provides the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This course also provides the students the foundations for data analytics with python. The course explains data science techniques and the various Python programming packages required to prepare data for analysis, perform data analytics and create meaningful data visualization.

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 Elaborate the use of Artificial Intelligence for the problem solving as Technological driver.

CO-2 Write Python Programmes for solving problems.

CO-3 Analyze given data by using NumPy package of Python.

CO-4 Analyze given data by using Pandas package of Python.**CO-5** Visualize given data set using Matplotlib.

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	-	2	2	-	-	-	1		
CO-2	-	3	3	3	-	-	2		
CO-3	-	3	3	3	-	-	2		
CO-4	-	2	3	3	-	-	2		
CO-5	-	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				
2400504B	Artificial Intelligence (Basics)	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)	
2400504B	Artificial Intelligence (Basics)	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: T2400504B

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
module in the Python TSO 2l. Describe procedure to Import Libraryand functions in the Python TSO 2m. Write program using Iterativestatements.	repetition, membership & slicing), traversing a string using loops, built-in functions. Lists: introduction, indexing, list operations (concatenation, repetition, membership & slicing), traversing a list using loops, built- in functions, linear search on list of numbers and counting the frequency of elements in a list Dictionary: accessing items in a dictionary using keys, mutability of dictionary (adding a new item, modifying an existing item), traversing a dictionary, built-in functions **Python Functions:** types of function (built- in functions, functions defined in module, user defined functions), creating user defined function, arguments and parameters, default parameters, positionalparameters, function returning value(s), flow of execution, scope of a variable (global scope, local scope) **Modules and Packages:** Importing module using 'import' Regular Expressions,Exception Handling, PyPI Python PackageIndex, Pip Python package manager, Importing Libraries and Functions	
TSO 3a. Explain Data Analytics and its elements TSO3b. Differentiate Data Analysis and Data Analytics TSO 3c. Explain the use of open source data TSO 3d. Differentiate Qualitative and Quantitative data analysis TSO 3e. Explain procedure to Install NumPy Library TSO 3f. Use NumPy library to perform various operations and functions on array TSO 3g. Write Programs using NumPy for array manipulations	**Unit-3.0 Data Analytics and Computing with NumPy** **Data Analytics**: Data, Types of Data, Importance of Data, Data Analysis Vs Data Analytics, Types of Data Analytics, Elements of Analytics, Data Analysis Process, Qualitative and Quantitative analyses, Open Source Data. **NumPy Library**: Introduction, Installation, **Ndarray**: creating an array, intrinsic creation of an array, Data types, basic operations, aggregate functions, Indexing, slicing, Iterating, Conditions and Booleanarrays, Array **manipulation:** Joining, splitting, shape changing, sorting, Structured arrays, Reading and Writing array data on a File.	**CO-3**
TSO 4a. Apply Pandas data structure for data analysis TSO 4b. Write Programs using Pandas to perform various operations and functions on series. TSO 4c. Perform various operation in a Data Frame columns and rows TSO 4d. Write Programme to read and write on CSV, XLS and Text data files TSO 4e. Apply various data cleaning operations and prepare data.	**Unit-4.0 Data Analysis with Pandas** **Pandas data structures**: Series, Declaration, selecting elements, assigning values, Filtering values, operations, mathematical functions, evaluating values, handling missing data, creating series from dictionaries, adding two series. **Data Frame:** Defining, selecting elements, assigning values, membership, deleting a column, filtering. Index Objects: Indexing, Re-indexing, Dropping, sorting and ranking, Descriptive Statistics **Data Loading**: Reading and Writing csv, xls, text data files, Data Cleaning and Preparation: Handling missing data, removing duplicates, replacing values,Vectorized String Methods,	**CO-4**

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

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

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

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

Practical/ Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
		3e. Write a program to merge two dictionaries.	
LSO 4.1 Use built-in functions to solve given problem LSO 4.2 Create user defined functions to solve given problem	4	**Python Functions** 4a. Write a function to reverse a string. 4b. Write a function to calculate the factorial of a number.	CO-2
LSO 5.1 use basic data structure using NumPy LSO 5.2 Convert the list and tuple as NumPy array	5.	**Basic data structures in NumPy** 5a. Create a List, set, tuple and dictionary which stores the details of a student (roll no, name, dept, branch, percentage of mark) in Python and print the values. 5b. Convert the list and tuple as NumPy array.	CO-3
LSO 6.1 Create Arrays in Numpy using different intrinsic methods LSO 6.2 Perform arithmetic operations and mathematical operations using arrange and ones intrinsic method.	6	**Arrays in NumPy** 6a. Create arrays using different intrinsic methods (ones, zeros, arange, linspace, indice) and print their values. 6b. Check the results of arithmetic operations like add(), subtract(), multiply() and divide() with arrays created using arrange and ones intrinsic method. 6c. Check the results of mathematical operations like exp(), sqrt(), sin(), cos(), log(), dot() on an array created using arrange intrinsic method.	CO-3
LSO 7.1 Apply aggregate functions on data by using Built-in function s in Numpy	7	**Built-in functions in NumPy.** 7a. Load your class Mark list data from a csv (comma separated value) file into an array. Perform the following operations to inspect yourarray. Len(), ndim, size, dtype, shape, info() 7b. Apply the aggregate functions on this data and print the results. (Functions like min(), max(), cumsum(), mean(), median(), corrcoef(), std())	CO-3
LSO 8.1 Handle multiple arrays by applying various operations on arrays	8	**Handling Multiple Arrays** 8a. Create two python NumPy arrays (boys, girls) each with the age of nstudents in the class. 8b. Get the common items between twopython NumPy arrays. 8c. Get the positions where elements of twoarrays match. 8d. Remove from one array those items thatexist in another. 8e. Extract all numbers between a given rangefrom a NumPy array.	CO-3
LSO 9.1 Apply indexing on the given set of data	9	**Indexing in NumPy** 9a. Load your class Mark list data from a csv file into an array. 9b. Access the mark of a student in a particular subject using indexing techniques. 9c. Select a subset of 2D array using fancy indexing (indexing using integer arrays	CO-3
LSO 10.1 Create series using list and dictionary in pandas	10	**Working with a Series using Pandas** 10a. Create a series using list and dictionary.	CO-4

Practical/ Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 10.2 Print different values from series.		10b. Create a series using NumPy functions in Pandas. 10c. Print the index and values of series. 10d. Print the first and last few rows from theseries.	
LSO 11.1 Perform various operation in a Data Frame rows	11	**Working with Data Frame Rows** 11a. Slicing Data Frame using loc and iloc.11b. Filter multiple rows using isin. 11c. Select first n rows and last n rows 11d. Select rows randomly n rows and fractionsof rows (use df. sample method) 11e. Count the number of rows with each unique value of variables 11f. Select nlargest and nsmallest values.11g. Order/sort the rows	CO-4
LSO 12.1 Apply different techniques to merge and combine data	12	**Merge and combine data** 12a. Perform the append, concat and combine first operations on Data Frames. 12b. Apply different types of merge on data. 12c. Use a query method to filter Data Frame with multiple conditions.	CO-4
LSO 13.1 Create Linear Plot to identify various relation in the data using Matplotlib LSO 13.2 Create Scatter Plot to identify various relation in the data using Matplotlib	13	**Consider the Salary dataset, which contains 30observations consisting of years of workingexperience and the annual wage. Download thedata set from** https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset 13a. Create a linear plot to identify the relationship between years of workingexperience and the annual wages withsuitable title, legend and labels. 13b. Create a scatter plot to identify the relationship between years of working experience and the annual wages with title, legend and labels. 13c. Also distinguish between observations that have more than 5 years of working experience and observations that have less than 5 years of working experience by using different colors in one single plot.	CO-5
LSO 14.1 Plot Bar graph by Changing the color of each bar, Change the Edge color, Linewidth and Line style.	14	**Consider the Iris dataset, where observationsbelong to either one of three iris flower classes.Download the data set from** https://www.kaggle.com/arshid/iris-flower-dataset 14a. Visualize the average value for each feature of the Set osa iris class using a bar chart. 14b. Format the obtained bar graph by Changingthe color of each bar, Change the Edge color, Line width and Line style.	CO-5

L) Suggested Term Work and Self Learning: **S2400504B** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

1. **Handing Two-dimensional array in NumPy**
   Download the data set from
   https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.datahttps://www.kaggle.com/arshid/iris-flower-dataset

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

   Expected Outcome (Use various operations on two dimensional arrays in NumPy)

2. **Handling missing data and duplicates in Pandas:**
   a. Identify rows with missing data (isnull(), notnull()) and replace NA/Null data with a given value.
   b. Drop rows and columns with any missing data (dropna(), dropna(1))
   c. Find duplicate values and drop duplicates.
   d. Fill the missing values using forward filling and backward filling.
   e. Replace the missing value with new value and write the dataframe to a CSV file in the local directory.

   Expected Outcomes (a. Identify missing data, b. Find Duplicates values, c. Write the dataframe to a CSV file in the local directory.)

3. **Working with Data Frame Columns:**
   a. Create and print a Data Frame.
   b. Find the descriptive statistics for each column.
   c. Group the data by the values in a specified column, values in the index.
   d. Set Index and columns in a Data Frame.
   e. Rename columns and drop columns
   f. Select or filter rows based on values in columns.
   g. Select single and multiple columns with specific names

   Expected Outcome (Perform various operation in a Data Frame columns)

4. **Indexing & Sorting in NumPy:**
   a. Load your class Mark list data from a csv file into an array.
   b. Sort the student details based on Total mark.
   c. Print student details whose total marks is greater than 250 using Boolean indexing.

   Expected Outcomes (a. Sort the given set of data, b. Use indexing in an array)

5. **Array Slicing in NumPy:**
   a. Load your class Mark list data into an array called “marks” to store students roll num, subject marks and result.

b. Split all rows and all columns except the last column into an array called “features”.
c. Split the marks array into 3 equal-sized sub-arrays each for 3 different subject marks.
d. Split the last column into an array “label”.
e. Delete the roll num column from the marks array and insert a new column student name in its place.

Expected Outcome (Use array slicing in Numpy for the given set of data)

6. Consider the Iris dataset, where observations belong to either one of three iris flower classes.
Download the data set from
https://www.kaggle.com/arshid/iris-flower-dataset

a. Visualize the Histogram for each feature (Sepal Length, Sepal Width, petal Length & petal Width) separately with suitable bin size and color.
b. Plot the histograms for all features using subplots to visualize all histograms in one single plot.Save the plot as JPEG file.
c. Plot the box plots for all features next to each other in one single plot. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.

Expected Outcomes (a. Plot the Histogram for the various features using subplot, b. Plot the box plots for all features next to each other in one single plot)

c. Other Activities:

1. **Lab Activities:**
   - Install Python IDE and important Python Libraries
   - Install Anaconda and find the features of Jupyter Notebook.
   - Import various module using 'import '
   - Use Pip Python package manager.
   - Import Libraries and Functions in Python

2. **Seminar Topics:**
   - Technological rivers of modern Artificial Intelligence
   - Intelligent Agents and Environments in Artificial Intelligence
   - Various Search Strategies
   - Python for Data Science
   - Python Libraries and Packages used in data Science
   - Data Visualization
   - Various data set available over Internet

3. **Self-Learning Topics:**
   - Use of AI in Engineering and Technology
   - Data Science and Machine Learning
   - Problem and Goal Formulation
   - Search strategies
   - Breadth First Search and Depth First Search
   - Back tracking Search
   - N Queen and 8 Puzzle Problem

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	20%	20%	20%	--	30%	--	--
CO-2	10%	20%	20%	--	20%	20%	25%
CO-3	20%	25%	20%	30%	20%	20%	25%
CO-4	30%	25%	20%	20%	30%	30%	25%
CO-5	20%	10%	20%	50%	--	30%	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 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. Artificial Intelligence	9	CO-1	14	6	5	3
Unit-2.0. Python Programming	12	CO-2	14	4	4	6
Unit-3.0. Data Analytics and Computing with NumPy	10	CO-3	17	4	5	8
Unit-4.0. Data Analysis with Pandas	10	CO-4	18	4	5	9
Unit-5.0. Data Visualization with Matplotlib	7	CO-5	7	2	2	3
Total Marks	**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.	Conditional and Iterative statements	CO-2	-	90	10
2.	String handling	CO-2	-	90	10
3.	List, Tuples and Dictionary	CO-2	20	70	10
4.	Python Functions	CO-2	-	90	10
5.	Basic data structures in NumPy	CO-3	-	90	10
6.	Arrays in NumPy	CO-3	-	90	10
7.	Built-in functions in NumPy.	CO-3	20	70	10
8.	Handling Multiple Arrays	CO-3	20	70	10
9.	Indexing in NumPy	CO-3	-	90	10
10.	Working with a Series using Pandas	CO-4	-	90	10
11.	Working with Data Frame Rows	CO-4	20	70	10
12.	Merge and combine data	CO-4	40	50	10
13.	Consider the Salary dataset, which contains 30 observations consisting of years of working experience and the annual wage.	CO-5	80	10	10
14.	Consider the Iris dataset, where observations belong to either one of three iris flower classes.	CO-5	80	10	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 beprepared 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 14
2.	Online Python IDE	https://www.online-python.com/	S. No. 1 to 14
3.	Jupyter Notebook	Download from https://jupyter.org/	S. No. 1 to 14
4.	Pip Python package Manager	Download Pip 22.3 From https://pypi.org/project/pip/	S. No. 1 to 14
5.	Various modules, Libraries and Packages	NumPy, Pandas, Matplotlib, PyPlot package	S. No. 1 to 14

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Artificial Intelligence Basics - A Non-Technical Introduction	TomTaulli	Apress (2019)
2.	Fundamentals of artificial Intelligence	Chowdhary K. R	Springer 2020
3.	Artificial Intelligence A Modern approach	Stuart J. Russell and Peter Norvig	PrenticeHall 2010, 3rdEdition
4.	Introduction to Computing and Problem-Solving using Python	E. Balagurusamy	McGraw Hill Education (India)Pvt. Ltd. 1st Edition /2016
5.	Learning Python Programming	Jeffrey Elkner, Allan B.Downey, Chris Meyers	Samurai Media Limited. 2016
6.	Python Programming	Ashok Namdev Kamthane and Amit Ashok Kamthane	McGraw Hill Education (India) Pvt.Ltd.2020, 2nd Edition
7.	Programming in Python	Dr. Pooja Sharma	BPB Publications 2017
8.	Taming Python by Programming	Jeeva ose	Khanna Book Publishing Co(P)Ltd, 2017, Reprinted2019
9.	Python Data Analytics	Fabio Nelli	Apress,2015
10.	Python for Data Analysis: Data Wrangling with Pandas, Numpy, and IPython	Wes McKinney	O'REILLY 2018, Second Edition

(b) Online Educational Resources:

1. NPTEL Web Content- Artificial Intelligence, Prof. P. Mitra, Prof. S. Sarkar, IITKharagpur URL: https://nptel.ac.in/courses/106/105/106105078/
2. https://www.learnpython.org
3. www.python.org
4. https://www.tutorialspoint.com/python

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:

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

*****

A) Course Code : 2400504C(T2400504C/P2400504C/S2400504C)

B) Course Title : Internet of Things (Basic)

C) Pre- requisite Course(s) : Digital Electronics, Electronics Circuits, Fundaments of Computers and Computer networks

D) Rationale :

The Internet of Things (IoT) is the upcoming field that has the capability to connect everything on the earth. This course focuses on the development of IoT concepts such as sensing, actuation with implementation of communication protocols.

The course also focuses on real life aspects of IoT and how to integrate it in real life projects. The course will simplify the concept of IoT by using the Node MCU board for IoT application development. In this course students will learn about the use of Node MCU and its applications as a beginner/intermediate in the field of IoT. Apart from this, students will learn about the APIs, by using which integration of features like send Email, WhatsApp messages and notification based on certain events in projects is possible. Overall, this course covers both hardware and software aspects of IoT with practical exposure.

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 Describe the functions of each block of the basic IoT system

CO-2 Explain communication protocol used in IoT and its applications

CO-3 Use appropriate sensors for the specific measurement through the IoT platform

CO-4 Explain APIs, client-server connections and its integration in real life applications.

