

# **Curriculum of Diploma Programme**

**in**

## **Architectural Assistantship**



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

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

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## Semester – VI

### Teaching & Learning Scheme

Course Codes	Category of Course	Course Titles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2437601	PCC	Architectural design & drawing- II	03	-	04	02	09	06
2437602	PCC	Professional practice & Byelaws	03	-	-	02	05	04
2437603	PCC	Acoustics & illumination	03	-	04	02	09	06
2400604	OEC	Open Elective**/ COE (Advanced - Any One)	03	-	04	02	09	06
2437605	PSI	Major Project (Common for all programmes)	-	-	08	04	12	06
2400408	NRC	Employability Skills Development (Common for All Programmes)	01	-	-	-	01	01
2400009	NRC	Open Educational Resources	01	-	-	-	01	01
<b>Total</b>			<b>14</b>	<b>-</b>	<b>20</b>	<b>12</b>	<b>46</b>	<b>30</b>

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

**Legend:**

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

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

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

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

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

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

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

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

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

## Semester - VI Assessment Scheme

Course Codes	Category of Course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment(LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2437601	PCC	Architectural design & drawing- II	30	70	20	30	20	30	200
2437602	PCC	Professional practice & Byelaws	30	70	20	30	-	-	150
2437603	PCC	Acoustics & illumination	30	70	20	30	20	30	200
2400604	OEC	Open Elective**/ COE (Advanced - Any One)	30	70	20	30	20	30	200
2437605	PSI	Major Project (Common for all programmes)	-	-	20	30	50	100	200
2400408	NRC	Employability Skills Development (Common for All Programmes)	25	-	-	-	-	-	25
2400009	NRC	Open Educational Resources	25	-	-	-	-	-	25
<b>Total</b>			<b>170</b>	<b>280</b>	<b>100</b>	<b>150</b>	<b>110</b>	<b>190</b>	<b>1000</b>

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

### Legend:

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

### Note:

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

A) **Course Code** : 2437601(T2437601/P2437601/S2437601)

B) **Course Title** : Architectural Design & Drawing -II

C) **Pre- requisite Course(s)** : Architectural Design

D) **Rationale** : Architectural Design and Drawing is a core subject that integrates creative thinking, functional planning, and graphical communication. The course aims to understand the ability of diploma students to understand human needs, site conditions, building regulations, and construction aspects and translate them into simple architectural design solutions. Emphasis is laid on understanding design thinking, space planning, scale, proportion, and preparation of presentation drawings suitable for small to medium-scale buildings relevant to diploma-level professional practice.

Teachers must supplement lectures and studio sessions with case studies, sketches, site visits, models, and audio-visual presentations to enhance design understanding.

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. Analyze user requirements, site conditions, and basic building bye-laws for architectural design
- CO-2. Prepare conceptual layouts and zoning diagrams for small buildings.
- CO-3. Develop architectural drawings including plans, elevations, sections, and details.
- CO-4. Apply basic principles of design, circulation, lighting, and ventilation in building design.
- CO-5. Present architectural design through appropriate drawings, sketches, and model making.

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 Lifelong Learning	PSO-1	PSO-2
CO-1	3	3	2	1	2	-	1		
CO-2	3	3	3	2	2	1	1		
CO-3	3	2	3	3	2	1	1		
CO-4	2	3	3	2	3	1	1		
CO-5	2	2	3	3	2	2	2		

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

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

G) **Teaching & Learning Scheme:**

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2437601	Architectural Design & Drawing - II	03	-	04	02	09	06

**Note: Prefix will be added to Course Code if applicable (T for theory Paper, P for Practical Paper and S for Term work)**

**Legend:**

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- 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)	
<b>2437601</b>	Architectural Design & Drawing - II	30	70	20	30	20	30	200

**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.)

- Note:**
- Separate passing is must for progressive and end semester assessment for both theory and practical.
  - 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: T2437601**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the stages of architectural design process.</p> <p><i>TSO 1b.</i> Identify factors affecting building design such as climate, site conditions and user requirements.</p> <p><i>TSO 1c.</i> Interpret basic building bye-laws.</p>	<p><b>Unit-1.0 Introduction to Architectural Design</b></p> <p>1.1 Meaning and scope of architectural design.</p> <p>1.2 Role of architect in society.</p> <p>1.3 Stages of design process (brief, analysis, concept, development, climatic condition).</p> <p>1.4 Introduction to building bye-laws (setback, FAR, height).</p>	CO1
<p><i>TSO 2a.</i> Prepare user requirement chart and area statement.</p> <p><i>TSO 2b.</i> Develop bubble diagrams showing relationship between spaces.</p> <p><i>TSO 2c.</i> Classify spaces into public, private and service zones.</p>	<p><b>Unit- 2.0 Space Planning and Zoning</b></p> <p>2.1 Principles of space planning.</p> <p>2.2 Anthropometry and space standards.</p> <p>2.3 Zoning – public, private, service.</p> <p>2.4 Bubble diagram and adjacency matrix.</p>	CO2
<p><i>TSO 3a.</i> Develop line plan of a residential building.</p> <p><i>TSO 3b.</i> Prepare detailed plan with dimensions and furniture layout.</p> <p><i>TSO 3c.</i> Draw elevation and section of residential building.</p>	<p><b>Unit 3.0 Design of Residential Building</b></p> <p>3.1 Design of single storey residence (2BHK/3BHK)</p> <p>3.2 Functional planning of living, kitchen, bedroom, toilet, staircase etc.</p> <p>3.3 Preparation of plan, elevation and section.</p> <p>3.4 Introduction to barrier-free planning</p>	CO3
<p><i>TSO 4a.</i> Analyze requirements of small public/semi-public buildings.</p> <p><i>TSO 4b.</i> Develop conceptual plan for public building.</p> <p><i>TSO 4c.</i> Organize circulation and activity areas effectively.</p> <p><i>TSO 4d.</i> Prepare plan, elevation and section for selected building.</p>	<p><b>Unit 4.0 Design of Public/Semi-Public Building</b></p> <p>4.1 Design of small clinic / primary school / office / library (any one).</p> <p>4.2 Functional zoning and circulation.</p> <p>4.3 Parking and basic services.</p>	CO4
<p><i>TSO 5a.</i> Explain principles of architectural presentation.</p> <p><i>TSO 5b.</i> Apply standard architectural lettering and dimensioning.</p> <p><i>TSO 5c.</i> Demonstrate basic rendering techniques in elevation.</p> <p><i>TSO 5d.</i> Prepare presentation sheet with title block and annotations.</p>	<p><b>Unit-5.0 Presentation Techniques</b></p> <p>5.1 Architectural lettering and dimensioning</p> <p>5.2 Symbols and graphical representation</p> <p>5.3 Introduction to rendering (pencil/colour)</p> <p>5.4 Preparation of presentation sheets</p> <p>5.5 Introduction to model making techniques</p>	CO3, CO5