CO-5 Build and test a complete, working IoT system involving prototyping, programming, and data analysis

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	1	2	2	2	2	-	-		
CO-3	1	3	2	2	2	2	2		
CO-4	1	1	2	3	-	2	2		
CO-5	1	1	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:

CourseCode	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				
2400504C	IoT (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400504C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a. Describe the concept of IoT. TSO.1. b. Explain the functions of each block of the Basic IoT system. TSO.1. c. Compare features of various IoT platforms TSO.1. d. List IoT Real time Applications. TSO.1. e. Describe the functioning of given real-time applications	**Unit-1.0 Introduction to IoT** 1.1 Basics of IoT, concepts of IoT, History of IoT 1.2 Basic IoT System and its building blocks 1.3 Various platforms for IoT (e.g. AWS, AZURE, GCP) 1.4 Introduction to Python programming and IoT software 1.5 Applications of IoT	**CO-1 and CO-5**
TSO.2. a. Explain various communication protocols. TSO.2. b. Explain working and application of blue tooth TSO.2. c. Explain working and application of ZigBee TSO.2. d. Explain working and application of LoRa TSO.2. e. Explain working and application of Wi-fi	**Unit 2.0 IoT Communication Protocols** 2.1 Basics of given communication protocol alongwith its applications 2.2 Explain Communication Protocols MQTT 2.3 Bluetooth Low Energy ZigBee LoRa Wi-fi	**CO-1 and C02**
TSO.3. a. Differentiate between sensor and Actuator. TSO.3. b. Classify IoT sensors on the basis of their application. TSO.3. c. Describe the function of each block of Node MCU. TSO.3. d. Explain the procedure to connect sensors with Node MCU.	**Unit-3.0 Sensors and Hardware for IoT** 3.1 Sensors and Actuators, Transducers, Classifications of sensors, IoT Sensors 3.2 Development Boards, classifications, and basics of wireless networks, WiFi libraries 3.3 Introduction to node MCU, block diagram, functions, interfacing with sensors and publishing data on webserver 3.4 Device integration with node MCU 3.5 Interfacing of sensors with boards	**CO-1, CO-3 and CO-5**
TSO.4. a. Define APIs and its uses TSO.4. b. Explain working and application of REST. TSO.4. c. Explain working and application of SOAP TSO.4. d. Explain working and application of json TSO.4. e. Explain the integration of API in IoT application development.	**Unit.4.0 IoT APIs and its Integration** 4.1 Explain APIs and its use 4.2 Explanation of given IoT APIs along with its applications 4.3 MQTT, Broker, subscriber, publisher **4.4 REST** **SOAP** **4.5 JSON** **4.6 Programming API using Python**	**CO-1 and CO-4**
TSO.5. a. Differentiate between industrial IoT and IoT. TSO.5. b. Describe the applications of IoT in the medical field. TSO.5. c. Describe the medical applications of IoT in the agriculture field. TSO.5. d. Describe the innovative IoT applications.	**Unit. 5.0 IoT Applications**: - 5.1 Industrial IoT and Internet of everything 5.2 IoT for consumer electronics products 5.3 IoT for Medical applications 5.4 IoT for Agriculture 5.5 IoT for security and Law enforcement	**CO-1 and CO-5**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant Cos Number (s)
LSO 1.1 List various IoT platforms. LSO 1.2 List Down broad features of given platforms. LSO 1.3 List IoT based features in python language.	1.	Prepare a list of platforms used for IoT. Prepare a list of features of above IoT platforms. Prepare a list of features provided by python language for IoT applications.	CO-1
LSO 2.1 Arduino connection with Arduino IDE. LSO 2.1 Connect Bluetooth with Arduino. LSO 2.3 verification of data communication with Bluetooth.	2.	Establish connectivity between various components of IoT. Establish connection between Arduino and Bluetooth module. Establish connection using WiFi	CO-2
LSO 3.1 Measure the temperature of the givensensor. LSO 3.2 Measure the humidity of the given sensor. LSO 3.3 Measure the pressure of the given sensor.	3.	Publish data on the IoT platform. Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system. Measure the humidity of a remotely located humidity sensor Using IOT based humidity data-monitoring system. Measure the pressure of a remotely located pressure sensor Using IOT based pressure data-monitoring system.	CO-3
LSO 4.1 Working with APIs. LSO 4.2 Implementation of APIs using POSTMANApplication.	4	Download and Configure POSTMAN Application Verify REST APIs through POSTMAN. Verify JSON APIs through POSTMAN. Verify SOAP APIs through POSTMAN.	CO-4
LSO 5.1 Identification of components for variousapplications. LSO 5.2 Estimate the cost for components.	5.	Identify components for given project Estimate the cost to make Project working.	CO-5

L) Suggested Term Work and Self Learning: S2400504C Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

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

c. Other Activities:

1. Seminar Topics: - "Future of IoT"
   "Technologies for IoT ", "Smart City and IoT"
2. Visit to industry for latest IoT setup in industrial process.

3. Surveys of market for availability of various types of sensors and its pricing.
4. Product Development: Development of projects for real life problem solution using IoT.
5. Software Development: various open source platform operations.

d. Self-Learning Topics:

1. IoT hardware and their use for various applications
2. IoT sensors technical specifications
3. IoT enabled services

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. Introduction to IoT	5	CO-1	7	3	4	-
Unit-2.0. IoT Communication protocols	5	CO-2	7	3	2	2
Unit-3.0. Sensors and Hardware for IoT	14	CO-3	21	6	7	8
Unit-4.0 IoT APIs and its Integration	14	CO-4	21	6	5	10
Unit-5.0. IoT Applications	10	CO-5	14	2	4	8
Total Marks	**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.	Prepare a list of platforms used for IoT.	CO-1	60	30	10
2.	Prepare a list of features of above IoT platforms.	CO-1	60	30	10
3.	Prepare a list of features provided by python language for IoT applications.	CO-1	60	30	10
4.	Establish connectivity between various components of IoT.	CO-2	60	30	10
5.	Establish connection between Arduino and Bluetooth module.	CO-2	60	30	10
6.	Establish connection using WiFi	CO-2	70	20	10
7.	Publish data on the IoT platform.	CO-3	70	20	10
8.	Measure the temperature of a remotely located temperature sensorUsing IOT based temperature data-monitoring system.	CO-3	60	30	10
9.	Measure the humidity of a remotely located temperature sensor Using IOT based temperature data-monitoring system.	CO-3	60	30	10
10.	Measure the pressure of a remotely located temperature sensor UsingIOT based temperature data-monitoring system.	CO-3	60	30	10
11.	Publish the data using Mqtt	CO-4	60	30	10
12.	Download and Configure POSTMAN Applications	CO-4	60	30	10
13.	Verify REST APIs through POSTMAN.	CO-4	60	30	10
14.	Verify JSON APIs through POSTMAN.	CO-4	60	30	10
15.	Verify SOAP APIs through POSTMAN.	CO-4	60	30	10
16.	Identify components for given project	CO-5	50	40	10
17.	Estimate the cost to make Project working.	CO-5	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 beprepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriatelyselected, 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	Bluetooth Modem-BlueSMiRF Silver	Sparkfun Bluetooth modem	As mentioned above list
2	Postman Software	Open-source downloadable	
3	Node MCU board	Generic	
4	IoT free cloud	Arduino cloud/Thing Speak/Blynk	
5	ATAL Lab Package-1 Package-2 Package-4	As per the list as address below ATAL Equipment list' (http://aim.gov.in/guidelines-for-school.php).	

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Internet of ThingsArchitecture and Design Principles	Raj Kamal	Mc Graw Hills, New Delhi ISBN 13: 978-93-90722-38-4
2	Internet of things (IoT): technologies,applications, challenges and solutions	Edited By BK Tripathy ,J Anuradha	CRC Press, ISBN 9780367572921, June 30, 2020
3	Internet-of-Things(IoT) Systems: Architectures, Algorithms, Methodologies	by Dimitrios Serpanos &Marilyn Wolf	Springer; 1st ed. 2018 edition (17 January 2018)
4	Custom Raspberry Pi Interfaces: Design and build hardware interfaces for the Raspberry	Pi by Warren Gay	Apress; 1st ed. edition (23 February 2017), ISBN- 10: 9781484224052, ISBN-13: 978-1484224052
5	'Learning Internet of Things',	Peter Waher	Packt Publishing, 2015, ISBN9781783553532, https://lib.hpu.edu.vn/handle/123456789/31693
6	Sensors, Actuatorsand Their Interfaces,	N. Ida	Scitech Publishers, 2014.

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

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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

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A) Course Code : 2400504D(T2400504D/P2400504D/S2400504D)

B) Course Title : Drone Technology (Basic)

C) Pre- requisite Course(s) :

D) Rationale :

Rapid technological innovation has provided users cutting-edge products at affordable prices. Traditionally, drones had been limited to military use due to high costs and technical sophistication. In recent years, the drone has number of commercial uses and are also proving to be extremely beneficial in places where a man cannot reach or is unable to perform in a timely and efficient manner. Today, drones are used in construction, photography, agriculture, defense, environmental studies and monitoring and other industries to protect the skies, repopulate forests and accomplish much more on a huge scale. This course will acquaint the student with the basic drone technology and applicable drone rules and regulations in India. Considering that the main operational areas of diploma holders, it is essential that he should be exposed to basic drone designing, programming, operating, maintaining and using them safely.

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 Operate a drone safely by applying appropriate drone rules and regulations.

CO-2 Design the structure of drone with drone components and equipment.

CO-3 Interface flight controller board with sensors, ESC and radio communication unit in drone technology.

CO-4 Use drone simulator and identify different types of ports and connectors of drone.

CO-5 Use python programming while drone designing.

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	2	-	-	-	3	-	2		
CO-2	3	2	3	3	-	-	-		
CO-3	3	2	3	3	-	-	-		
CO-4	2	-	-	2	-	3	2		
CO-5	-	2	2	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				
2400504D	Drone Technology (Basics)	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)	
2400504D	Drone Technology (Basics)	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: T2400504D

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

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

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504D

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1 Choose suitable materials for makingdrone frame.	1.	Determine the strength of materials used in drones frame.	CO-2
LSO 2 Select suitable materials for making drone propellers.	2.	Determine the strength of materials used in drones Propellers.	CO-2
LSO 3 Use appropriate battery as per need of flight time for specific drone application.	3.	Test different parameters of batteries used in drones	CO-2
LSO 4 Identify suitable motors as per payload of specific drone application.	4.	Test motors suitable for specific Drone application.	CO-2
LSO 5 Operate Gyro sensor and Accelerometer.	5.	Test and measure Gyro sensor and Accelerometer and their characteristics.	CO-2
LSO 6.1 Identify different sensors based on their characteristics. LSO 6.2 Interface different types of sensor in drone.	6.	Test different sensors and their characteristics with Microcontroller based Flight controller board.	CO-2, CO-3
LSO 7 Demonstrate four type of drone motion.	7.	Determine thrust/torque of motor by changing different drone motion	CO-2, CO-3
LSO 8.1 Configure Flight control board (FCB) LSO 8.2 Demonstrate use of Flight control board (FCB	8.	Test and troubleshoot Flight control board (FCB).	CO-3

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

L) Suggested Term Work and Self Learning: S2400504D Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

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

c. Other Activities:

1.Seminar Topics-History of Drone, Drone regulations, Proximity sensor, Bernoulli's principle apply in drone, Radio communication used in drones, Drone Simulator, Python Programming.
2.Visits: Visit nearby tool room, small industry, Drone training institute facilities. Prepare report of visit with special comments of drone technology used, material used, cost of printed component.
3.Surveys: Survey nearby electronics shop and Prepare report of list of drone component and its specification and explore Drone simulator.
4.Product Development
5.Software Development

d. Self-Learning Topics:

1. History of Drones
2. Drone in Indian aspect
3. Drone regulations
4. Principle of aerodynamics for Drones
5. Drone simulator

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%	10%	--	10%	--	--
CO-2	30%	30%	30%	33%	30%	30%	30%
CO-3	30%	30%	30%	34%	30%	30%	30%
CO-4	15%	10%	15%	--	15%	20%	20%
CO-5	15%	20%	15%	33%	15%	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 (Cl) Hours	Relevant Cos Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to Drone Technology	6	CO-1	08	03	02	03
Unit-2.0. Drone and its component	12	CO-2	20	05	07	08
Unit-3.0. Drone controller and motion	12	CO-3	20	05	07	08
Unit-4.0. Connections and Interfaces of Devices in Drone and Drone Simulator	8	CO-4	08	03	02	03
Unit-5.0. Introduction to Python for Drone	10	CO-5	14	04	04	06
Total Marks	**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 strength of materials used in drones frame.	CO-2	60	30	10
2.	Determine the strength of materials used in drones Propellers.	CO-2	60	30	10
3.	Test different parameters of batteries used in drones	CO-2	50	40	10
4.	Test motors suitable for specific Drone application.	CO-2	50	40	10
5.	Test and measure Gyro sensor and Accelerometer and their characteristics.	CO-2	50	40	10
6.	Test different sensors and their characteristics with Microcontroller based Flight controller board.	CO-2, CO-3	50	40	10
7.	Determine thrust/torque of motor by changing different dronemotion	CO-2, CO-3	60	30	10
8.	Test and troubleshoot Flight control board (FCB).	CO-3	60	30	10
9.	Test and perform communication of Flight control board (FCB) with sensor	CO-3, CO-2	60	30	10
10.	Test and perform communication of Flight control board (FCB) with motor.	CO-3, CO-2	60	30	10
11.	Test and perform communication of Flight control board with ESC.	CO-3	60	30	10
12.	Test and perform communication of Flight control board with RF transceiver.	CO-3	60	30	10
13.	Test Hardware assembly for drone.	CO-4 CO-3	50	40	10
14.	Perform different motion in drone simulator.	CO-4	50	40	10
15.	Build and run loops and decision statements for specific applicationin Python.	CO-5	50	40	10
16.	Build and Run functions for specific application and pass arguments in Python.	CO-5	50	40	10
17.	Write basic programming in python to interface different componentof Drones.	CO-5, CO-3	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/ ImplementationStrategies 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 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	1-13
2.	Propellers	10X4.5 CW/Others	1-13
3.	Speed Sensor	3.3 or 5.0Vdc	1-13
4.	Distance Sensor	5Volt operating voltage	1-13
5.	Gyro sensor and Accelerometer	5Volt operating voltage	1-13
6.	Barometer	Altitude tracking, temp range from 25°C to 40°C	1-13
7.	TOF Sensor	Accurate ranging up to 4 m, Fast ranging frequency up to 50	1-13
8.	Battery	Lithium Polymer Battery,2200mAH/others	1-13
9.	Motor	BLDC,1000kv or 1000RPM/volt	1-13
10.	Electronic speed Controller (ESC)	30 Amp,2-4s or cell	1-13
11.	Flight Controller Unit	KK 2.1.5/ ArdupilotAPM 2.8/ Pixhawk/others	1-13
12.	Transmitter and Receiver for radio signal	4 channels/6 Channels, 2.4 GHz & 5.8 GHz	1-13
13.	Drone Simulator Software	RC flight simulator	14
14.	Python Software	Hardware required-More than 4 GB RAM, 64-bitCPU preferable	15,16,17

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Terry Kilby&Belinda Kilby	Shroff/Maker Media, First edition 2016, ISBN-978-9352133147
2.	Agricultural Drones: A Peaceful Pursuit	K R Krishna	Apple Academic Press,1st edition 2018, ISBN-978-1771885959
3.	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
4.	Building Multicopter Video Drones: Build andfly multicopter drones to gather breathtakingvideo 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

(b) Online Educational Resources:

1. https://nptel.ac.in/courses/101104073
2. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
3. https://www.scienceabc.com/innovation/what-is-drone-technology.html
4. https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or- how-does-drone-technology-work/
5. https://www.youtube.com/watch?v=OWaXIK9sHeE
6. https://books.google.co.in/books?id=2M0hEAAAQBAJ&printsec=copyright&redir_esc=y#v=onep age&q&f=false

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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

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A) Course Code : 2400504E(T2400504E/P2400504E/S2400504E)

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

C) Pre- requisite Course(s) : Computer Aided Modeling

D) Rationale :

Additive manufacturing (AM) or Additive layer manufacturing (ALM) is the industrial production name for 3D Printing. 3D Printing is a process that makes solid objects from a digital model. It involves depositing material either metal, powdered plastic, or liquid in thin layers (2D) to get a 3D object. This basic course on 3D Printing tries to develop understanding of the process of making real object from digital model in the students. It also covers the software/hardware required, various materials used for FDM based 3D Printing and details about printing process parameters. The knowledge gained through this course will help the students to take up advanced course on 3D Printing in next 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 Develop CAD models for 3D Printing.

CO-2 Import and Export CAD data in .STL file format to generate GCODE file.

CO-3 Select suitable FDM based 3D Printing material for given applications.

CO-4 Select suitable FDM based 3D Printing process parameters for given situations.

CO-5 Produce products using FDM based 3D Printing 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	-	-	2		
CO-2	3	2	-	2	-	-	-		
CO-3	3	3	-	2	3	-	-		
CO-4	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 Credits (C)
		L	T				
2400504E	3D Printing and Design (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400504E	3D Printing and Design (Basics)	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: T2400504E

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5a. Select suitable 3D Printer (FDM) and software for the given application with justification. *TSO 5b.* Analyze the effect of given FDM based 3D printing process parameters using 3D printer software simulation. *TSO 5c.* List steps to perform 3D scanning of the given object. *TSO 5d.* Repair 3D scanned digital model. *TSO 5e.* Set different FDM 3D printing process parameters to get a sound plastic component.	**Unit-5.0 3D Printers and Software and Scanners** 5.1 Construction details and working of established FDM based 3D printers for plastics parts. 5.2 Accuracy, Precision and Tolerance in 3D printing. 5.3 3D Printer software- Fusion 360, Solidworks, Onshape, Tinkercad, Ultimaker Cura, MeshLab, Simplyfy 3D, Repetier host, Slic3r, etc. – use and operation of anyone. 5.4 3D Scanners and working. 5.5 Producing a part using FDM based 3D Printer.	**CO4, CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504E

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Use CAD software. *LSO 1.2.* Prepare digital models of simple 3D entities.	1.	Develop digital models of following simple components using any CAD software: • Nut • Bolt • Network cable Jack • Coat button • Spoon	CO1
LSO 2.1. Prepare digital models of complex 3D entities and assemblies.	2.	Develop digital models of following assemblies using any CAD software: • Connecting Rod • Piston • Electric switch • Bathroom Tap • Mouse	CO1
LSO 3.1. Surf web for downloading readymade free CAD models. *LSO 3.2.* Convert one CAD file format into another.	3.	Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format.	CO1
LSO 4.1. Use the given Slicing software for 3D Printing. *LSO 4.2.* Perform slicing operation on the given digital model.	4.	Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3.	CO2
LSO 5.1. Use the available 3D printing software. *LSO 5.2.* Selection of 3D printing process and performance parameters.	5.	Analyse the effect of different process parameters, materials on printing time, material required, surface finish, etc. through simulation using 3D printing software on sliced models available from Pr. No. 4	CO3, CO4, CO5
LSO 6.1. Produce single plastic components using available 3D printer. *LSO 6.2.* Perform post processing operations on printed component.	6.	Print one single component on available FDM based 3D printer with PLA/ABS material	CO3, CO4, CO5
LSO 7.1. Select appropriate layer thickness, tolerance, fit.	7.	Print one assembly on available FDM based 3D printer with PLA/ABS material	CO3, CO4, CO5

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

L) **Suggested Term Work and Self Learning: S2400504E** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

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

c. Other Activities:

1. Seminar Topics:
   - Commercially available 3D printers and software.
   - Strength of 3D printed Plastic components as compared to Die cast Plastic components.
   - Properties of PLA and ABS 3D printing materials.
   - Reverse engineering application of 3D Printing.

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

3. Self-Learning Topics:
    - 3D printing of flexible plastic components.
    - 3D printing of micro/mini components.
    - Conversion of CAD file formats into IGES.
    - 3D scanning process.

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 Additive Manufacturing Introduction and CAD	8	CO1	10	3	3	4
Unit-2.0 Data Preparation for 3D Printing	8	CO1, CO2	10	3	2	5
Unit-3.0 Additive Manufacturing Techniques	8	CO3, CO4	10	5	2	3
Unit-4.0 Application of 3D Printing	12	CO3, CO4	20	5	6	9
Unit-5.0 3D Printers and Software and Scanners	12	CO4, CO5	20	4	6	10
Total	**48**	**-**	**70**	**20**	**19**	**31**

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 digital models of following simple components using any CAD software: • Nut • Bolt • Network cable Jack • Coat button • Spoon	CO1	30	60	10
2.	Develop digital models of following assemblies using any CAD software: • Connecting Rod • Piston • Electric switch • Bathroom Tap • Mouse	CO1	40	50	10
3.	Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format.	CO1	30	60	10
4.	Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3.	CO2	30	60	10
5.	Analyse the effect of different process parameters, materials on printing time, material required, surface finish, etc. through simulation using 3D printing software on sliced models available from Pr. No. 4	CO3, CO4, CO5	30	60	10
6.	Print one single component on available 3D based Printer with PLA/ABS material	CO3, CO4, CO5	30	60	10
7.	Print one assembly on available 3D based Printer with PLA/ABS material	CO3, CO4, CO5	30	60	10
8.	Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect)	CO3, CO4, CO5	40	50	10
9.	Change printing process parameters and repeat experiment number 6.	CO4, CO5	40	50	10
10.	Scan the given complex component using available 3D Sanner.	CO5	40	50	10
11.	Print the 3D scanned digital model of Pr. No. 10 on available 3D based Printer with PLA/ABS material	CO5	30	60	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	1,2
3.	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	6, 7, 8, 10
4.	3D Printing Material	ABS/PLA **OR** Available with CoE	6, 7, 8, 10
5.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE	3,4
6.	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 etc.	6, 7, 8, 10
7.	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	10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074
2.	3D Printing and Design	Sabrie Soloman	Khanna Publishing House, Delhi ISBN: 9789386173768
3.	3D Printing and Rapid Prototyping- Principles and Applications	C.K. Chua, Kah Fai Leong	World Scientific, 2017 ISBN: 9789813146754
4.	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
5.	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing	Lan Gibson, David W. Rosen, Brent Stucker	Springer, 2010 ISBN: 9781493921133
6.	Laser-Induced Materials and Processes for Rapid Prototyping	L. Lu, J. Fuh, Y.S. Wong	Kulwer Academic Press, 2001 ISBN: 9781461514695

(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://www.youtube.com/watch?v=b2Od4YHcLAQ

4. https://www.youtube.com/watch?v=EF8CNR-gcXo
5. https://www.academia.edu/41439870/Education_Resources_for_3D_Printing
6. https://www.think3d.in/landing-pages/beginners-guide-to-3d-printing.pdf
7. https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/

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. 3D Printer Users' Guide
4. 3D Printer Material Handbook
5. Lab Manuals

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A) Course Code : 2400504F(T2400504F/P2400504F/S2400504F)

B) Course Title : Industrial Automation (Basic)

C) Pre- requisite Course(s) : Basic Mechanical Engineering, Basic Electrical Engineering, Digital Electronics and Basic programming skills

D) Rationale :

The technological education and research scenario, all over the world, is turning towards a multidisciplinary one. The present scenario is different as compared to the recent past in the sense that the engineering disciplines are now dilating instead of diverging. The primary reason being that the current technological designs are of highly complex and inter-interdisciplinary nature involving synergistic integration of many aspects of engineering knowledge base**.** Industrial automation has become an essential part of every modern industry. Automation helps industry to increase the productivity, quality, accuracy and precision of industrial processes. Stiff competition, higher quality standards and growing concerns of safety & environmental damage have pushed the Industrial sector to adapt state-of-the-art Automation Techniques for effective utilization of resources and optimized performance of the plants. Today engineer is needed to meet the requirements of designing appropriate automation systems. They should have the knowledge of different fields like PLC and PID based Controller, Instrumentation, Networking, Industrial Drives, SCADA/HMI, High speed data acquisition, etc., to become a successful automation engineer. The discipline Automation is enormous in magnitude. The students passing this course will gain basic understanding about industrial automation and will be prepared to take up the advance course in Industrial automation in next 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 Apply principles and strategies for automation for a given situation.

CO-2 Use sensors and input devices as per given situation.

CO-3 Test the given PLC for its functionality.

CO-4 Use actuators and output devices as per given situation.

CO-5 Test the working of various types of control system and controllers

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	2	-	2	2	-	2		
CO-2	3	2	2	2	-	-	2		
CO-3	3	2	2	2	2	-	2		
CO-4	3	2	2	2	2	-	2		
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				
2400504F	Industrial Automation (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature control, Conveyor system control	
TSO.3.a Identify the commonly used input field devices in PLC installations along with their symbols. TSO.3.b Draw symbol of various switches used in PLC installations describing the function of each switch. TSO.3.c Identify the various digital input devices used in a PLC installation. TSO.3.d Identify the commonly usedsensors as input field devices found in PLC installations. TSO.3.e Describe the working of different types of discrete sensors giving their applications. TSO.3.f Describe the working of different types of advanced sensors giving their applications. TSO.3.g Select Sensors as per the given requirement for ecofriendly automation	**Unit 3.0 – Sensors and Input field Devices** Analog input devices-Electromagnetic relays,Contactors, Motor starters, Manually operated Switches Toggle switch, pushbutton switch, knife switch and selector switches Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols Discrete/Digital Input device, Constructionand working of Sensors • Proximity sensors- Inductive, Capacitive, Optical and ultrasonic Advanced sensors- Construction and workingof • Temperature sensors- Thermistor, Thermocouple and Resistance temperature Detector (RTD) • Liquid level sensor -Capacitive and Ultrasonic • Force -Strain/Weight sensors • Flow sensors – turbine flow sensor • Pressure sensors- Linear Variable Differential Transformer (LVDT) • Inclination sensor -Inclinometer • Acceleration sensor- Accelerometer Angular and linear position sensor	**CO3**
TSO.4.a Classify the actuators. TSO.4.b Describe the construction and working of a given actuator. TSO.4.c Explain the basic principle of operation of a given actuator. TSO.4.d Differentiate between hydraulic and pneumatic actuators TSO.4.e Explain the basic principle of operation of a given control valve. TSO.4.f Select actuators and valves as per the given requirement for ecofriendly automation. TSO.4.g Develop different hydraulic and pneumatic circuits for simple application. TSO.4.h Identify the commonly used output field devices in PLC installations TSO.4.i Draw the symbol of various output devices used in PLC installations describing the function of each. TSO.4.j Select output devices for a PLC installation as per the requirement.	**Unit 4.0- Actuators and Output Devices** Introduction to actuators, Classification ofactuators Mechanical actuators -Translational and rotation motion, kinematic chains, cams, gears, belt and chain drives, bearings Hydraulic and Pneumatic actuators- linear and rotary actuators, single and doubleacting cylinder, directional, process and pressure control valves Electrical actuators • Electromechanical actuators Construction, working and application of Stepper motors, AC/DC Servo motors,BLDC Motor (Very brief) • Electrohydraulic actuators-Construction, working and application of Electro- hydrostatic actuator (EHA), ON/OFF Electro-hydraulic Rotary Actuator (E2H90, Control Valve Rotary Actuator (E2HR), Solenoid valve Thermal actuators -Construction, workingand application of Hot-And-Cold-Arm Actuators, Chevron-Type Actuators Magnetic actuators- Construction, working principle	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	and application of Moving coil actuators, moving magnet actuator, Moving iron actuator Selection criteria of actuators Other Output devices- Indicators, Alarms Pilot Lights, Buzzers, Valves, Motor starters, Horns and alarms, Stack lights Control relays,Pumps and Fans.	
TSO.5.a Describe the basic process control system with the help of a block diagram TSO.5.b Explain the types of control available in a process control TSO.5.c Describe the different types of controllers in a closed loop systemwith the help of a block diagram TSO.5.d Describe the construction, working and application of a given control system components.	**Unit 5.0– Control System** Block diagram of a basic control system Open and closed loop system, their transfer function First order and second order system and their output response and parameters Different types of inputs-step and ramp Types of control – On-off, Feed forward, Open loop and closed loop control and Transfer function Controllers in closed loop control • Proportional Controller (P Controller) • Integral Controller (I Controller) • Derivative controller (D- Controller) • P-I Controller • P-D Controller PID Controller	**CO5**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify various building blocks and major automation components in a given robotic system LSO 1.2 Identify various building blocks and major automation components in a given electrical drives	1.	Identify major automation components in a given system	CO1
LSO 1.3 Analyze and plan the steps to automate the given system.	2.	Analyze given traditional machine in the laboratory for and identify thesteps and components required to automate it.	
LSO 1.4. Identify the building blocks of a given typical SCADA system LSO 1.5. Identify the symbol library of SCADA software	3.	Use Scada software for simple application	
LSO 2.1 Identify the various parts and front panel status indicators of the given PLC.	4.	Observe various parts and frontpanel indicators of a PLC	CO2
LSO 2.2 Identify different input and output devices that can be connected to a given PLC.	5.	Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC	
LSO 2.3 Test the analog input and output lines of the given PLC.	6.	Identify Analog input and outputlines of a PLC	
LSO 2.4 Test the digital input and outlines of the given PLC.	7.	Identify digital input and output linesof a PLC	

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.5 Use PLC to control the devices like Lamp, Alarm, motor using push button switches	8.	Practice using PLC to control various digital and analog output devices	
LSO 3.1. Test the response of digital inductive proximity sense or used to detect different types of materials	9.	Identify different types of digital inductive proximity sensor and itsuse	CO3
LSO 3.2. Test the response of digital capacitive proximity sensors used to detect o different materials	10.	Identify different types of digital capacitive proximity sensor and itsuse	
LSO 3.3. Test the response of digital optical proximity sensor used to detect different materials	11.	Identify different types of digital optical proximity sensor and its use	
LSO 3.4. Test the response of digital ultrasonic proximity sensors used to detect different materials	12.	Identify different types of digital ultrasonic proximity sensor and itsuse	
LSO 3.5. Use thermistor to measure temperature of a given material	13.	Identify different types ofthermistor and its use	
LSO 3.6. Use Thermocouple to measure the temperature of a given liquid and plot the output voltage versus temperature	14.	Observe the conversion of temperature to electric parameterconversion of a Thermocouple	
LSO 3.7. Use RTD to control the temperature of an oven	15.	Observe different types of RTDs usedin industries for temperature measurement	
LSO 3.8. Use flow sensors to measure the flow of a given liquid or gas	16.	Observe different types of flow sensors used in industries for flowmeasurement	
LSO 3.9. Use pressure sensors to measure the pressure of a liquid or gas	17.	Observe different types of pressure sensors used in industries for pressure measurement	
LSO 3.10. Use load cell for measurement of mechanical force/weight.	18.	Observe the different types of loadcell used in industries for force/weight measurement	
LSO 4.1 Design and actuate pneumatic circuit for lift control LSO 4.2 Design a pneumatic system that rivets the pockets on jeans LSO 4.3 Design pneumatic circuit to open and close the security gate and control the speed. LSO 4.4 Design a circuit for speed control of hydraulic motor meter out circuit by using 4/3 DC valve. LSO 4.5 Design a circuit for speed control of double acting cylinder meter in by using 4/2 dc solenoid valve. LSO 4.6 Designing a circuit for speed control of double acting cylinder meter out by using 4/3 solenoid valve	19.	Design and actuate pneumatic/ hydraulic circuit for the given situation	CO4
LSO 4.7 Direct acting of hydraulic motor	20.	Operate hydraulic motor	
LSO 4.8 Operate stepper motor and control the motor by changing number of steps, the direction of rotation and speed.	21.	Operate stepper motor	
LSO 4.9 Identify the components of thermal and magnetic actuators available in the laboratory. LSO 4.10 Use thermal and magnetic actuators	22.	Thermal and magnetic actuators	

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1	Test the output response of a open loop closed loop and feed forward path	23.	Analyze the given system to studyopen loop, closed loop and feed forward path.	CO5
LSO 5.2	Build and test the output response of a first order system for a step input using a CRO	24.	Analyze the given first order systemand its transfer function and output response	
LSO 5.3	Build and test the response of a second order system for a step input using CRO. Also mark various parameters	25.	Analyze the given second order system and its transfer function andoutput response	
LSO 5.4	Test the Output response of an on-off and Proportional control-based level control system.	26.	Analyze the given water level control system with on-off, Proportionalcontrol.	
LSO 5.5	Test the Output response pf a P+I+D based level control system.	27.	Analyze the given water level control system with P+I+D control.	