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

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2437601**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Identify site features and prepare requirement analysis for given design problem.	1.	Prepare site analysis sheet including orientation, access, climate and surroundings.	CO1,
<i>LSOs 2.1</i> Develop relationship between spaces using bubble diagram and adjacency matrix <i>LSOs 2.2</i> Translate conceptual plan into measured line plan.	2.	Prepare bubble diagram and zoning plan for a small residential building.	CO2, CO3
	3	Draft line plan and detailed plan of single-storey residential building with proper dimensioning.	
<i>LSO 3.1.</i> Prepare elevation and section from finalized plan.	4	Draft elevation and section of the designed residential building.	CO3
<i>LSO 4.1.</i> Analyze functional requirements of small public/semi-public building <i>LSO 4.2.</i> Develop complete set of drawings for public/semi-public building	5	Prepare conceptual plan for clinic/primary school/office/library (any one)	CO4
	6	Draft plan, elevation and section of selected public/semi-public building.	
<i>LSOs 5.1</i> Apply architectural presentation techniques <i>LSOs 5.2</i> Demonstrate basic model making skills	7	Prepare presentation sheet with rendering, lettering and title block.	CO5
	8	Prepare simple physical model of the designed building using suitable materials.	

**L) Suggested Term Work and Self Learning: S2437601** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**1. Assignments:**

- Prepare anthropometric study sheet for residential spaces (kitchen, toilet, bedroom)
- Furniture layout planning for a 2BHK unit with area calculation.
- Case study of a G+1 residential building with photographs and drawings.

**2. Micro Projects:**

- Design a compact 1BHK house for economically weaker section (EWS)
- Design a primary school classroom unit with ventilation strategy
- Prepare 3D view (hand-drawn or simple CAD) of designed project.
- Model making project using recycled materials.

### 3. Other Activities:

#### 1. Seminar Topics:

- Role of vernacular architecture in modern design.
- Universal design in public buildings.

#### Visits:

- Visit to residential construction site and documentation of planning stages.
- Visit to architect's office for understanding drawing process.

#### 2. Self-learning topics:

- Low-cost housing techniques
- Study of standard room sizes as per national guidelines.
- Basics of AutoCAD for architectural drafting.

**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%	10%	15%	-	-	20%	20%
CO-2	20%	20%	10%	25%	-	10%	20%
CO-3	25%	20%	15%	25%	33%	15%	20%
CO-4	20%	20%	30%	25%	33%	15%	20%
CO-5	10%	30%	30%	25%	34%	40%	20%
<b>Total Marks</b>	<b>30</b>	<b>70</b>	<b>20</b>	<b>20</b>	<b>10</b>	<b>20</b>	<b>30</b>
			<b>50</b>				

#### 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 Architectural Design	8	CO1	14	2	4	8
Unit-2.0 Space Planning and Zoning	10	CO2	16	4	6	6
Unit-3.0 Design of Residential Building	10	CO3	14	4	4	6
Unit-4.0 Design of Public/Semi-Public Building	10	CO4	12	2	2	8
Unit-5.0 Presentation Techniques	10	CO5	14	4	4	6
<b>Total</b>	<b>48</b>	<b>-</b>	<b>70</b>	<b>16</b>	<b>20</b>	<b>34</b>

**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):

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Prepare site analysis sheet including orientation, access, climate and surroundings.	CO1	40	50	10
2.	Prepare bubble diagram and zoning plan for a small residential building.	CO2	40	50	10
3.	Draft line plan and detailed plan of single-storey residential building with proper dimensioning.	CO2, CO3	30	60	10
4.	Draft elevation and section of the designed residential building.	CO3	30	60	10
5.	Prepare conceptual plan for clinic/primary school/office/library (any one)	CO3	40	50	10
6.	Draft plan, elevation and section of selected public/semi-public building.	CO4	40	50	10
7.	Prepare presentation sheet with rendering, lettering and title block.	CO5	30	60	10
8.	Prepare simple physical model of the designed building using suitable materials.	CO5	40	50	10