L) Suggested Term Work and Self Learning: S2400504F 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. Prepare a list of open source PLC software
iii. Prepare a list of open source SCADA software.
iv. List the practical applications of PLC systems
v. List the practical applications of SCADA systems.
vi. Compare the PLC and PC with regard to:
   - Physical hardware differences
   - Operating environment
   - Method of programming
   - Execution of program
vii. Prepare classification chart of different types of actuators.
viii. Differentiate between Nano and micro actuators.

b. Micro Projects:

1. Develop a relay-based motor control automation such that the motor reverses its direction when the limit switches are activated.
2. Develop a simulation to connect analog and digital input to the PLC.
3. Develop a simulation to connect analog and digital output to the PLC.
4. Develop a simple automatic water level controller using magnetic float switch.
5. Develop a simple automatic door system using optical sensor and linear actuator.
6. Troubleshoot the faulty equipment/kit available in automation laboratory
7. Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
8. Develop a working model of a given application using given actuators and valves.

c. Other Activities:

1. Seminar Topics- PLC architecture, Different types of sensors, Industrial Applications of PLC and SCADA
2. Visits – Visit any industry with full or semi automation and prepare a report on type of automation used.
3. Surveys-Carry out a market/internet survey of PLC and prepare the comparative technicalspecifications of any one type of PLC (Micro or Mini) of different manufacturer.
4. Product Development- Develop a prototype automatic railway crossing system
   Software Development- Download any open source software for PLC and install on your laptop/PC and carry out basic PLC programming
5. Surveys – carry out market survey for different types of electrical actuators available and prepare the comparative technical specifications of electrical actuators used in industries.
6. Visit industry and prepare a report on different types of hydraulic and pneumatic circuits used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.

d. Self-Learning Topics:

1. Use of PLC for different industrial applications
2. Use of sensors in commercial field
3. Use of sensors in home automation
4. Compare Specifications of PLCs of different manufacturers of any one type 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 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	15%	15%	20%	--	30%	20%	20%
CO-2	20%	25%	20%	--	20%	25%	20%
CO-3	25%	20%	20%	30%	20%	20%	20%
CO-4	25%	20%	20%	20%	30%	20%	20%
CO-5	15%	20%	20%	50%	--	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 (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Overview of Industrial Automation	8	CO1	11	3	4	4
Unit-2.0 Fundamentals of PLC	12	CO2	17	5	5	7
Unit-3.0 Sensors and Input field Devices	9	CO3	14	4	6	4
Unit-4.0 Actuators and Output Devices	10	CO4	14	4	6	4
Unit- 5.0 Control System	9	CO5	14	4	5	5
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.	Identify major automation components in a given system	CO1	50	40	10
2.	Analyze given traditional machine in the laboratory for and identify the steps and components required to automate it.	CO1	50	40	10
3.	Use Scada software for simple application	CO1	50	40	10
4.	Observe various parts and front panel indicators ofa PLC	CO2	50	40	10
5.	Observe different types of switches and theirsymbols sensors, lamp, alarm, motor, fan used in a PLC	CO2	50	40	10
6.	Identify Analog input and output lines of a PLC	CO2	50	40	10
7.	Identify digital input and output lines of a PLC	CO2	50	40	10
8.	Practice using PLC to control various digital andanalog output devices	CO2	50	40	10
9.	Identify different types of digital inductiveproximity sensor and its use	CO3	50	40	10
10.	Identify different types of digital capacitiveproximity sensor and its use	CO3	50	40	10
11.	Identify different types of digital optical proximity sensor and its use	CO3	50	40	10
12.	Identify different types of digital ultrasonicproximity sensor and its use	CO3	50	40	10
13.	Identify different types of thermistor and its use	CO3	50	40	10

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
14.	Observe the conversion of temperature toelectric parameter conversion of a Thermocouple.	CO3	50	40	10
15.	Observe different types of RTDs used in industries for temperature measurement	CO3	50	40	10
16.	Observe different types of flow sensors used inindustries for flow measurement	CO3	50	40	10
17.	Observe different types of pressure sensors used in industries for pressure measurement	CO3	50	40	10
18.	Observe the different types of load cell used inindustries for force/weight measurement	CO3	50	40	10
19.	Design and actuate pneumatic/ hydraulic circuitfor the given situation	CO4	50	40	10
20.	Operate hydraulic motor	CO4	50	40	10
21.	Operate stepper motor	CO4	50	40	10
22.	Thermal and magnetic actuators	CO4	50	40	10
23.	Analyze the given system to study open loop,closed loop and feed forward path.	CO5	50	40	10
24.	Analyze the given first order system and its transfer function and output response	CO5	50	40	10
25.	Analyze the given second order system and itstransfer function and output response	CO5	50	40	10
26.	Analyze the given water level control system with on-off, Proportional control.	CO5	50	40	10
27.	Analyze the given water level control system withP+I+D control.	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 beprepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ ImplementationStrategies 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.	SCADA software (reputed make like Allen Bradley, Siemensetc.,)	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	3
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	4,5,6,7,8
3.	Proximity sensors kit	The kit should comprise of the following proximity sensor - Inductive Proximity Sensor, Capacitive Proximity Sensor,Magnetic Sensor, Optical Sensor, Audio and LED indicator for the object detection. Along with learning material	9,10,11,12
4.	Temperature transducer kit	Temperature Transducers Test Bench includes different types of temperature sensors including bimetallic strip, RTD, thermocouple, thermistor, RTD/thermocouple temperature display and thermistor, temperature display, heater, fan, switches and its indicator. Separate heater and fan chamber withstand. On panel digital voltmeter, digital ammeter, RTD/thermocouple temperature display, NTC temperature display, toggle switch for heater and fan with indicator, experiments configurable through patch board, heavy duty Test bench, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration.	12,13,14
5.	Pressure transducer kit	Pressure transducer kit should include different types of pressure sensors including capacitive pressure transducer, load cell, bourdon tube pressure gauge, and pressure vessel. Pressure vessel with pressure gauge, safety valve, non-returning valve bourdon gauge and capacitive transducer and air compressor, on panel digital voltmeter, digital ammeter, 4-20ma display, 0-10V DC display, toggle switch for compressor, load cell	16

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		withsuitable weight, experiments configurable through patch board, self -contained, bench-mounting arrangement, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration. Detailed experiment manual should be supplied with the kit.	
6.	Flow sensor kit	Turbine flow sensor kit	15
7.	Strain Gauge kit	The kit should provide study of Strain Gauge and their application for measurement of Strain. It should help to study bridge configuration of Strain Gauge and the signal conditioning circuits required to measure strain. It should use cantilever beam arrangement to produce strain on Strain Gauge. The Strain Gauges are firmly cemented to the cantilever at the point where the strain is to be measured. Weights are placed on free end of cantilever. Strain developed changes the resistance of Strain Gauge which is detected by full bridge configuration. It should comprise of Seven-segment LED display showing strain in micro strain units. Different weights should be provided to perform linearity and sensitivity experiments. Detailed experiment manual should be supplied with the kit. Test-points to observe input output of each block, onboard gain and offset null adjustment, built in DC Power Supplies, 3½ digits LED display, onboard Cantilever arrangement, high repeatability and reliability The kit should be capable of performing following experiments: • Measuring strain using strain gauges and cantileverassembly. • Determination of linear range of operation of strainmeasurement. Determination sensitivity of the kit	17
8.	Cut sections of pumps, actuators, valves and accessories used in hydraulic systems	Suitably cut and mounted on a sturdy base to show the internal details.	18
9.	Working models of pumps, actuators, valves and accessories used in hydraulic systems	Working models mounted on sturdy base to demonstrate theoperation.	18
10.	Working models of pumps, actuators, valves and accessories used in pneumatic systems	Working models mounted on sturdy base to demonstrate theoperation.	18
11. 8	Oil Hydraulic trainer	Mounted on sturdy base fitted with all standard units andaccessories to create various hydraulic circuits. Hydraulic trainer with simulation software Pneumatic trainer with simulation software • Filter Regulator Combination with Lubricator (FRL Unit) withpressure gauge, Junction Box with slide valve, Push Button Valve, 3/2 NC Roller lever valve ,3/2 NC Roller lever valve	18

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		,5/2 Double external pilot operated valve, 5/2 External pilot operated valve with spring return, 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent – for maintained pilot operation of a SAC, 5/2 Valve with Lever head, 5/2 Value with Mushroom head, Flow control valve – Metering IN & OUT, Shuttle Valve (OR valve), Quick ExhaustValve with Quick coupler plug • Double Acting Cylinder (DAC) with Quick coupler socket (with accessories: Screw driver – for cushioning adjustment),Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug, Multi distributor fittings (for cascading circuit designing) • Single Solenoid Valve with Spring Return (with LED), Double Solenoid Valve (with LED), Magnetic Reed Switch, Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit, Timer	
12.	Pneumatic Trainer	Mounted on sturdy base fitted with all standard units and accessories to create various Pneumatic circuits. Pneumatic trainer with simulation software • Filter Regulator Combination with Lubricator (FRL Unit) with pressure gauge, Junction Box with slide valve • Push Button Valve, 3/2 NC Roller lever valve, 3/2 NC Roller lever valve, 5/2 Double external pilot operated valve (Memoryvalve) • 5/2 External pilot operated valve with spring return, 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent, 5/2Valve with Lever head ,5/2 Value with Mushroom head, Flow control valve, Shuttle Valve (OR valve), AND valve • Quick Exhaust Valve with Quick coupler plug, Double Acting Cylinder (DAC) with Quick coupler socket, Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug • Aluminum Profile Table Top, Profile Table Top, Miniature Double Acting Cylinder (DAC), Single Solenoid Valve with Spring Return, Double Solenoid Valve (with LED) • Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit (Black Selector – 1 no, Green Push Button – 1 no), Timer, Simulation software	18
13.	Advanced Electro - Hydraulic and Electro - Pneumatic Hardware systems with work stationsand simulation software	• Electro - Hydraulic and Electro - Pneumatic Hardware systemswith PLC and simulation software Profile plate, Frame with Castor Wheels, Filter, Lubricator, Regulator with pressure gauge, Hand Slide Valve, Connectioncomponent set, Plastic Tubing, Power Supply & cables, Pressure Gauge, 3/2 Way double solenoid valve	18
14.	Output devices	Servomotor, DC motor, AC motor, stepper motor, Conveyer Belt control by PLC, water level control etc.	18,19,20

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
15.	Thermal actuators	Hot-And-Cold-Arm Actuators, Chevron-Type Actuators	21
16.	Magnetic actuators	Moving Coil Controllable Actuators, Moving Iron ControllableActuator	21
17.	Open and closed loop control system kit	Open and closed loop system kit should be able to measure theoutput response using CRO	22
18.	First and second order control system	First and second order system with input and output terminalsprovision	23,24
19.	Process control system with feed forward path kit	Process control system with feed forward path kit with input and output terminals provision	22
20.	PID Controller Test Bench	PID Controller Test Bench is a complete setup to control process through two-point (on/off) and three-point (PID) controllers. Industrial PID controller with RS485 communication facility, Thermocouple temperature sensor, Float switch for detection of water level, Temperature measurement and control, User friendly software, USB Interface, Heavy duty Test bench, Electrical control panel, Leak proof sturdy piping and tanks, SS Sump tank for inlet and outlet of water, Enhanced electricalsafety considerations, Caster wheel (with locking mechanism) at the legs of Testbench for easy movement.	25,26

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,ISBN13: 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 IndustrialAutomation - 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

(b) Online Educational Resources:

1. Process Automation Control- online Tutorial: www.pacontrol.com
2. PLC product: www.seimens.com
3. www.ab.rockwellautomation.com
4. PLC product: www.abb.co.in
5. Different product of PLC and Peripherals, Smart Tile CPU Board, All in one lighting energy controller, Classic PLC www.triplc.com
6. Simulation software:http://plc-training-rslogix-simulator.soft32.com/free-download/
7. Simulator :www.plcsimulator.net/
8. https://www.youtube.com/watch?v=y2eWdLk0-Ho&list=PLln3BHg93SQ_X5rPjqP8gLLxQnNSMHuj-
9. https://www.youtube.com/watch?v=86CrhxgAKTw

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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

******

A) Course Code : 2400504G(T2400504G/P2400504G/S2400504G)

B) Course Title : Electric Vehicle (Basic)

C) Prerequisite Course(s) :

D) Rationale :

Fossil fuel consumption and its adverse impact on the environment have led most nations in the world to adopt electric vehicles for mobility. Most automobile companies are switching from internal combustion engines to electric, a cleaner, and more sustainable alternative. But, in the present scenario, the automobile industries are facing a shortage of skilled technicians needed for the transition to electric drives as the primary source of motive power. There is a huge skill gap between industry and academia when it comes to the task of taking the entire automobile industry towards electric mobility. Therefore, this basic course on an electric vehicle is included in the curriculum of the diploma programme as an open elective course to fill this gap and gain a basic understanding of the importance and necessity of electric vehicles. This course tends to enable participants with multidisciplinary exposure and give them a brief idea about electric vehicles, and their importance. This course gives some basic technical foundations regarding electric vehicles to help them move on to advanced electric vehicle courses.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of the 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 student will be able to-

CO-1 Classify the EVs based on configurations.

CO-2 Identify relevant Motors for the given EV application.

CO-3 Test the performance of batteries used for EV applications.

CO-4 Distinguish between the EV Charging stations based on their Configurations.

CO-5 Follow regulatory requirements and policies for EV Industry.

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	2	-	2	2	-	3		
CO-2	3	2	2	2	2	1	3		
CO-3	2	2	3	3	2	2	3		
CO-4	2	2	1	2	2	1	2		
CO-5	1	1	-	-	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	CourseTitle	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504G	Electric Vehicles (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400504G

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

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 4.2 Test the given power electronic components using digital meters LSO 4.3 Identify the given Power Electronic Circuits used in EVs LSO 4.4 Identify the components of the Charging System LSO 4.5 Recognize the types of Charging Systems available in the Laboratory			

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

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

b. Micro Projects:

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

c. Other Activities:

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

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

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

d. Self-Learning Topics:

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

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%	--	33%	10%	20%
CO-2	20%	20%	20%	--	33%	15%	20%
CO-3	20%	30%	20%	--	34%	15%	20%
CO-4	20%	25%	20%	50%	--	30%	20%
CO-5	20%	10%	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 (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Electric Vehicle	8	CO1	12	3	5	4
Unit-2.0 Electric Motors used in EVs.	10	CO2	14	4	5	5
Unit- 3.0 EV Batteries and Energy Storages.	14	CO3	20	5	7	7
Unit- 4.0 EV Charging Systems	10	CO4	15	5	6	4
Unit- 5.0 Regulatory Requirements and Policies for EV Industry	6	CO5	9	3	4	3
Total Marks	**48**		**70**	**20**	**27**	**23**

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. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Practice using digital meters such as AC, DC Clamp Meters, DigitalMultimeters, Lux Meters, etc.	CO1	90	-	10
2	Practice using Screw Driver Kit, Vernier Caliper, Micrometer,Ampere Meter, Voltage Meter, and Techno-meter.				
3	Practice using safety kits.				
4	Identification of motors used in EV	CO2	60	30	10
5	Testing of Batteries used in EVs	CO3	60	30	10
6	Battery Management System				
7	Power electronic circuits	CO4	30	60	10
8	Identification of Charging systems				

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 beprepared 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, Labs, and 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.	AC, DC Clamp Meters	Application: Non-contact AC/DC Voltage and Current measurement **AC Application:** Current: 0-200Amp, Voltage: 0-600Volt **DC Application:** Current: 4-20mA, Voltage: 0-30Volt.	1
2.	Digital Multimeters	Display: 4 ½ digit Indications: overload protection, polarity indication, over range indication. Auto range change and auto polarity change facility, auto display of polarity and decimal point. **DC**: Volt: 200mV-600V, Current: 200mA-2A **AC**: Volt: 200mV-1000V, Current: 200mA-2A	1, 3

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		Resistance: 200W-20mW, Power supply: 230V, 50Hz Battery operation: 9 Volt battery Electronic components testing facility should be provided in the Multimeter. A provision for an A.C. adaptor(eliminator) must be available along with the multimeter.	
3.	Lux Meters	Functions: MAX / MIN, Backlight, Auto Power Off Range: 0 ~ 200,000 lux 0 ~ 20,000 fc Accuracy: ± 5% rdg + 10 dgt (< 10.000 lux / fc) ± 10% rdg + 10 dgt (>10.000 lux / fc) Resolution: 0.1 lux or 0.1 fc Accessories: Carrying Case, Installation Manual, 9V Battery (installed).	1
4.	Screw Driver toolbox	All types of screw drive sets.	1
5.	Vernier Caliper	**Range:** Lower scale: 0-200mm, Upper Scale: 0-12inch **Vernier Resolution:** Lower Scale: 0.02mm, Upper Scale: 0.001inch	1
6.	Micrometer	0-25mm (inside/outside)	1
7.	Ampere Meter	Moving iron and Moving Coil	1
8.	Voltmeter	AC(0-250V)/DC(0-24V)	1
9.	Tachometer	For speed measurement (0-3000rpm)	1
10.	Resistors	Low-value Resistors of different types	1,4
11.	Capacitors	Low-value electrolyte Capacitors.	1,4
12.	Inductors	Low-value inductors.	1,4
13.	Safety Kit	First Aid Kit, Helmet, Face Mask, Gloves etc.	1
14.	Motors for Electric Vehicleapplication	Brushless DC, Induction, Permanent Magnet Synchronous Motors, Switched Reluctance Motors	2
15.	EV Machine Cut-out section	for demonstration & training	2
16.	EV mock layout	for demonstration & training	2
17.	Lithium Ion Battery	12V, 7Ah	3
18.	Lead-acid battery	12V, 7Ah	3
19.	Nickel-based batteries (metal hydride and cadmium battery).	12V, 7Ah	3

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
20.	Battery internal resistance meter	For O.C. voltage & internal battery resistance of each cell	3
21.	Cell Capacity tester	Up to 15V batteries and 3A load current, 10mV voltage and 1mA current resolution, Automatic detection of termination voltage, LED display with a 3-button interface.	3
22.	BMS setup	For Demonstration & training	3
23.	DC power supply	0-32V	3
24.	Power diodes	Power diodes of different current values.	1, 4
25.	Transistors	Power Transistors (NPN, PNP) for Low-frequency high-power applications.	1,4
26.	Voltage Sensors	0-12 Volts.	1,3,4
27.	Current Sensors	Volts: + 15v, 0-5v, Current: 4-20mA.	1,3,4
28.	Converter Models	DC to DC and DA to AC converter model	4
29.	Charging Station Simulator	For Demonstration & training purposes.	4
30.	EV Technology layout 3D posterwith frame	Fuel cell, EV- Charging Systems, HEV, FCEV, Motors & Controllers etc.	3,4

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Handbook on Electric Vehicles Manufacturing (E-Car, Electric Bicycle, E- Scooter, E-Motorcycle, Electric Rickshaw, E- Bus, Electric Truck with Assembly Process, Machinery Equipment's &Layout)	P.K. Tripathi	Niir Project Consultancy Services; 1st edition (1 January 2022) ISBN-13: 978-8195676927
2.	Electric Vehicles: And the End of the ICE age	Anupam Singh	Kindle Edition ASIN: B07R3WFR28
3.	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
4.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles	EHSANI	CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465
5.	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
6.	New Perspectives on Electric Vehicles	Marian Găiceanu (Editor)	IntechOpen (30 March 2022) ISBN-13: 978-1839696145

(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

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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

******

A) Course Code : 2400504H(T2400504H/P2400504H/S2400504H)

B) Course Title : Robotics (Basic)

C) Pre- requisite Course(s) :

D) Rationale :

Currently, industries demand non-stop and fine quality work in different processes used. It is difficult for the human beings to give same quantity and quality of work with respect to time, environment and complexity of the work in any process industry. To get quality and quantity of work in toughest environment or the environment which is not suitable for the humans to work, industries demand for robots and its operator. Operators who will operate these robots need some basic knowledge of robotics. To fulfill the need of industries and looking to the advancement in technology, this course aims for the diploma engineers to have knowledge and skills in robotics.