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

S. No.	Name of Equipment and Tools Broad Specifications	Exp. No.
1.	Drawing boards, drafting tools , T-Square and Set Squares	1 to 8
2.	Drawing Sheets, Pencil Set (2H, H, HB, B, 2B grades for drafting and rendering)	1 to 8
3.	Models making tools: Cutter, cutting mat, glue, scale, foam board, cardboard sheets	7,8

**R) Suggested Learning Resources:**

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Form, Space and Order	D. K. Ching	John Wiley & Sons ,publishing
2.	Time-Saver Standards for Building Types	Joseph De Chiara	McGraw-Hill Education publishing company
3.	Architectural Graphics	D. K. Ching	John Wiley & Sons , publishing company
4.	Building Planning and Drawing	S P Arora,	Dhanpat Rai Publication Delhi

(b) Online Educational Resources:

1. [www.nptel.ac.in](http://www.nptel.ac.in)
2. [www.archdaily.com](http://www.archdaily.com)
3. [www.bis.gov.in](http://www.bis.gov.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.

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- A) **Course Code** : **2437602 (T2437602/S2437602)**  
 B) **Course Title** : Professional Practice & Byelaws  
 C) **Pre- requisite Course(s)** : Professional Practice & Byelaws  
 D) **Rationale** :

Professional Practices and Building Bye-Laws are essential for students to understand the legal, ethical, technical, and administrative framework of architectural practice. The subject provides knowledge about roles and responsibilities of architects, building regulations, approval procedures, tendering process, contracts, and professional conduct.

This course prepares students for professional office work, interaction with clients and authorities, and understanding statutory regulations applicable to building construction.

- 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 structure and scope of architectural profession.  
**CO-2** Describe duties, responsibilities and professional ethics in architectural practice.  
**CO-3** Interpret building bye-laws and development control regulations.  
**CO-4** Understand building approval process and documentation.  
**CO-5** Explain basic contract procedures, tendering, and professional fees structure.

- 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 Lifelong Learning	PSO-1	PSO-2
CO-1	3	1	-	-	1	1	1		
CO-2	3	2	1	-	2	2	2		
CO-3	3	3	2	1	3	1	1		
CO-4	3	2	2	-	2	2	1		
CO-5	2	3	1	-	2	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 &amp; Learning Scheme:

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		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
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<b>2437602</b>	Professional Practice & Byelaws	03	-	-	02	05	04

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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:

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		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
<b>2437602</b>	Professional Practice & Byelaws	30	70	20	30	-	-	150

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## Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- 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: T2437602**

<b>Major Theory Session Outcomes (TSOs)</b>	<b>Units</b>	<b>Relevant COs Number(s)</b>
<p><i>TSO 1a.</i> Explain structure of architectural profession.</p> <p><i>TSO 1b.</i> Describe role of Council of Architecture.</p> <p><i>TSO 1c.</i> Explain registration process of architect.</p>	<p><b>Unit-1.0 Architectural Profession</b></p> <p>1.5 Role of architect</p> <p>1.6 Structure of architectural office</p> <p>1.7 Registration procedure</p>	<b>CO1</b>
<p><i>TSO 2a.</i> Describe professional ethics and code of conduct.</p> <p><i>TSO 2b.</i> Explain duties towards client and society.</p> <p><i>TSO 2c.</i> Identify professional misconduct.</p>	<p><b>Unit- 2.0 Professional Practice &amp; Ethics</b></p> <p>2.1 Code of professional conduct</p> <p>2.2 Duties and liabilities</p> <p>2.3 Scale of charges</p>	<b>CO2</b>
<p><i>TSO 3d.</i> Define key terms in building bye-laws.</p> <p><i>TSO 3e.</i> Interpret setbacks, FAR, ground coverage, height regulations.</p> <p><i>TSO 3f.</i> Explain occupancy classifications</p>	<p><b>Unit 3.0 Building Bye-Laws &amp; Development Control</b></p> <p>3.5 Definitions and terminology</p> <p>3.6 Setbacks and open spaces</p> <p>3.7 FAR/FSI calculations</p> <p>3.8 Building height control</p> <p>3.9 Fire safety norms</p>	<b>CO3</b>
<p><i>TSO 4a.</i> Explain building approval process.</p> <p><i>TSO 4b.</i> Identify required documents for submission.</p> <p><i>TSO 4c.</i> Describe completion and occupancy certificate procedure</p>	<p><b>Unit 4.0 Building Approval &amp; Documentation</b></p> <p>4.4 Submission drawings</p> <p>4.5 Approval from local authority</p> <p>4.6 Completion certificate</p> <p>4.7 Occupancy certificate</p>	<b>CO4</b>
<p><i>TSO 5a.</i> Explain types of contracts.</p> <p><i>TSO 5b.</i> Describe tendering procedure.</p> <p><i>TSO 5c.</i> Explain basic contract documents</p>	<p><b>Unit-5.0 Contracts &amp; Tendering</b></p> <p>5.6 Types of contracts</p> <p>5.7 Tender notice and process</p> <p>5.8 Agreement and conditions</p>	<b>CO5</b>

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

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

**L) Suggested Term Work and Self Learning: S2437602** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**4. Assignments:**

- Study of local municipal bye-laws.
- FAR calculation sheet for given plot
- Case study of building approval procedure

**5. Micro Projects:**

- Drafting a sample agreement between client and architect.
- Tender document preparation for small residential project

**6. Other Activities:****3. Seminar Topics:**

- Importance of professional ethics
- Legal issues in construction industry

Visits:

**4. Self-learning topics:**

- National Building Code.
- Real Estate Regulatory Act.

**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%	10%	15%	-	-	-	-
CO-2	10%	20%	10%	25%	-	-	-
CO-3	15%	20%	15%	25%	33%	-	-
CO-4	30%	20%	30%	25%	33%	-	-
CO-5	30%	30%	30%	25%	34%	-	-
<b>Total Marks</b>	<b>30</b>	<b>70</b>	<b>20</b>	<b>20</b>	<b>10</b>	-	-
			<b>50</b>				

- 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 Architectural Profession	8	CO1	14	2	4	8
Unit-2.0 Professional Practice & Ethics	10	CO2	16	4	6	6
Unit-3.0 Building Bye-Laws & Development Control	12	CO3	14	4	4	6
Unit-4.0 Building Approval & Documentation	10	CO4	12	2	2	8
Unit-5.0 Contracts & Tendering	8	CO5	14	4	4	6
<b>Total</b>	<b>48</b>	<b>-</b>	<b>70</b>	<b>16</b>	<b>20</b>	<b>34</b>

**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): N/A**

**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 and Tools Broad Specifications
1.	Model Bye-law Documents
2.	Sample Agreement Copies (standard format)
3.	Software : (a) Autocad ( for submission drawing)

**R) Suggested Learning Resources:****(b) Books:**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Professional Practice	K.K.Khandelwal	S.Chand Publishing
2.	National Building Code Of India	Bureau of Indian Standards	BIS Publication

**(b) Online Educational Resources:**

4. [www.youtube.com](http://www.youtube.com) for videos regarding building bye-laws.
5. [www.nptel.ac.in](http://www.nptel.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.

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- A) **Course Code** : **2437603 (T2437603/P2437603/S2437603)**  
 B) **Course Title** : Acoustics & Illumination  
 C) **Pre- requisite Course(s)** : Acoustics & Illumination  
 D) **Rationale** :

Acoustics and Illumination are essential components of building design that directly affect human comfort, productivity, and health. Students must understand the principles of sound control, room acoustics, natural lighting, and artificial lighting to design functionally efficient and comfortable spaces.

This course aims to develop knowledge of acoustic behavior in buildings and principles of lighting design applicable to residential, commercial, and public buildings. Emphasis is placed on practical application and building-oriented solutions rather than theoretical physics.

- 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-6** Explain basic principles of sound and acoustics related to buildings.  
**CO-7** Analyze acoustic defects in rooms and suggest remedial measures  
**CO-8** Apply principles of sound insulation and noise control in buildings.  
**CO-9** Explain principles of natural and artificial illumination.  
**CO-10** Design basic lighting layout for residential and small public buildings.

- 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 Lifelong Learning	PSO-1	PSO-2
CO-1	3	2	1	-	1	-	1		
CO-2	3	3	2	1	2	-	1		
CO-3	3	3	3	1	2	1	1		
CO-4	3	2	2	2	3	-	1		
CO-5	2	3	3	3	3	1	2		

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

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

- G) **Teaching & Learning Scheme:**

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
<b>2437603</b>	Acoustics & Illumination	03	-	04	02	09	06

**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)

**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)	
<b>2437603</b>	Acoustics & Illumination	30	70	20	30	20	30	200

**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.

**Note:**

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- 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.

**II) 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: T2437603

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1d.</i> Define sound, frequency, wavelength and intensity.</p> <p><i>TSO 1e.</i> Explain sound propagation and reflection</p>	<p><b>Unit-1.0 Fundamentals of Sound</b></p> <p>1.8 Nature of sound</p> <p>1.9 Frequency, wavelength, intensity</p> <p>1.10 Sound pressure level and decibel</p> <p>1.11 Reflection, absorption and transmission</p>	CO1
<p><i>TSO 2d.</i> Identify acoustic defects such as echo and reverberation.</p> <p><i>TSO 2e.</i> Explain reverberation time and Sabine's formula (basic concept only).</p> <p><i>TSO 2f.</i> Suggest remedies for acoustic defects</p>	<p><b>Unit- 2.0 Room Acoustics</b></p> <p>2.4 Echo, reverberation, sound focusing</p> <p>2.5 Reverberation time (concept)</p> <p>2.6 Acoustic materials and finishes</p> <p>2.7 Acoustic treatment of auditorium/classroom</p>	CO2
<p><i>TSO 3g.</i> Explain airborne and structure-borne noise.</p> <p><i>TSO 3h.</i> Describe methods of sound insulation.</p> <p><i>TSO 3i.</i> Suggest noise control measures in building</p>	<p><b>Unit 3.0 Sound Insulation &amp; Noise Control</b></p> <p>3.10 Sources of noise (traffic, industry)</p> <p>3.11 Sound insulation materials</p> <p>3.12 Double walls, cavity walls</p> <p>3.13 Noise control planning</p>	CO3
<p><i>TSO 4d.</i> Define illumination terms (lumen, lux, candela).</p> <p><i>TSO 4e.</i> Explain principles of natural lighting.</p> <p><i>TSO 4f.</i> Describe daylight factor concept.</p>	<p><b>Unit 4.0 Natural Illumination</b></p> <p>4.8 Laws of illumination</p> <p>4.9 Daylight factor</p> <p>4.10 Window design and orientation</p> <p>4.11 Glare control and shading devices</p>	CO4
<p><i>TSO 5d.</i> Classify types of artificial lighting.</p> <p><i>TSO 5e.</i> Explain lighting schemes (direct, indirect).</p> <p><i>TSO 5f.</i> Prepare simple lighting layout.</p>	<p><b>Unit-5.0 Artificial Illumination</b></p> <p>5.9 Types of lamps (LED, fluorescent etc.)</p> <p>5.10 Lighting levels for buildings</p> <p>5.11 Lighting layout principles</p> <p>5.12 Energy-efficient lighting</p>	CO5