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 robots for given applications employing basic concepts of design and functions of robots.

CO-2 Interpret co-ordinate systems and degree of freedom for robots.

CO-3 Use sensors and drives in context of various robotic applications.

CO-4 Select appropriate robot control techniques,

CO-5 Use programs to operate robots.

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	2	1	2	-	-	-		
CO-3	3	2	1	2	2	-	2		
CO-4	3	1	1	2	-	-	-		
CO-5	3	2	3	3	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:

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				
2400504H	Robotics (Basics)	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)	
2400504H	Robotics (Basic)	30	70	20	30	20	30	200

Legend:

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

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Note:

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

J) Theory Session Outcomes (TSOs) and Units: T2400504H

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Explain the basic terms used in robotics TSO 1b. Identify components used in robots. TSO 1c. Explain various types of movements. TSO 1d. Distinguish various robots' configurations and their workspace. TSO 1e. Evaluate the degrees of freedom of the given robot. TSO 1f. Specify the methods of conversion of the given linear motion into rotary motion and vice-versa. TSO 1g. List the criteria for selecting robot for the given simple application with justification.	**Unit-1.0 Basics of Robotics Systems** 1.1 Definition, need, brief history of robotics 1.2 Basic Robot terminology, configuration and its working 1.3 Robot components overview - Manipulator, End effecters, Drive system, Controller, Sensors 1.4 Basic structure of a Robot and Classification – Cartesian, Cylindrical, Spherical, Horizontal articulated (SCARA), Parallel; Mechanic al arm, Degree of freedom, Links and joints, Wrist rotation,Mechanical transmission-pulleys, belts, gears, harmonic drive (gear box) 1.5 Linear and Rotary motion and its devices 1.6 Selection criteria for robots	**CO1, CO2**
TSO 2a. Explain the working of various types of End effecters used in robots with diagram. TSO 2b. Explain with sketches the function of the given sensing device used in a robot. TSO 2c. Describe working of the given sensor used in robot. TSO 2d. Explain the given robot configuration. TSO 2e. Select relevant robot sensors for a given application with justification. TSO 2f. Describe robot machine vision concepts along with block diagram of robot vision system. TSO 2g. Select vision equipment for a given robotic application.	**Unit– 2.0 Robot Components** 2.1 End effecters: types, sketches, working and applications 2.2 Sensing and Feedback devices: Optical sensors, Proximity sensors, LVDT, Thermocouple, RTD, Thermistor, Force sensing – strain gauge, Piezoelectric, Acoustic sensing Feedback devices; Potentiometers; Optical encoders; DC tachometers; 2.3 Robot machine vision: Block diagram of robot vision system, Vision equipment-camera, Imaging Components: Point, Line, Planar and Volume Sensors, Image processing, Part recognition and range detection	**CO3**
TSO 3a. Explain with sketches the function of the specified actuator used in a robot. TSO 3b. Differentiate between open loop and closed loop systems. TSO 3c. Explain various robotic controls. TSO 3d. Describe block diagrams of the given control system. TSO 3e. Specify drive system used for robotic control as per requirement. TSO 3f. Differentiate the various robot path controls. TSO 3g. Justify the selection of actuators, drives, control system, AC servo motor and path control for making of a robot.	**Unit– 3.0 Robotic Drive System and Controller** 3.1 Actuators; Hydraulic, Pneumatic and Electrical drives; linear actuator; Rotary drives 3.2 Control systems: Open loop and close loop with applications and its elements, Servo and non-servo control systems – Types, basic principles and block diagram Robot controller; Level of Controller 3.3 AC servo motor; DC servo motors and Stepper motors; 3.4 Robot path control: Point to point, Continuous path control and Sensor based path control	**CO4**
TSO 4a. Explain various robot programming languages. TSO 4b. Programme robot for a given simple job.	**Unit– 4.0 Introduction to Robot Programming** 4.1 Need and functions of programming	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 4c. Describe the procedure to simulate the given robot movements using the relevant software.	4.2 Methods of robot programming: Manual Teaching, Teach Pendant, Lead through, Programming languages. Programming with graphics. 4.3 Programming languages: Types, features and applications 4.4 Controller programming 4.5 Simulation for robot movement	
TSO 5a. Select a robot for the given application. TSO 5b. Describe various applications of Robotics. TSO 5c. Explain safety norms in robot handling. TSO 5d. Describe maintenance procedure for the given robot. TSO 5e. Describe common problems in robot operations and suggest remedial action.	**Unit– 5.0 Robotics Applications and Maintenance aspects** 5.1 Application robots including special types 5.2 Robot maintenance: Need and types 5.3 Common troubles and remedies in robot operation. 5.4 General safety norms, aspects and precautions in robot handling	**CO1, CO2, CO3, CO4**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1 Identify parts of Robot on the basis of function. LSO 1.2 Identify joint type & link parameters (link length, link twist, and Link offset), rotational vs. linear motion, used in robot.	1.	Identify components and different configurations of robots.	CO1
LSO 2.1Identify different types of robot end effecters. LSO 2.2 Use Mechanical grippers to hold objects. LSO 2.3 Use Vacuum grippers to hold objects.	2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2
LSOs 3.1 Assemble the complete robot using the components as per the procedure LSO 3.2 Apply the functionalities available in rotor trainer kit. LSO 3.3 Test for various configurations. LSO 3.4 Test for various degrees of freedom.	3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2
LSO 4.1 Identify various types of sensors used in robotic application. LSO 4.2 Measure angular motion using Synchros. LSO 4.3 Detect objects using optical sensors.	4.	Use different types of robotic sensors for a specific situation.	CO3
LSO 5.1 Interface stepper motor. LSO 5.2 Control robot with stepper motor interfacing.	5.	Perform robot control with stepper motor interfacing	CO3
LSO 6.1 Draw the labelled sketch of individual parts and robot arm. LSO 6.2 Assemble the arm using the parts as per the procedure. LSO 6.3 Interface the motor drive and operate.	6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3
LSO 7.1 Use open source or available relevant software to develop pick and place programme. LSO 7.2 Perform simulation.	7.	Perform pick and place operation using Simulation Control Software.	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 8.1 Develop programme for using a robot arm with three degrees of freedom. LSO 8.2 Execute the programme.	8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5
LSO 9.1 Apply stepper motor control with direction control and step control logic simulation. LSO 9.2 Perform basic PLC programming LSO 9.3 Develop ladder logic programs LSO 9.4 Use programming timers	9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5
LSO 10.1Develop a program for a simple application. LSO 10.2 Execute the robot programme.	10.	Program to execute a simple robot application (like painting, straight welding) using a given configuration.	CO4, CO5

L) Suggested Term Work and Self Learning: S2400504H Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

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

1. Develop stair climb robot using robotic components.
2. Develop RF controller robot using robotic components.
3. Develop robot for metal detection application using robotic components.
4. Develop line follower robot using robotic components.
5. Develop solar floor cleaner robot using robotic components.
6. Develop solar tracker system using robotic components.
7. **Develop a greenhouse managing robot for a horticulture application.**

c. Other Activities:

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

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%	29%	20%	10%	25%	10%	20%
CO-2	20 %	23%	20%	10%	25%	**20%**	20%
CO-3	20%	17%	20%	25%	25%	**20%**	20%

CO-4	20%	14%	20%	15%	25%	**20%**	20%
CO-5	15%	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 (Cl) Hours	Relevant Cos Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Basics of Robotics Systems	10	CO1, CO2	20	7	8	5
Unit– 2.0 Robot Components	12	CO2, CO3	16	3	9	4
Unit– 3.0 Robotic Drive System and Controller	10	CO3, CO4	12	4	4	4
Unit– 4.0 Introduction to Robot Programming	8	CO5	10	2	5	3
Unit– 5.0 Robotics Applications and Maintenance aspects	8	CO1, CO2, CO3, CO4	12	4	4	4
Total Marks	**48**		**70**	**20**	**30**	**20**

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 components and different configurations of robots.	CO1	30	60	10
2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2	60	30	10
3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2	70	20	10
4.	Use different types of robotic sensors for a specific situation.	CO3	60	30	10
5.	Perform robot control with stepper motor interfacing	CO3	70	20	10

6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3	60	30	10
7.	Perform pick and place operation using Simulation Control Software.	CO5	70	20	10
8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5	60	30	10
9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5	60	30	10
10.	Program to execute a simple robot application (like painting, straight welding) using a given configuration.	CO4, 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 beprepared 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 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.	Programmable Robot trainer kit	Trainer kit with - Minimum 3 linkages, Minimum 4 degree of freedom, Mechanical end effecter with servo control, interfacing card (RC servo output, sensors input)	1,2,3
2.	Robotic Arm Control Trainer Kit	Robotic Arm with five axis control application through PLC.; PLC; Digital Inputs: 8 Nos with 4mm banana sockets for getting the external inputs; Digital Outputs: 6 Nos with 4mm banana sockets for applying the inputs; Digital Input Controls: On board Toggle switches, Push Buttons & input potentiometers; Digital Outputs Controls: 6 nos. on board LED indicators; PC interfacing facility through RS-232.	8,9
3.	Proximity trainer kit	Indicator Type:LED; PCB Type Glass Epoxy SMOBC PCB; Interconnections: 2mm banana Patch cords; On board DC motor to see the application of Proximity sensor. Test points to analyse the signal On board variable supply to vary the speed of DC motor. ON/OFF switch and LED for power indication. All interconnections to be made using 2mm banana Patch cords. User manual and patch cords. Built-in power supply. Robust enclosure wooden/plastic box.	4
4.	Robot - Line Tracking Mouse Kit	Product Dimensions (20.3 x 11.4 x 8.9 cm); programmed IC, 2 unassembled gear motors, printed circuit boards, mouse-shaped plastic body, necessary components and wires, step-down power converter	3, 4,5
5.	Intelligent Robot Actuator Module	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	3, 4, 5

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		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 aluminium, 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)	
6.	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 processors**;** Record and Play capability**;** Optional interfacing with PL**C;** Touch operated ON/OFF switch**;** Auto set to home position**;** Applications can be developed**;** Data acquisition using USB	3, 4, 5
7.	Robotic Drive System	AC servo motor; DC servo motors, Stepper motors; DC tachometers, etc.	1,3,5,6,7,10
8.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	8, 10
9.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc	4
10.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4,10

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.	Industrial Robotics -Technology, Programming and Applications	Nicholas Odrey Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta	McGraw Hill Education; 2nd Edition; 978 -1259006210
3.	Robotic engineering: an integrated approach	Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin	Prentice Hall of India, N.Delhi , 978-8120308428
4.	Industrial Robotics Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey	McGraw-Hill Education, Second Edition, 978-1259006210
5.	Robotics	Appuu Kuttan K. K.	Dreamtech Press, First Edition, 2020, 978-9389583281
6.	Introduction to Robotics: Analysis, Control, Applications	Saeed B. Niku	Wiley; Second Edition, 978-8126533121

7.	Essentials of Robotics Process Automation	S. Muhkerjee	Khanna Publication, First edition, 978-9386173751
8.	Robotics	R R Ghorpade, M M Bhoomkar	Nirali Prakashan 978-9388897020

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105249/
2. https://openlearning.mit.edu/mit-faculty/residential-digital-innovations/task-centered-learning-intro-eecs-robotics
3. http://www.mtabindia.com/
4. http://www.robotics.org/
5. https://en.wikipedia.org/wiki/Industrial_robot
6. http://www.servodatabase.com
7. https://www.youtube.com/watch?v=fH4VwTgfyrQ
8. https://www.youtube.com/watch?v=aW_BM_S0z4k
9. https://uk.rs-online.com/web/generalDisplay.html?id=ideas-and-advice/robotic-parts-guide
10. https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud
11. https://www.iqsdirectory.com/articles/machine-vision-system.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.

(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

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A) Course Code : 2400504I(T2400504I/P2400504I/S2400504I)

B) Course Title : Transformer Manufacturing and Repairing (Basics)

C) Pre- requisite Course(s) : Electric Motors and Transformers

D) Rationale :

Transformers are an essential component in Power systems. They help transmit electrical energy at various voltage and current levels to minimize losses and achieve other technical objectives. They are rated from a few kVA to large MVA. Power systems are growing to meet the increased demand. Hence, the manufacturing of new transformers and repair of existing transformers are vital. This course will pave the way to understand the concepts of manufacturing and repair of transformers. The knowledge gained through this course will help the students choose their career in transformer 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 Explain the fundamental working principles of a transformer.

CO-2 Explain the different types of construction and cooling mechanism.

CO-3 Analyze the different vector groups in practical power transformers and their connections.

CO-4 Illustrate the different types of transformer protection.

CO-5 Analyze the different types of tests required for a transformer.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme SpecificOutcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Developmentof Solutions	**PO-4** EngineeringTools	**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	-	-	-	-	3		
CO-2	3	1	-	-	2	-	3		
CO-3	3	2	2	-	-	-	3		
CO-4	3	3	2	2	1	-	3		
CO-5	3	3	-	2	1	-	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				
2400504I	Transformer Manufacturing and Repairing (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

I) Course Curriculum Detailing:

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: T2400504I

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the use of transformers in power systems. *TSO 1b.* List the various types of transformers. *TSO 1c.* Explain the exact and approximate equivalent circuits of a transformer. *TSO 1d.* Explain the relations between input and output quantities through phasor diagrams. *TSO 1e.* List the necessity of open and short circuit tests and explain how they should be performed. *TSO 1f.* Explain the concept of voltage regulation and efficiency and list the ways to improve them in transformers.	**Unit-1.0 Transformer Fundamentals** 1.1 Use of Transformers. 1.2 Types of Transformers. 1.3 The equivalent circuit of a transformer. 1.4 Phasor Diagrams 1.5 Open circuit and short circuit tests. 1.6 Voltage regulation and efficiency.	**CO1**
TSO 2a. Explain the different constructional parts of a transformer. *TSO 2b.* List the different types of core and its construction and sections. *TSO 2c.* Explain the different types of windings and the necessity of insulation. *TSO 2d.* Explain the different types of cooling. *TSO 2e.* List the different tank structure. *TSO 2f.* Explain the necessity of transformer oil.	**Unit-2.0 Transformer Construction** 2.1 Constructional Parts. 2.2 Core Construction and Core Sections. 2.3 Windings and Insulation. 2.4 Cooling: Natural Cooling, Forced Oil cooling and Internal Cooling. 2.5 Tanks. 2.6 Transformer oil.	**CO1, CO2**
TSO 3a. Explain the different connections and vector groups. *TSO 3b.* Explain the three phase to two phase and three phase to single phase connection. *TSO 3c.* List the different types of tap changing positions. *TSO 3d.* Explain the open delta configuration.	**Unit-3.0 Transformer Operation** 3.1 Connection for transformers: star/star, star/delta, delta/star. Zig-zag/star. 3.2 Three phase to two phase connections: Scott connection. 3.3 Three phase to one phase connection. 3.4 Tap changing: On-load and off-load tap changing positions. 3.5 Three phase banks of single phase transformers: Open delta configuration.	**CO3, CO4**
TSO 4a. List the classification of transformer protection. *TSO 4b.* Explain the Buchholz relay and its use in transformers. *TSO 4c.* Explain the different types of transformer protection and the use of indicators in transformers.	**Unit-4.0 Transformer Protection** 4.1 Classification of transformer protection. 4.2 Buchholz Relay 4.3 Differential protection 4.4 Over current, Over voltage and surge protection. 4.5 Temperature indicators, oil level indicators, oil preservation systems, silica gel breather, gas sealed conservators.	**CO3, CO4**
TSO 5a. Explain the objectives of testing of transformers. *TSO 5b.* List the different types of tests.	**Unit-5.0 Transformer Testing** 5.1 Objectives of transformer testing.	**CO4, CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5c. Explain different transformer tests including the Sumpner's test. *TSO 5d.* Explain the insulation and impulse tests.	5.2 Polarity Test, DC Resistance and voltage ratio tests. 5.3 Magnetizing current and core loss tests. 5.4 Temperature rise test, back to back connection. 5.5 Insulation and Impulse Tests.	

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

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

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

L) Suggested Term Work and Self Learning: S2400504I Some sample suggested assignments, micro project and other activities are mentioned here for reference.

1. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
   - Discuss the role of insulation in transformer reliability and longevity.
   - Outline the steps involved in the construction of power transformers.
   - Discuss the testing procedures to ensure quality and performance standards.
   - Explore how environmental factors (temperature, humidity, pollution) affect transformer operation.
   - Investigate modern monitoring techniques, including online monitoring systems and diagnostic tools.
   - Compare different cooling methods (oil-immersed, air-cooled, water-cooled) and their effectiveness.
   - Review recent advancements in transformer protection technologies.
   - Discuss the importance of testing for ensuring reliability, efficiency, and safety.

2. **Micro Projects:**

   - Simulate and analyze the operation of overcurrent protection relays in a transformer protection system.
   - Implement a Buchholz relay for gas detection in oil-filled transformers.
   - Design an earth fault protection system for transformers.
   - Measure the insulation resistance of transformer windings to ensure insulation integrity.
   - Measure the resistance of transformer windings to detect winding issues such as short circuits or open circuits.
   - Assess the dielectric strength of transformer oil to ensure effective insulation.
   - Build a simple step-up and step-down transformer.
   - Investigate the impact of core material and shape on transformer efficiency.

3. **Other Activities:**

1. Seminar Topics:
   - Advancements in Transformer Core Materials
   - Winding Techniques in Transformer Construction
   - Temperature Management and Cooling Techniques
   - Protection Against Transformer Overheating
   - Transformer Oil Testing and Analysis
2. Visits: Visit to nearby transformer repair station and prepare technical report on transformer repair process, observe diagnostic techniques, repair procedures, and quality assurance practices.
3. Self-learning topics:
   - Phenomenon of inrush current in transformers.
   - Causes, effects, and methods to mitigate inrush currents.
   - Arc flash incidents in transformers.
   - Strategies and equipment used to mitigate arc flash hazards.
   - Impact of harmonics on transformer protection systems.
   - Partial discharge testing

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 **Transformer Fundamentals**	12	CO1	10	3	3	4
Unit-2.0 **Transformer Construction**	8	CO1, CO2	10	3	2	5
Unit-3.0 **Transformer Operation**	8	CO3, CO4	10	5	2	3
Unit-4.0 **Transformer Protection**	8	CO3, CO4	20	5	6	9
Unit-5.0 **Transformer Testing**	12	CO4, CO5	20	4	6	10
Total	**48**	**-**	**70**	**20**	**19**	**31**

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.	Conduct open circuit and short circuit tests on a transformer	CO1	30	60	10
2.	Perform load tests on a transformer.	CO1	40	50	10
3.	Perform the Sumpner's test on two identical transformers.	CO1	30	60	10
4.	Perform various connections on three phase transformers and understand vector groups.	CO2	30	60	10
5.	Three phase to Two phase connection	CO3, CO4, CO5	30	60	10
6.	Three phase to single phase connection.	CO3, CO4, CO5	30	60	10
7.	Perform open delta connection from banks of single phase transformers.	CO3, CO4, CO5	30	60	10
8.	Understand the differential protection with different CT connections and the working of Buchholz relay.	CO3, CO4, CO5	40	50	10
9.	Perform a polarity test on a transformer.	CO4, CO5	40	50	10
10.	Perform the impulse test on a transformer.	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.

Q) 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.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter.	Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-1 QTY Auto-Transformer (0-270 V,5 kVA), Multi-Meter, Voltmeter (0-300 V,0-150 V 0-50 V: -3 Qty), Ammeter (0-5 A,0-10 A,0-1 A:3Qty), Wattmeter (0-300 V,5/10A-3 Qty), Wattmeter (0-150 V,1/2 A-3 QTY), Connecting Wire.	Conduct open circuit and short circuit tests on a transformer
2.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-1 QTY Auto-Transformer (0-270 V,5 kVA), Multi-Meter, Voltmeter (0-300 V,0-150 V: -2 Qty), Ammeter (0-5 A,0-10 A,: 2 Qty), Wattmeter (0-300 V,5/10A-2 Qty), Connecting Wire.	Perform load tests on a transformer.
3.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter.	Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-2 QTY Auto-Transformer (0-270 V,5 kVA:-2 QTY), Multi-Meter, Voltmeter (0-300 V,0-150 V 0-50 V: -3 Qty), Ammeter (0-5 A,0-10 A,0-1 A:3Qty),Wattmeter(0-300 V,5/10A-3 Qty),Wattmeter(0-150 V,1/2 A-3 QTY), Connecting Wire.	Perform the Sumpner's test on two identical transformers.
4.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	Transformer (1 Phase, 1 kVA) - 3 Qty, multi-meter, Series Bulb, Connecting Wire, 3 Phase Auto transformer-1 Qty, Connecting Wire.	Perform various connections on three phase transformers and understand vector groups.
5.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	3 Phase Auto transformer, Transformer (1 kVA, 1 Phase)-3 Qty, Ammeter (0-20 A)-5 Qty, Voltmeter (0-500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), 1 Phase Electric Load-2 Qty, Connecting Wire.	Three phase to Two phase connection
6.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	3 Phase Auto transformer-1 Qty, Transformer (1 kVA, 1 Phase)-3 Qty, Ammeter(0-10A)-2 Qty, Voltmeter (0-300/500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), 1 Phase Load, Connecting Wire.	Three phase to single phase connection.
7.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	Transformer (1 kVA, 1 Phase)-3 Qty, 3 Phase Load-1 Qty, 3 Phase Auto Transformer -1 Qty. Ammeter(0-10A)-2 Qty, Voltmeter (0-300/500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty),	Perform open delta connection from banks of single phase transformers.
8	Power Transformer, Differential relay, CT, Buchholz Relay	3 Phase Differential relay, Current transformer-3 Qty, Power Transformer with Buchholz relay -1 Qty, Connecting Wire.	Understand the differential protection with different CT connections and the working of Buchholz relay.
9	Transformer, Auto Transformer, Ammeter, Voltmeter, Multi-meter.	1 Ph Transformer (same rating)-2 Qty,1 Ph Autotransformer -1 Qty, Ammeter (0-2 A)-1 Qty, Voltmeter(0-300V), Voltmeter(0-150V)-1 Qty, Connecting Wire.	Perform a polarity test on a transformer.
10	Transformer, Impulse test Kit	3 Phase transformer -1 Qty, High voltage generating kit (rating in kV), Connecting Wire.	Perform the impulse test on a transformer.

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	The Performance and Design of Alternating Current Machines	M. G. Say	CBS Publishers, 2002 ISBN: 81-239-1027-4
2.	Electrical Machines	D. P. Kothari and I. J. Nagrath	Tata McGraw Hill India, 2004 ISBN: 0070583773, 9780070583771

(b) Online Educational Resources:

1. https://nptel.ac.in/courses/108105017
2. https://nptel.ac.in/courses/108106071

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:

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A) Course Code : 2400504J(T2400504J/P2400504J/S2400504J)

B) Course Title : **Optical Fiber and 5G Communication (Basics)**

C) Pre- requisite Course(s) : Principle of Electronics Communication, Digital Communication

D) Rationale :

An optical fiber and 5G communication course is essential for interpreting modern high-speed data transmission, which is crucial for supporting the growing demand for fast and reliable internet services. It equips students with the knowledge to design and implement fiber optic networks, which are integral to both wired and wireless communication infrastructures. The course also covers the principles andtechnologies behind 5G, the latest generation of mobile networks, enabling enhanced connectivity, low latency, and greater capacity. By combining these fields, students gain comprehensive insights into how advanced communication systems operate and interact and preparing them for careers in telecommunications and networking field.

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 performvarious 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 Describe EM wave propagation through an optical fiber.
CO-2 Measure different types of losses of a given optical fiber cable.
CO-3 Perform optical fiber power launching and slicing.
CO-4 Test the performance of the Optical fiber source and detector.
CO-5 Compare mobile communication generations (2G, 3G, 4G and 5G).

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 Managemen	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	3	2	-	-	2		
CO-2	3	2	-	2	-	-	-		
CO-3	3	3	-	2	3	-	-		
CO-4	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 Credits (C)
		L	T				
2400504 J	Optical Fiber and 5G Communication(Basics)	03	-	04	02	09	06

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Casemethod, 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 feedbackof 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)	
2400504 J	Optical Fiberand 5G Communication (Basics)	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%)** aswell 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 ofinternal 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 leveland 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 relatedreforms like green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2400504J

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the need for Optical fiber and 5G Technologies. *TSO 1b.* Define numerical aperture. *TSO 1c.* Classify optical fiber modes with proper sketch. *TSO 1d.* Explain with examples modes of wave propagation through an optical fiber. *TSO 1e.* Classify optical fiber	**Unit-1.0 Introduction of Optical Fibers** 1.1 Introduction to general optical fibercommunication (OFC) system 1.2 Basic optical laws and definitions 1.3 Structure of optical cable- core, cladding, cover 1.4 Numerical aperture 1.5 Optical fiber modes and configurations–mode analysis for optical propagation through fibers 1.6 Classification of optical fiber, single mode fiber,graded index fiber	**CO1**
TSO 2a. Explain the reason for attenuation in the optical fiber cable. *TSO 2b.* Describe fiber losses with examples. *TSO 2c.* Explain various aspects of dispersion *TSO 2d.* Describe how to optimize the dispersion *TSO 2e.* Describe how to generate R-I profile *TSO 2f.* calculate cut-off wavelength, and modefield diameter	**Unit-2.0 Transmission Characteristics of OpticalFiber** 2.1 Attenuation in Optical Fiber 2.2 Fiber Losses (Material, Scattering, Splice,Absorption, Radiative) 2.3 Dispersion (Chromatic, Modal, Material, Waveguide, Polarization mode) 2.4 Dispersion optimization of single mode fiber,characteristics of single mode fiber 2.5 R-I Profile 2.6 Cut off wavelength, dispersion calculation, and mode field diameter	**CO2**
TSO 3a. Explain the need for a source and detector in an optical fiber system. *TSO 3b.* Describe about direct and	**Unit-3.0 Optical Sources and Detectors** 3.1 Sources- Intrinsic and extrinsic material,direct and indirect band gaps 3.2 LED structures- Surface-emitting	**CO3**

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

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

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

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

L) Suggested Term Work and Self Learning: S2400504J Some sample suggested assignments, micro project and otheractivities are mentioned here for reference.

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

b. Micro Projects:

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

1. Design and Implementation of a Basic Fiber Optic Network:
2. Perform splicing and monetarization on actual fiber optic cables.
3. Test the network for signal loss and attenuation using OTDR.
4. Prepare a report detailing the design, implementation process, and test results.
5. Simulation and Analysis of Wavelength Division Multiplexing (WDM) Systems: Objective: Simulate a WDM system and analyze its performance. Tasks: Use simulation software (e.g., Opti System or MATLAB) to design a WDM system. Simulate the transmission of multiple wavelengths through a single optical fiber. Analyze the system's performance in terms of signal quality, crosstalk, and data capacity.
6. Development of a Simple 5G NR Base Station

Objective: Develop and test a simple 5G NR base station using software-defined radios (SDRs).

c. Other Activities:

1. Seminar Topics: here are 5 seminar topics

   I. "Advancements in Optical Fiber Technology "
   II. "The Future of Wireless Communication: 5G and Beyond"
   III. "Integrating Optical Fiber with 5G Networks: Opportunities and Challenges"
   IV. "Security Strategies for 5G Networks: Ensuring Robust Protection"
   V. "Smart Cities Powered by 5G and Optical Fiber: Innovations and Implementation"

2. Visits: Visit nearby telephone exchanges or wireless communication-related companies

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 relatedto 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 of Optical Fibers**	8	CO1	10	2	4	4
Unit-2.0 **Transmission Characteristics of Optical Fiber**	8	CO2	10	4	2	4
Unit-3.0 **Optical Sources and Detectors**	8	CO3	14	4	4	6
Unit-4.0 **Optical Receiver, Coupling and Measurements**	12	CO4	16	4	6	6
Unit-5.0 **Fundamentals of 5G Communication**	12	CO5	20	4	6	10
Total	**48**	**-**	**70**	**18**	**22**	**30**

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.	Identification of various components of Optical fiber communication system	**CO1**	30	60	10
2.	Measurement of Numerical aperture	**CO1**	40	50	10
3.	Attenuation and Signal Loss Measurement	**CO2**	30	60	10
4.	Fiber Optic Cable Testing and Troubleshooting	**CO2, CO3**	30	60	10
5.	Performance of optical source (LED, LASER)	**CO3**	30	60	10
6.	Performance of optical doctor (Photo diode, PIN diode)	**CO3**	30	60	10
7.	Optical Fiber Splicing and Monitorization	**CO4**	30	60	10
8.	Analyze the optical communication system.	**CO4**	30	60	10
9.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	**CO5**	30	60	10
10.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	**CO5**	30	60	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 maybe 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:
Please insert laboratory equipment in this format

Sl. No.	Name of Equipment,Tools, and Software	Relevant Experiment/Practical Number
1.	Optical Time-Domain Reflectometer (OTDR) Used for measuring the length, loss, and faults in optical fiber cables.	1-3
2.	Fusion Splicer (For splicing optical fibers with minimal loss).	1-3
3.	Optical Power Meter and Light Source (For measuring the power levels in fiber optic links and testing signal loss).	1-3
4.	Visual Fault Locator (VFL): Helps to identify faults, breaks, and bending in optical fibers.	1-3
5.	Optical Spectrum Analyzer (OSA): Used for analyzing the wavelength and spectral characteristics of light in fiber optics.	1-3
6.	Software-Defined Radio (SDR): Allows for the implementation and testing of 5G communication protocols.	4-7
7.	5G NR Testbed: Complete test setups for developing and testing 5G NR systems.	4-7
8.	Vector Signal Analyzer (VSA) and Vector Signal Generator (VSG): For generating and analyzing complex modulated signals used in 5G communication.	4-7
10.	MIMO (Multiple Input Multiple Output) Test System: For testing MIMO technology, which is essential for 5G networks.	7
11.	Optical Fiber Cables and Connectors: Various types of single-mode and multi-mode fibers, along with connectors and adapters.	1-3
12.	Network Simulators: Software tools like Opti System for simulating optical networks and NS-3 for 5G network simulations.	1-3
13	MATLAB/Mathematica	1-7

R) Suggested Learning Resources:

(a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Fiber-Optic Communication Systems	Govind P. Agrawal	John Wiley & Sons, 2012, ISBN 97804705113
2.	Optical Fiber Communications	Gerd Keiser	McGraw-Hill Science, Engineering & Mathematics, 1983. ISBN: 0-07-064810-7
3.	5G NR: The Next Generation Wireless Access Technology	Erik Dahlman, Stefan Parkvall, and Johan Skold	Academic Press, 2020. ISBN-10. 0128143231; ISBN-13. 978-0128143230
4.	Principles of Optical Fiber Measurements	Dietrich Marcuse	Elsevier, 2012. ISBN:012470980X

(b) Online Educational Resources: (Please provide link also if available)

Here are five valuable online references for a course in Optical Fiber and 5G Communication:

1. edX - PurdueX: Fiber Optic Communications: This advanced course covers wave propagation, optical transmitters and receivers, optical communication network architectures, and future optical networks. It's ideal for gaining in-depth knowledge of fiber optic systems and their applications in modern communicationnetworks (edX).
2. Johns Hopkins Engineering - Fiber-Optic Communication Systems: This online course explores the fundamentals of fiber-optic communication systems, including the properties of optoelectronic componentsand system design issues for both terrestrial and submerged point-to-point optical links (Johns Hopkins Engineering Online).
3. Purdue University - Fiber Optics Communications Course: This course provides a comprehensive overview ofthe key components and system-level interactions in fiber optic communication systems, with a focus on current technologies and future advancements in the field (Purdue Eng.).
4. Coursera - Post Graduate Certificate in 5G Technology and IoT: This program covers the essentials of 4G and5G systems, including key technical advancements and challenges. It also delves into topics such as massiveMIMO, OFDM, and mm Wave communication, providing a solid foundation in modern wireless communication (Coursera).
5. Coursera - 5G and Beyond Wireless Technologies: This course provides an in-depth understanding of 5G New Radio standards, beam management, cell-free massive MIMO, and intelligent reflecting surfaces, making it an excellent resource for those looking to explore the cutting-edge aspects of 5G technology (Coursera).