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

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2437603**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.2.</i> Measure sound level using sound level meter	1.	Measurement of sound intensity in classroom	CO1, CO2
<i>LSOs 2.3</i> Identify acoustic defects in a room	2.	Case study of auditorium/classroom for acoustic defects	CO2
<i>LSO 3.2.</i> Study sound insulation material	3	Identification of acoustic materials and preparation of report.	CO3
<i>LSO 4.3.</i> Calculate daylight factor ( basics)	4	Daylight analysis for a classroom plan	CO4
<i>LSOs 5.3</i> Prepare artificial lighting layout <i>LSOs 5.4</i> Compare different lighting fixtures	5	Design lighting layout for residential room	CO5
	6	Study of lighting fixtures and preparation of sheet	

**L) Suggested Term Work and Self Learning: S2437603** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**7. Assignments:**

- Case study of auditorium acoustics.
- Illumination study of classroom.
- Comparison of LED and conventional lighting.

**8. Micro Projects:**

- Lighting design of 2bhk apartment.
- Acoustics improvement proposal of classroom

**9. Other Activities:**

## 5. Seminar Topics:

- Green lighting systems
- Acoustics design in auditorium
- Smart lighting and automation

Visits:

## 6. Self-learning topics:

- Green Acoustic Materials (eco-friendly sound panels)
- Role of False Ceiling in Acoustic Control
- Smart Acoustic Panels and New Technologies

**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%	10%	15%	-	-	20%	20%
CO-2	10%	20%	10%	25%	-	10%	20%
CO-3	15%	20%	15%	25%	33%	15%	20%
CO-4	30%	20%	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 (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Fundamentals of Sound	12	CO1	14	2	4	8
Unit-2.0 Room Acoustics	10	CO2	16	4	6	6
Unit-3.0 Sound Insulation & Noise Control	10	CO3	14	4	4	6
Unit-4.0 Natural Illumination	8	CO4	12	2	2	8
Unit-5.0 Artificial Illumination	8	CO5	14	4	4	6
<b>Total</b>	<b>48</b>	<b>-</b>	<b>70</b>	<b>16</b>	<b>20</b>	<b>34</b>

**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):**

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
9.	Measurement of sound intensity in classroom.	CO1	40	50	10
10.	Case study of auditorium/classroom for acoustic defects.	CO2	40	50	10
11.	Identification of acoustic materials and preparation of report.	CO3	30	60	10
12.	Daylight analysis for a classroom plan.	CO4	30	60	10
13.	Design lighting layout for residential room.	CO5	40	50	10
14.	Study of lighting fixtures and preparation of sheet.	CO5	40	50	10

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

S. No.	Name of Equipment and Tools Broad Specifications
1.	Sound level meter (digital, 30-130 db range)
2.	Sample acoustics materials (foam, fiberboard, gypsum panel), lighting fixtures (LED, spotlight, florescent )
3.	Software : (b) Autocad (c) Sketchup (d) DIALux evo

**R) Suggested Learning Resources:****(c) Books:**

<b>S. No.</b>	<b>Titles</b>	<b>Author(s)</b>	<b>Publisher and Edition with ISBN</b>
1.	Architectural Acoustics	M. David Egan	J. Ross Publishing
2.	Environmental Science In Building	R. McMullan	Palgrave Macmillan
3.	Building Construction	S.C.Rangwala,	Charotar Publishing House Dist- Anand

**(b) Online Educational Resources:**

6. [www.youtube.com](http://www.youtube.com) for videos regarding acoustics, illumination
7. [www.nptel.ac.in](http://www.nptel.ac.in)

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

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- A) **Course Code** : 2400604B(T2400604B/P2400604B/S2400604B)  
 B) **Course Title** : Artificial Intelligence (Advanced)  
 C) **Pre- requisite Course(s)** : Artificial Intelligence (Basic)  
 D) **Rationale** :

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

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to 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 Machine learning in Artificial Intelligence.  
 CO-2 Implement various supervised and unsupervised learning models and methods.  
 CO-3 Illustrate Artificial neural networks and its applications.  
 CO-4 Implement various Neural network models and Learning Methods.  
 CO-5 Solve machine learning and artificial neural network problems using Tens or flow.

- F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, 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	3	-	-	2		
CO-3	-	3	3	3	-	-	2		
CO-4	3	1	3	3	-	-	2		
CO-5	3	3	3	3	-	-	2		

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

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

- G) **Teaching & Learning Scheme:**

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

**Legend:**

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

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

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

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

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

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

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

**H) Assessment Scheme:**

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

**Legend:**

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

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

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

**Note:**

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

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

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

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

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

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

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

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

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

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

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

b. **Micro Projects:**

Use python programming for the solutions of Microproject problems

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

width.

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

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

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

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

**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 Machine Learning	8	CO1	11	5	4	2
Unit-2.0. Supervised and Unsupervised Learning	10	CO2	18	5	6	7
Unit-3.0. Introduction to Neural Networks	10	CO3	17	5	7	5
Unit-4.0. Neural Networks Models and Learning Methods	10	CO4	14	3	3	8
Unit-5.0. Tensor Flow	10	CO5	10	2	6	2
<b>Total Marks</b>	<b>48</b>		<b>70</b>	<b>20</b>	<b>26</b>	<b>24</b>

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

- O) Suggested Assessment Table for Laboratory (Practical):**

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Write a program to implement k-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2	-	90	10
2.	(a) Implement SVM for Iris Dataset- download the dataset from ( <a href="https://gist.github.com/netj/8836201">https://gist.github.com/netj/8836201</a> ) (b) Find confusion matrix and evaluation matrix for SVM	CO-2	-	90	10
3.	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2	20	70	10
4.	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2	-	90	10
5.	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4	10	80	10
6.	Implement the perceptron algorithm from scratch in python.	CO-4	10	80	10
7.	Write a programme to implement two dimension and three-dimension Tensor.	CO-5	-	90	10
8.	Write a programme to add and multiply two 4x4 matrix, you can Import "tens or flow" and "numpy".	CO-5	-	90	10
9.	Solve a classification problem on the Tens or flow playground.	CO-5	20	70	10
10.	Implement algorithm for linear regression in tens or flow	CO-2, CO-5	10	80	10

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

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

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

**R) Suggested Learning Resources:****(a) Books:**

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

**(b) Online Educational Resources:**

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

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

**(c) Others:****Data Source:**

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

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- A) **Course Code** : 2400604C(T2400604C/P2400604C/S2400604C)  
 B) **Course Title** : Internet of Things (Advanced)  
 C) **Pre- requisite Course(s)** : IoT (Basics), Computer Networks  
 D) **Rationale** :

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

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

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

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

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

- F) **Suggested Course Articulation Matrix (CAM):**

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

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

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

## G) Teaching &amp; Learning Scheme:

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

## Legend:

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

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

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

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

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

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

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

## H) Assessment Scheme:

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

## Legend:

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

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

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

## Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.1. a. Write the steps to install Python.</p> <p>TSO.1. b. Explain given types of variables in python.</p> <p>TSO.1. c. Explain use and importance of Tuple, Dictionary, operators in python</p> <p>TSO.1. d. Explain use of array in python.</p> <p>TSO.1. e. Explain use of 2-Dimensional Array in python</p> <p>TSO.1. f Explain uses of given type of Conditional statement in python.</p>	<p><b>Unit-1.0 Python Basics: -</b></p> <p>1.1 Installation of Python</p> <p>1.2 Variables, Print () function, Escape character sequence and run python Program</p> <p>1.3 Python Tuple, Dictionary, operators</p> <p>1.4 Python arrays, create, reverse and append data into it.</p> <p>1.5 Python 2 Dimensional arrays.</p> <p>1.6 Python Conditional statement.</p>	CO-1 and CO-5
<p>TSO.2. a. Explain uses of given type of do &amp; while loops in python</p> <p>TSO.2. b. Explain working of break, continue and pass statement in python</p> <p>TSO.2. c. Write the benefits of using OOP methodology in python.</p> <p>TSO.2. d. Explain given type of string operation related to python.</p> <p>TSO.2. e. Explain given function in python</p> <p>TSO.2. f Explain use of Lambda function in python.</p>	<p><b>Unit 2.0 Python Advance: -</b></p> <p>2.1 Python Do &amp; while loops</p> <p>2.2 Python break, continue, pass statements</p> <p>2.3 Python OOPs Class, Object, Inheritance and Constructor</p> <p>2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length</p> <p>2.5 Python Functions, Built-in functions and user defined functions</p> <p>2.6 Lambda function and uses</p>	CO-1 and CO5
<p>TSO.3. a. Differentiate between Cloud and IoT cloud.</p> <p>TSO.3. b. Explain features of Cloud in IoT environment</p> <p>TSO.3. c. List features of various types of Cloud</p> <p>TSO.3. d. List features of cloud services like SaaS, PaaS and IaaS</p> <p>TSO.3. f List advantages of cloud data storage.</p> <p>TSO.3. g Explain Arduino architecture and its applications.</p> <p>TSO.3.h Explain Raspberry pi architecture and its applications.</p>	<p><b>Unit-3.0 Cloud Features: -</b></p> <p>3.1 Cloud computing and IoT cloud</p> <p>3.2 Benefits of cloud in IoT</p> <p>3.3 Types of Cloud public, private and hybrid</p> <p>3.4 Cloud services like SaaS, PaaS and IaaS</p> <p>3.5 Cloud connectivity and Data storage on Cloud.</p> <p>3.6 Arduino: Architecture, Programming, and Applications</p> <p>3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications</p>	CO-1, CO-2 and CO-5
<p>TSO.4. a. Explain wired network</p> <p>TSO.4. b. Explain short range wireless network</p> <p>TSO.4. c. Explain M2M communication</p> <p>TSO.4. d. Explain various generation of wireless network</p> <p>TSO.4. e. Explain the importance of LWPAN in IoT</p> <p>TSO.4. f Differentiate between SigFox &amp; LoRaWAN</p> <p>TSO.4. g Explain use of NB-IOT (Narrow Band IOT)</p> <p>TSO.4.h Create heterogenous network using RFID.</p>	<p><b>Unit.4.0 IoT Networking and Application: -</b></p> <p>4.1 Wired and short-range wireless network</p> <p>4.2 M2M – 2G, 3G, 4G &amp; 5G networks</p> <p>4.3 LPWAN – Low Power Wide Area Networks</p> <p>4.4 SigFox &amp; LoRaWAN.</p> <p>4.5 NB-IOT (Narrow Band IOT)</p> <p>4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors-Cables- Readers- encoder/ printers for smart labels- Controllers software</p> <p>4.7 RFID advantages over Bar codes.</p>	CO-1 and CO-4
<p>TSO.5. a. Identify suitable framework for IoT app development</p> <p>TSO.5. b. Identify various stages of selected app</p> <p>TSO.5. c. Develop the app.</p> <p>TSO.5. d. Implement and deploy the app</p>	<p><b>Unit. 5.0 IoT App Development: -</b></p> <p>5.1 Framework selection for IoT app development</p> <p>5.2 Identify stages of app to be developed.</p> <p>5.3 Develop, Implement, and Deploy the App</p> <p>5.4 Testing and Integration</p>	CO-4 and CO-5