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: In this section provide the software name (if any) data sheet according to this course.

a. Operating / Manufacturers' Manuals
b. b. Lab Manuals

A) Course Code : 2400505(P2400505/S2400505)

B) Course Title : Entrepreneurship Development & Start-ups
(Common for all Programmes)

C) Pre-requisite Course(s) :

D) Rationale :

A fast-growing economy provides ample opportunities for diploma engineers to succeed in entrepreneurship and start-ups. Start-up ecosystem and Entrepreneurship Development skills are fully developed providing many opportunities to the youths. Diploma engineers can be their own masters and provide jobs to others by starting their service-industry / assembly/ marketing/ consultancy/ manufacturing enterprises. Entrepreneurship requires a distinct set of skills that will be developed in this course. This course aims at developing competencies in the diploma engineer for becoming an intrapreneur, a successful entrepreneur, or a startup Co-Founder. After successfully completing this course students who develop the qualities of a successful entrepreneur can establish their own manufacturing industry/business startup or be self-employed. Those who prefer jobs can become intrapreneurs and share profits with their company.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of the 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 the classroom/laboratory/workshop/field/industry.

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

CO-1 Demonstrate traits of a successful intrapreneur/ entrepreneur/ start-up co-founder.
CO-2 Innovate products and services using creativity and innovation techniques.
CO-3 Manage critical resources from support institutions.
CO-4 Prepare sustainable small business plans.

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	2		
CO-2	3	2	3	-	2	3	2		
CO-3	3	3	3	-	2	3	2		
CO-4	3	3	-	-	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:

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				
2400505	Entrepreneurship Development & Startups	-	-	04	02	06	03

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)	
2400505	Entrepreneurship Development & Startups	-	-	20	30	20	30	100

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: (Not Applicable)

K) Suggested Laboratory (Practical) Session Outcomes (LSOs)and List of Practical: P2400505

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

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

L) Suggested Term Work and Self-Learning: S2400505 Some sample suggested assignments, micro-projects, and other activities are mentioned here for reference.

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

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

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

b. Micro Projects:

i. Interview successful entrepreneurs and startup co-founders in the city and innovate their products/services, pricing, packaging, advertisements, propositions, etc.

ii. Identify different entrepreneurship support institutions in the city.
iii. Prepare a collage for specific entrepreneurship development institutions.
iv. Conduct a market survey for a specific product idea.

c. Other Activities:

1. Seminar Topics:

- Charms of entrepreneurship.
- Challenges of entrepreneurship.
- Startup ecosystem in India.
- One district one product scheme
- Setting up of a business.
- Market study of specified business.
- Prepare a business plan for your chosen small scale enterprise.
- Business opportunity suitable for you.

2. **Visits:** Visit DIC, MSME, NSIC, NABARD, KVIC, IDBI, SBI, State Consultancy Organization, Industrial Development Center, Trade Exhibitions, Export Fairs, Trade Shows, etc.
Visit nearby tool room/industry and learn to prepare budget of that industry. Also learn to grow low scale business and marketing. Prepare list of advertisement to grow business.

3. Self-Learning Topics:

- Achievement Motivation.
- Need for achievement.
- Calculated risk.
- CSR (Corporate Social Responsibility)
- MSME Development Institute.
- Marketing their business.
- Growing their business.
- Financial management.
- Dealing with the pressure and stress

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%	-	-	30%	25%
CO-2	-	-	10%	33%	-	10%	25%
CO-3	-	-	30%	33%	50%	30%	25%
CO-4	-	-	30%	34%	50%	30%	25%
Total Marks	**-**	**-**	**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: (NOT APPLICABLE)

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Profile summary (about 500 words) of a successful entrepreneur indicating milestone achievements.	CO1	50	40	10
2.	Discussion session with your institute's pass-out students who are successful entrepreneurs.	CO1	50	40	10
3.	SWOT analysis to arrive at your business idea of a product/service.	CO1	50	40	10
4.	Sale of products to different customers	CO1	50	40	10
5.	Creativity and Innovation in Business	CO2	50	40	10
6.	Exhibition cum sale of products prepared out of waste.	CO2	50	40	10
7.	Business ideas (product/service) for intrapreneurial and entrepreneurial opportunities through brainstorming.	CO2	50	40	10
8.	Self–assessment test to discover entrepreneurial traits.	CO1	50	40	10
9.	Survey industries (your stream), and grade them according to the level of scale of production, investment, turnover, and pollution to prepare a report on it.	CO2	50	40	10
10.	Compile the information from the government agencies that will help you set up your business enterprise.	CO3	50	40	10
11.	Visit a bank / financial institution to enquire about various funding schemes for small-scale enterprises.	CO3	50	40	10
12.	Collect loan application forms of nationalized banks / other financial institutions.	CO3	50	40	10
13.	Compile the information from financial agencies that will help you set up your business enterprise.	CO3	50	40	10
14.	Identify the business opportunity suitable for you.	CO2	50	40	10
15.	Market Survey for an Enterprise	CO3	50	40	10
16.	Industrial land and building for Entrepreneurship.	CO4	50	40	10
17.	Vision statement and mission statement for a Startup.	CO4	50	40	10
18.	Branding for a product and a Company.	CO4	50	40	10
19.	Marketing communication for business.	CO4	50	40	10
20.	A techno-feasibility report of a chosen product/service.	CO4	50	40	10
21.	Business plan for the enterprise.	CO4	50	40	10
22.	Online Marketing for Business.	CO4	50	40	10
23.	Goal setting for an enterprise.	CO3	50	40	10

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
24.	Marketing management for an enterprise.	CO3	50	40	10
25.	Supply Chain Management	CO3	50	40	10
26.	Market Intelligence for Entrepreneurship	CO3	50	40	10
27.	Risks in business	CO4	50	40	10
28.	Breakeven point for a business	CO4	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 beprepared 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: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Entrepreneurial Development	Khanka S.S. (2006)	S. Chand Publishing, 20068121918014,
2.	Un-Boxing Entrepreneurship Your self-help guide to setup a successful business	Dr. Nishith Dubey Aditya Vyas, AnnuSoman, AnupamSingh, CharulChaturvedi, Praveen Shukla	Indra Publishing House, 2023, ISBN- 978-93-93577-70-2
3.	Skill Development and Entrepreneurship in India	Rameshwari Pandya	Ingram 2016, 8177084186
4.	Production and Operations Management	SV Deshmukh, A K Chitale and Nishith, Rajaram Dubey,	Archers & Elevators Publishing House, Bangalore ISBN 9789386501197
5.	Entrepreneurship Development	Sapna Jarial	New India Publishing Agency- Nipa 2022, 9395319240
6.	The Entrepreneurial Instinct: How Everyone Has the Innate Ability to Start a Successful Small Business	Monica Mehta	Tata McGraw Hill Education, New Delhi, 2012, ISBN 978-0-07-179742-9
7.	The Learn Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically	Eric Ries	Penguin UK ISBN-978-0670921607

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
	Successful Businesses		
8.	Entrepreneurship and Start-ups	Ekta Sharma	FPH
9.	The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business	Clayton M. Christensen	Harvard business ISBN: 978-142219602

(b) Online Educational Resources:

1. Coir Board http://coirboard.gov.in/
2. National Institute for Micro, Small and Medium Enterprises (ni-msme) https://www.nimsme.org/
3. MSME / Udyam Registration https://udyamregistration.gov.in/Government-India/Ministry-MSME-registration.htm
4. CHAMPIONS https://champions.gov.in/Government-India/Ministry-MSME-Portal-handholding/msme-problem-complaint-welcome.htm
5. Prime Minister Employment Generation Programme and Other Credit Support Schemes https://msme.gov.in/prime-minister-employment-generation-programme-and-other-credit-support-schemes
6. Marketing Promotion Schemes https://msme.gov.in/marketing-promotion-schemes
7. Start-up India https://www.startupindia.gov.in/
8. DPIIT Recognition https://www.startupindia.gov.in/content/sih/en/startup-scheme.html
9. Startup India Seed Fund Scheme https://seedfund.startupindia.gov.in/
10. STARTUP INDIA INVESTOR CONNECT https://investorconnect.startupindia.gov.in/
11. Startup Funding https://www.startupindia.gov.in/content/sih/en/funding.html
12. Women Entrepreneurship in India https://www.startupindia.gov.in/content/sih/en/women_entrepreneurs.html
13. Incubators https://www.startupindia.gov.in/content/sih/en/incubator-framework.html
14. Start-up Mentors https://www.startupindia.gov.in/content/sih/en/search.html?roles=Mentor&page=0
15. NEN https://nen.org/
16. TIE https://tie.org/
17. MoE Innovation Cell https://www.mic.gov.in/
18. https://youtu.be/8iKsZZYv90k
19. https://youtu.be/Tzzfd6168jk
20. https://youtu.be/9-O15gDqebg

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: -

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A) Course Code : 2415506(P2415506/S2415506)

B) Course Title : Summer Internship -II / Industrial training

C) Pre- requisite Course(s) :

D) Rationale :

With the advancement in technology and skill requirements of industry 4.0, we need to prepare our young Indian technical talent to meet the present demand. Our diploma pass outs are either supposed to work as supervisor in the industries or start their own enterprise, hence upon the completion of diploma programme, they need to be adequately equipped with knowledge, skills and attitude required by the world of work in their relevant field. To attain this, students need to be sent for internship, industrial visit and industrial training during the course of study. One or two mandatory internships are placed in the programme structure to equip the students with practical knowledge, problem solving attitude and also provide the exposure to real time industrial environments. It also helps the students to understand the industrial requirements, develop expertise through hands on experience and take up project work relevant to industry. With these provisions of industrial exposures relevant practical and professional skills are developed in the students and as a result they are readily employed and widely accepted by industries, even sometimes during such trainings itself.
In the context of above after having gone through the summer internship-I (after the second semester), the summer internship-II/ industrial training is planned after the completion of fourth 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 Develop the comprehensive view of industry 4.0 elements and 21st century skills requirements in the relevant diploma engineering programme through Summer Internship-II.

CO-2 Outline the importance of industrial training and Internship for gaining direct practical skills on their relevant domain area of industrial equipment, automation, machinery, processes, product, management, operations, software development etc.

CO-3 Use the knowledge and skills gained during industrial training or world of work.

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	-	2	1		
CO-2	-	-	-	3	-	2	1		
CO-3	3	2	2	3	-	2	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				
2415506	Summer Internship - II	-	-	02	04	06	03

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)						
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2415506	Summer Internship - II	-	-	20	30	20	30	100

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) Guidelines to Teachers for Implementation & Assessment of Industrial Internship/Training:

1. Rationale:

During implementation of the curriculum, industrial exposure in the form of industrial internship/training is very important for developing and reinforcing many concepts and principles and also to get exposure of industrial environment, working culture, latest developments in relevant field, layout, management, culture, hierarchy, discipline, safety norms, different department/sections, quality control/assurance in processes, services and products, demonstration and operation of specific equipment/machinery, rules and procedures and many other aspects of the industries, where diploma holders are going to work. Students also get exposed to the different kinds of problems which can be brought into the institutional laboratories or workshop. Organizing industrial training of students is essentially required to enhance the prospects of employability, after undergoing industrial training, students get the direct exposure to the world of work in their relevant field. They get hands on experience in the industries.

Planning before Industrial internship/training is essentially required to be done for effective implementation of the same.

2. Planning for industrial internship/training:

Following points need to be planned and briefed by the teachers to the students before proceeding for industrial training. Student should take into consideration these points and carry the relevant format/data/log book with them.

- Analyze curriculum analysis and identify curricular gaps and topics which need industrial intervention;
- Objectives /Purposes of the industrial internship/training
- Outcomes targeted before proceeding to industrial internship/training.
- Pre-requisite knowledge or skills required to be developed in the students in the form of demonstration or classroom sessions.
- Identification and planning for demonstration of any equipment or experiments, concepts, under the content beyond syllabus.
- Preparation of database of nearby relevant industries.
- Good rapport needs to be developed and maintained with the industries by the teachers, so that the students are ultimately benefitted by the industrial internship/training.
- Industrial policy of the state also needs to be taken care of while planning of industrial training
- For assessing the students on various dimensions of industrial internship/training, assessment rubric may be prepared by the implementing teachers in advance.
- Make arrangements for student insurance during the industry internship/training
- Prepare instructions to be followed by students in the industries.
- Following formats need to be developed by the teachers and briefed to the students before proceeding to industrial internship/training –
  - Formats of observations on layout, ambience, and work culture to be developed, and briefed to the students.
  - Formats of outcome attainment, related to observation on relevant technical area also need to be developed by the teachers and briefed to the students.
  - Formats and contents of report writing and presentation.
  - Formats and contents on assessment of industrial training.
  - Continuous observation formats on many points such as behavioral aspects related to soft skills development such as initiativeness, observation, notes taking skills, inquisitiveness, obedience, sincerity, follow the instructions, positive attitude and many other aspects.

Formats of Assessment Rubric on different parameters of both behavioral aspects and technical aspects of the programme.

3. Major outcomes expected to be attained and assessed:

Outcomes expected from the industrial internship/training should be clearly defined and briefed to the students. Evaluation criteria for assessing students, need to be prepared for different outcomes set, during the planning stage. The list of major outcomes expected to be attained are –

- Development and reinforcement of Basic knowledge
- Development and reinforcement of Engineering knowledge through reinforcement of concepts or principles.
- Gaining Engineering Knowledge i.e operations, performance, maintenance, demonstrations of specific skills relevant to the content of the programme.
- Experiment and practice – Development of experimental practical skills and technical skills relevant to the course programme.
- Development of learning to learn skills and lifelong teaching skills for latest advancement in technology.
- Outcome attainment through content beyond syllabus
- Development of positive attitude, professional ethics and etiquettes.
- Development of skills for individual and team work during performance and otherwise.
- Maintaining Business Secrecy
- Development of Communication Skills
- Ability to follow the instructions
- Ability to follow the safety precautions
- Ability to supervise the task
- Ability to coordinate with subordinates and higher ups
- Development of Interpersonal skills
- Environmental Consciousness and Sustainability
- Development of Observational Skills
- Development of Self-discipline and Integrity
- Development of Time Management habits
- Development of generic skills such as pro-activeness, commitment
- Development of Problem-Solving abilities
- Achievement of target
- Concern for Environment, Sustainability Society
- Communication ability
- Industrial System and its development
- Safety Awareness
- Systematic Operations and Productions
- Quality control
- Management of work place and work force
- Development of positive attitude
- Work culture/Quality Culture
- Development of Professional Ethics
- Industrial Management
- Systematic planning, Implementation & Evaluation
- Use of engineering tools, techniques, software's and Procedures
- Development of Lifelong learning skills

It is important to note that outcomes attained during industrial visit are at the awareness level only.

4. Actions to be taken by the Students and Teachers:

Students are sent to Industrial training after briefing on various aspects. During industrial training, observational skills in students are required to a great extent -

- Students need to be alert, meticulous and record the data, as briefed to them before the industrial training.
- Record of observations on safety precaution to be followed, any special point during performance and handling of equipment, performance on technical aspects and other related aspects need to be taken care of.
- Continuous observation, monitoring and assessment on various behavioral and performance of technical aspects of each student need to be critically observed and recorded by the teachers using different assessment tools.

5. Post Training Assessment:

The students need to be assessed on report writing, presentation and interpretation of data recorded, on various dimensions, planned and performed, after the industrial training. The actions are required to be taken for assessment during report writing, analysis, interpretation, presentation of data and its assessment.