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Python installation LSO 1.2 Prepare and run python program on given problem LSO 1.3 Prepare python program on Dictionary, Tuple and operators. LSO 1.4 Prepare program on arrays LSO 1.5 Prepare a program on 2-dimensional array LSO 1.6 Create program on conditional statement	1.	1.1 Install given version of Python on the computer system. 1.2 Prepare a python program using print() function and run it. 1.3 Access given value from the tuple 1.4 Print the given value of key from the dict. 1.5 Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes 1.6 Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array. 1.7 Write a python program to check whether person is eligible for voting or not. (accept age from the user) 1.8 Write a python program to check whether the entered number is even or odd. 1.9 Write a python program to check whether entered number is divisible by another entered number. 1.10 Write a python program to display "Yes" is entered number is divisible by 5 otherwise display "No"	CO-1
LSO 2.1 Prepare python program on Do & while loops LSO 2.2 Prepare python program on break and continue statement. LSO 2.3 Prepare Python program using break and continue statements LSO 2.4 prepare python program using OOP LSO 2.5 Prepare Python program using functions	2.	2.1 Prepare a python program which can print first 10 even and odd numbers using while statement 2.2 Write a python program which can print first 10 integers and its square using while/for loop. 2.3 Write a python program which can print sum of first 10 natural numbers using while/for loop. 2.4 Write a python program which can identify the prime number between the range given using while/for loop. 2.5 Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use. 2.6 Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use. 2.7 Create a Class with instance attributes	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		2.8 Create a Vehicle class without any variables and methods 2.9 Write a Python function to find the Max of three numbers. 2.10 Write a Python program to reverse a string.	
LSO 3.1 Signup for free cloud storage LSO 3.2 Store data into cloud and retrieve it.	3.	3.1 Create a free cloud account 3.2 Store data on cloud and retrieve it	CO-3
LSO 4.1 Design various types of network cables LSO 4.2 Connect computer in LAN. LSO 4.3 Connect devices using wireless network LSO 4.4 Connect machine with machine LSO 4.5 Connect devices using IEEE 802 LSO 4.6 Connect devices using LPWAN LSO 4.7 Connect devices using RFID	4	4.1 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool. 4.2 Connect the computers in Local Area Network 4.3 Connect 2 or more devices using Bluetooth 4.4 Connect 2 or more devices using infrared 4.5 Connect 2 more machine using m2m 4.6 Connect 2 or more different devices using access point 4.7 Connect 2 devices using LPWAN (Smart Meter) 4.8 Connect 2 or more devices using RFID	CO-4
LSO 5.1 Develop a IoT app LSO 5.2 Develop IoT applications using smartphones.	5.	5.1 Identify a problem and develop an app 5.2 Building a temperature monitoring system using sensors and Smartphone	CO-5

L) **Suggested Term Work and Self Learning: S2400604C** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. **Micro Projects:**

1. Prepare a report on Python programming language.
2. Develop a small software in python to solve a IoT data analysis.
3. Create a id on free cloud storage and share data on it for others.
4. Create a heterogenous network and connect different dives.
5. Create a an IoT app for the identified problem

c. **Other Activities:**

1. Seminar Topics: - "Future of wireless network."
2. "Smart electricity billing ", "Cloud computing and IoT"
3. Visit to industry for IoT implementation in industrial process.
4. Reading RFID cards using 8051- RFID in the supply chain- Vehicles parking using RFID- library management system- electronic toll payment- smart shipping containers fleet monitoring and management.
5. Building IoT Applications like pressure, air quality, temperature and motion detector using Arduino and raspberry-pi Universal boards.
6. Surveys of market for availability of various types of network devices and its pricing.
7. Product Development: Development of projects for real life problem solution app.
8. Software Development: Using Python

d. **Self-Learning Topics:**

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

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

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

**Legend:**

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

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

# : Mentioned under point-(O)

**Note:**

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

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

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

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

**O) Suggested Assessment Table for Laboratory (Practical):**

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

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

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

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

**R) Suggested Learning Resources:****(a) Books:**

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

**(b) Online Educational Resources:**

1. [nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm](https://nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm)
2. [en.wikipedia.org/wiki/Shear\\_and\\_moment\\_diagram](https://en.wikipedia.org/wiki/Shear_and_moment_diagram)
3. [www.freestudy.co.uk/mech%20prin%20h2/stress.pdf](http://www.freestudy.co.uk/mech%20prin%20h2/stress.pdf)
4. [www.engineerstudent.co.uk/stress\\_and\\_strain.html](http://www.engineerstudent.co.uk/stress_and_strain.html)
5. [https://www.iit.edu/arc/workshops/pdfs/Moment\\_Inertia.pdf](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](http://www.engineerstudent.co.uk/stress_and_strain.html)
9. [https://www.iit.edu/arc/workshops/pdfs/Moment\\_Inertia.pdf](https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf)  
Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work.  
<https://github.com/OpenRCE/sulley>