J) Initiatives by Govt. of India and other Agencies for Industrial Internship/ Training/Visit for Skills Development:

1. Initiatives by Govt. of India, GOI

a. Initiatives by Ministry of Skills Development and Entrepreneurship: Many efforts are initiated by different agencies in this direction as per our Prime Minister's Skills Development Mission. Make in India, Skills India etc are such initiatives taken by ministry for the benefit of the students. The Ministry is responsible for co-ordination of all Skill Development efforts across the country, removal of disconnect between demand and supply of skilled manpower, building the vocational and technical training framework, skill up-gradation, building of new skills and innovative thinking not only for existing jobs but also jobs that are to be created. The Ministry aims to skill on a large scale with speed and high standards in order to achieve its vision of a 'Skilled India'.

b. Initiatives by Ministry of Education, Govt. of India

i. Ministry of Education, Government of India is providing students a platform to inculcate a culture of product innovation and a mindset of problem solving to solve some of pressing problems solving to solve some of pressing problems we face in our daily lives through Smart India Hackathon (SIH) 2019.
SIH 2023 brings the next generation evolution by inclusion of new methodology to inculcate the culture of startup and innovation ecosystem across different age groups i.e. are as follows: -

- SIH Junior (Jr) School students from 6th to 12th class will be able to showcase their talent and generate out-of-the-box open innovation ideas.
- SIH Senior (Sr) Regular Students of HEI's pursuing "Graduate/Post-Graduate/Ph.D." will be able to showcase their talent and generate out-of-the-box open innovation ideas

ii. Internshala: Internshala is India's largest internship and training platform where more than 80,000 companies look for interns in various profiles (Engineering, management, media, arts etc.) AICTE has also partnered with Internshala for providing internship opportunities to every student in AICTE approved colleges. This facility is created to provide a platform for hands on experience to our future technicians on the relevant industries. With this experience, they are updated with the latest advances in their field of work.

Government of India through, AICTE is engaged in promoting the concept of industrial training through its various scheme, such as Internshala. The teachers now have the responsibility to understand in depth and implement such schemes in the institution for the benefit of students. At institute level also, there is need to develop policy for sending the students for industrial training.

c. Initiatives by All India Council for Technical Education (AICTE)

All India Council for Technical Education (AICTE) has been actively promoting various schemes to enhance internship, industrial training, and industrial visit opportunities for students pursuing technical education. These schemes aim to provide practical exposure, industry-relevant skills, and hands-on experience to students enrolled in AICTE-approved institutions. Since the schemes are reviewed continuously, the latest update can be referred through AICTE website.

i. **AICTE Training and Learning (ATAL) Academy**: The ATAL Academy provides opportunities for faculty and students to participate in various skill development programs, including internships and industrial training, to enhance their technical knowledge and expertise.

ii. **AICTE Doctoral Fellowship Scheme**: This scheme offers financial support to full-time Ph.D. scholars to undertake internships, research visits, or collaborative work with industry and research organizations in India and abroad.

iii. **Margdarshan Scheme**: The Margdarshan Scheme encourages faculty members to interact with industries and update their technical knowledge, which, in turn, benefits the students through better industry exposure and guidance. The National Education Policy (NEP) 2020 has also stressed on accreditation and it forms one of the four pillars for benchmarking and ensuring quality. The creation of National Accreditation Council as envisaged under NEP is thus only a matter of time after the suitable legislation is enacted. As per the NEP, accreditation shall be the sole driver for all future educational restructuring and changes. Hence it has become much more essential for an institute to strive and obtain accreditation for their programmes. This Margdarshan Initiative was last revised in May 2022. While the scheme has progressed, a need was felt to undertake a review and amplify the guidelines based on the feedback from the environment and other developments.

iv. **AICTE Training and Learning (ATAL) FDP Internship**: Under this scheme, faculty members have the opportunity to undergo internships at reputed industries to gain practical insights and update their teaching methodologies.

v. **AICTE Internship Policy**: AICTE has laid down an Internship Policy to encourage students to undertake internships as part of their academic curriculum. This policy aims to enhance their employability and bridge the gap between industry and academia.

vi. **AICTE-MODROBS (Modernization and Removal of Obsolescence) Scheme**: The MODROBS scheme supports the modernization of laboratories and workshops in technical institutions to enhance students' hands-on training experience. The scheme aims to modernize and remove obsolescence in the Laboratories / Workshops / Computing facilities (Libraries are excluded), so as to enhance the functional efficiency of Technical Institutions for Teaching, Training and Research purposes. It also supports new innovations in Class Room and Laboratory / Teaching Technology, development of Lab Instructional Material and appropriate Technology to ensure that the practical work and project work to be carried out by students is contemporary and suited to the needs of the Industry.

vii. **AICTE Vocational Education Programs**: AICTE supports vocational education programs that incorporate practical training, internships, and apprenticeships to make students industry-ready.

viii. **Industrial Visits and Training by Institutions**: While not a specific AICTE scheme, AICTE-approved institutions often organize industrial visits and training programs as part of their curriculum to provide practical exposure to students.

d. Initiatives by Ministry of Labour and Employment, Govt. of India

Ministry of Labour and Employment, Government of India launched a National ICT based job portal known as National Career Service (NCS) portal to connect the opportunities with the aspirations of youth. This portal facilitates registration of job seekers, job providers, and skill providers. Career counsellors, etc. The portal provides job matching services in a highly transparent and user-friendly manner. These facilities along with career counselling content are delivered by the portal through multiple channels like career centres, mobile devices, CSCs, etc.

The portal provides information on over 3000 career options from 53 key industry sectors. Job seekers also have access to industry trends in a user-friendly way. The NCS portal links job-seekers, employers, counsellors and training providers all through Aadhaar-based authentication. Registration to NCS portal is online and free of charge. The salient feature of NCS portal includes the following:

- Career counselling and Guidance
- Enabling Skill Development
- Empowering Job Seekers to find the right job
- Enabling employers to pick the right talent
- Enhancing capabilities of students through training
  Information's related to Job Fairs/Placements

Employment Exchanges Mission Mode Project (EE - MMP)

The Employment Exchange Mission Mode project is one of the 31 Mission Mode Projects under National e-Governance Plan (Ne-GP). Budget of INR 148.70 crore has been approved for 12th Five Year Plan for this project in December, 2013. The aim of EE-MMP is to provide career options and facilitate informed choice to the job seekers by providing a national platform for interface between stakeholders for responsive, transparent and efficient career services in order to meet the skill needs of a dynamic economy. The objective of EE-MMP is to take up process

Re-engineering and convert NES (National Employment Service) into NCS (National Career Service).

National Career Service (NCS)

NCS is proposed to have variety of services like information about skill development courses, apprenticeship, internship, career counseling, etc. along with all employment related services. It is expected that the NCS would be accessible to all stakeholders, based on partnerships and would provide larger number of services supported by call centers/helpdesk and through network of new nodes like CSC (common service centers), etc.

The main stakeholders for the NCS would include:

- Unemployed candidates seeking jobs
- Students seeking career counseling
- Candidates seeking vocational / occupational guidance
- Illiterate, under-privileged sections of society, blue-collar workers seeking placements and guidance
- Person with different abilities (PWDs), ex-servicemen, veterans / senior citizens, etc.
- Employers seeking suitable candidates

e. Initiatives by Telecom Sector Skill Council (TSSC)

TSSC has taken a step towards fulfilling the emerging requirements of the industry by partnering with key stakeholders in order to bring the latest content to the forefront. TSSC have got into partnership with All India Council for Technical Education (AICTE) for summer internship programme and various other MNCs to impart

Skilling in new emerging technologies. Some of the prime courses in new emerging technologies being offered by TSSC in addition to TSSC Qualification packs are as under:

- Artificial Intelligence & Data Science
- Cyber Security
- Internet of Things
- Android
- AR/VR

In addition to this certain course on life skills/soft skills, employability related skills are also planned for the students such as

- Problem solving and analytic
- Communication skills
- Lifelong learning
- Behavioural Skills
- Professional Behavioural etc.

The main objectives of TSSC are as follows

- Bridge the gap and enhance employability of our students
- Training young minds towards 21st Century skills assisting industry cross-sector
- Meet the needs of school leavers and graduates, employers, government educational institutions and society.
- Address the need for quality, skill training for human resources to complement the large goal of accomplishing the include growth.
- Address the limited capacity of skills development facilities in India
- To develop extensive placement linkages with employers in all sectors to provide gainful entry-level employment opportunities to youth undergoing the skill training.
- Industry participation in developing the skill training solutions to address critical skill gaps by standardization of training content, delivery and assessment process o improve overall competitiveness of the industry.
- Set up a comprehensive pan- India Labour Market Information System (LMIS) i.e. preparing a web-based compendium of job roles and skill types to assist in planning for re-skilling, delivery of training and employability.
- Undertake occupational mapping and skill gap analysis i.e. identification of skill development needs based on LMIS and emerging technologies.
- Rationalize and maintain a skill inventory.
- Create a skill development plan in coordination with Electronic and IT sector skill councils.
- Review and identify emerging skill gaps by trend analysis.
- Develop National Occupational Standards (NOS) that feature skill competency standards and qualifications.
- Refine the existing curricula to align it with NOS, obtain approval from an industry led body of experts and facilitate building of delivery capacity.
- Plan and institutionalise an effective system for training of trainers.

- Steer the affiliation and accreditation processes to enable quality assurance in training in par with international standards. Steer the affiliation and accreditation processes to enable quality assurance in training in par with international standards.
- Create an assessment framework to award tamper proof certifications to trainees.
- Promote academies of excellence by nurturing state of vocational training.
- Manage resources efficiently to achieve results and value for money.

2. Initiatives by other agencies

a. Initiatives by Engineering Council of India (ECI)

(ECI has also taken initiatives to organize series of interactive workshops to update and apprise the students about the products and services being offered by respective corporate house. This interaction will definitely bring the institute and industry closer and help in planning for effective implementation of industrial training.

b. Others

Many public sector and private organizations are also contributing to the course of quality improvement in technical education system by way of arranging industrial visit of providing industrial training to the students as a part of their corporate social responsibility and also for the growth of technical education system of the country.

K) **Assessment Rubric for Internship, Industrial Visit & Industrial Training:** Assessment Rubric for Internship, Industrial visit and industrial training should be prepared based on the objectives set and type of industries where internship/visit or training has been planned. Specific criteria of performance/assessment before, during and after the internship, industrial visit and industrial training should be identified by the implementing teachers for designing the rubric. For objective, valid and reliable assessment of Industrial Training, Industrial Visit and Internship, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared by teachers. Even the students may be encouraged to adopt self-assessment techniques using the assessment rubrics.

L) **CO-PO, PSO Mapping:** Based on the requirement of programme, objectives set and type of internship, industrial visit and industrial training placed at different semesters, CO-PO, PSO mapping need to be done. This mapping will vary at different semesters for same programme. Implementing teachers play very important role in developing the CO-PO, PSO matrix.

M) References:

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- **AICTE Internship Portal-** https://internship.aicte-india.org/

- **Industrial Visit-** https://www.dsu.edu.in/commerce-management/scms-industrial-visit
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- **Internship Policy-** https://iar.ac.in/wp-content/uploads/2022/02/IAR-Internship-Policy.pdf
- **Industry Institute Interaction Policy-** http://www.gcekarad.ac.in/Placement/III_Policy_2021_Main.pdf
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- **Internship Policy: Guidelines and Procedures with Effect from Academic Year 2020-2021-** https://www.kitcoek.in/documents/academics/internship-policy/kit-internship-policy-2020.pdf
- **Internship / Industrial Training-** https://www.dkte.ac.in/placement/internship
- **Ministry of Commerce and Industry (DPIIT Internship Scheme)**- https://www.myscheme.gov.in/schemes/dpiit-is

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A) Course Code : 2415507(P2415507/S2415507)

B) Course Title : Minor 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 a higher level of cognitive, psychomotor and affective domain skills. It encourages the critical thinking process in the students. Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in a new situation or task to solve the problems of the industries/real world. Project work 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.

In diploma programme of state of Bihar, minor project is being carried out at 5th semester where all aspects of project planning will be deal in detail.

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** Identify a real-world problem in the form of a project to be developed.
- **CO-2** Perform literature survey related to the identified area/problem.
- **CO-3** Identify preliminary resource requirements (Equipment, Tools, Software, Manpower, Services)
- **CO-4** Prepare project synopsis for the identified problem/project title within stipulated time period.

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** EngineeringTools	**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	2	-	-	-	2	1		
CO-3	3	2	-	2	-	2	1		
CO-4	3	-	-	-	-	3	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				
2415507	Minor Project	-	-	02	02	04	02

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)	
2415507	Minor Project	-	-	10	15	10	15	50

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 Plan of Minor Project:

Suggested implementation plan of minor project along with guidelines to teachers and students are mentioned below. For effective implementation of the project work in totality, different steps are to be carried out at different stages of the comprehensive project work.

- Project Planning. } (**Minor Project**)
- Design, development and execution of the project. } (**Major Project**)
- Quality of report writing and presentation.

In this semester, under the minor project work, the students are guided and monitored to under take Project planning steps as mentioned below. While, the remaining steps of project implementation will be carried out during major project work in next the semester.

1.0 Guidelines to Students for Implementation of Minor Project.

Students are guided to undergo following steps under the minor project. Teacher are advised to guide the students on each and every step.

1.1 Identification of Area/Problem and Project Titles
1.2 Literature Survey
1.3 Identification of Outcomes of the Project
1.4 Identification of the recourses required.
1.5 Preparation of Synopsis
1.6 Presentation of Synopsis

1.1 Identification of Project Titles and Allocation Methodology:

Though the teachers and students, both are involved in identification of project titles, but the prime responsibility o identification of project titles goes to the respective teachers involved in implementing the course or programm Teachers are fully aware of course/programme curriculum and they are also aware of related industrial problem hence, they try to explore the possibility of identification of project titles through these problems.

These small industrial problems in the form of project titles may be brought into the laboratories or workshop o institutions of a specific programme, which are equipped with all necessary facilities and resources to carry out th project work. These labs or workshop can function as miniature industry to solve the industrial problems in the for of simulated industrial projects. These projects may be integrated problem of courses or programme.

Criteria for Identification of Project Titles.

The identification of problem statement must be based on the following criteria:

- 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

1.2 Literature Survey:

Literature survey on the project title needs to be done through journals, websites, open source technologies available, discussion with the practicing engineers/industry persons and other relevant sources available.

1.3 Outcomes of the Project:

The project guide should ensure that the project outcomes are written properly as clear, specific, measurable and attainable statements. The outcomes formulated will decide the overall scope or course of action, depth and breadth of the project and implementation plan.

1.4 Identification of the recourses required:

Students under the guidance of teacher should try to identify all the resources required for the completion of the project like equipment, devices, experimental test rig, software, computer, persons to be contacted, suppliers, funds, availability of internal/external lab. The sample size has to be delimited and decided as per the time limit allotted, feasibility and many other considerations.

1.5 Preparation of Synopsis:

The students at the end of the semester are expected to submit 'Project Synopsis' after interaction with guide, as per the guidelines and format provided.

1.6 Presentation of Synopsis:

After developing the synopsis, student(s) should prepare a Power Point Presentation and present the same in front of examiner, guide and audience. Quality of presentation of data need to be ensured using the following criteria through Rubric-

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

2.0 Guidelines to Teachers for Implementation of the Minor Project:

The teacher alongwith the students should identify the different types of project title(s) as per need of the client as mentioned below:

- Prototype Development
- Experimentation Type
- Software Development Type
- Solving Industrial Problem Type
- Market Survey Type
- Feasibility Study Type
- Simulation Based
- Application Type
- Product Type
- Research Type
- Review Type

The project must be feasible. The guide allocated for each project are responsible for the quality of student's work, on different criteria including the synopsis writing which can be monitored on continual basis.

The guide must ensure that the feasibility of the project, the availability of resources/ software technology, sufficiency of time, finance and requirements during each and every step or activity of project work in advance.

J) Assessment of the Minor Project:

Continual Monitoring and feedback mechanism should be developed by the guide. An assessment plan on weekly progress/updates, action taken on different criteria and sub-criteria of the project work is suggested below. Path-breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

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 below mentioned assessment criteria at project planning stage. The Project guide must prepare detailed rubric(s) for each criteria to have valid and reliable assessment.

Assessment Scheme for Minor Project

S. No.	Suggested Assessment Criteria	Suggested Weightage (%)
1.	Identification of Area/Problem Statement	10
2.	Literature Survey	20
3.	Formulation of Project Title	10
4.	Clarity in Formulation of Outcomes of The Project	10
5.	Preparation of Synopsis	30
6.	Presentation of Synopsis	20
	Total	**100**

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