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

**(c) Others:**

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

- A) **Course Code** : 2400604D(T2400604D/P2400604D/S2400604D)  
 B) **Course Title** : Drone Technology (Advanced)  
 C) **Pre- requisite Course(s)** : Drone Technology (Basics)  
 D) **Rationale** :

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

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

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

- CO-1** Apply the concept of engineering mechanics for stability of drone.  
**CO-2** Design the structure of drone using GPS module and thermal Image camera.  
**CO-3** Operate drone using advance flight controller board.  
**CO-4** Perform drone maintenance and assembly.  
**CO-5** Use drone in advance applications like precision agriculture, security, IoT, etc.

- F) **Suggested Course Articulation Matrix (CAM):**

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

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

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

**G) Teaching & Learning Scheme:**

Legend:

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

CI:

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

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

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

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

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

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

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

**H) Assessment Scheme:**

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

Legend:

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

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

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

**Note:**

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

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
	3.8 Safety features of advance FCB	
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	<b>Unit-4.0 Maintenance and Assembling of Drone</b> 4.1 Need and scope of drone maintenance 4.2 Types of maintenance 4.3 Routine drone maintenance and its checklist <ul style="list-style-type: none"> <li>• Recording basic details</li> <li>• Structural inspection</li> <li>• Battery check</li> <li>• Software/firmware</li> </ul> 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones <ul style="list-style-type: none"> <li>• Concept of interchangeability</li> <li>• Principle of gauging and their applicability in drone assembly</li> <li>• Parameters and profile measurements of standard propellers</li> <li>• Concepts of drone assembly using 3D modeling</li> </ul>	<b>CO-4</b>
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	<b>Unit-5.0 Advance Drone Application</b> 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in <ul style="list-style-type: none"> <li>• Military</li> <li>• Precision Agriculture</li> </ul>	<b>CO-5</b>

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1 Identify different component of GPS module LSO 5.2 Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	CO-2
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identify different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	CO-3
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator. LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.	12.	Measure various electric parameters in drone hardware	CO-4
LSO 13.1 Inspect drone as per the given checklist LSO 13.2 Diagnose drone problems after flying of 50 and 100hrs	13.	Perform preventive maintenance of drone components	CO-4
LSO 14.1 Perform dismantle process of drone. LSO 14.2 perform services need for operation LSO 14.3 Check and Install different parts of the drone system. LSO 14.4 Assemble drone component.	14.	Dismantle and service of different parts of drone system	CO-4

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

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

b. **Micro Projects:**

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

**c. Other Activities:**

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

**d. Self-Learning Topics:**

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

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

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

**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)
<b>Unit 1.0</b> Engineering mechanics for Drone Technology	8	CO-1	12	04	04	04
<b>Unit 2.0</b> Drone frame and components	10	CO-2	14	04	04	06
<b>Unit 3.0</b> Advance Flight Controller Board	12	CO-3	16	04	06	06
<b>Unit 4.0</b> Maintenance and assembling of drone	10	CO-4	16	04	06	06
<b>Unit 5.0</b> Advance Drone Application	8	CO-5	12	04	04	04
<b>Total Marks</b>	<b>48</b>		<b>70</b>	<b>20</b>	<b>24</b>	<b>26</b>

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

**O) Suggested Assessment Table for Laboratory (Practical):**

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

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

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

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

**R) Suggested Learning Resources:****(a) Books:**

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

**(b) Online Educational Resources:**

1. <https://archive.nptel.ac.in/courses/101/104/101104083/>
2. [https://onlinecourses.nptel.ac.in/noc21\\_ae14/preview](https://onlinecourses.nptel.ac.in/noc21_ae14/preview)
3. [https://en.wikipedia.org/wiki/Unmanned\\_aerial\\_vehicle](https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle)
4. <https://fusion.engineering/>
5. <https://robocraze.com/blogs/post/best-flight-controller-for-drone>
6. <https://www.youtube.com/watch?v=lrkFG7GilPQ>
7. <https://www.youtube.com/watch?v=KjG6FKCNCbM>
8. <https://ardupilot.org/>
9. <https://px4.io/>

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

**(c) Others:**

1. Development of an Autonomous IoT-Based Drone for Campus Security, Abdelrahman Mahmoud Gaber, Rozeha A. Rashid, Nazri Nasir, Ruzairi Abdul Rahim, M. Adib Sarijari, A. Shahidan Abdullah, Omar A. Aziz, Siti Zaleha A. Hamid, Samura Ali, 2021
2. IoT based UAV platform for emergency services; S. K. Datta, J. L. Dugelay, & C. Bonnet, 2018
3. Development of an Autonomous Drone for Surveillance Application; M. A. Dinesh, S. Santhosh Kumar, J. Sanath, K. N. Akarsh & K. M. Manoj Gowda, 2018
4. Autonomous cloud-based drone system for disaster response and mitigation; C. Alex & A. Vijaychandra, 2016
5. <https://www.geeetech.com/Documents/CC3D%20flight%20control%20board.pdf>
6. [https://www.bhphotovideo.com/lit\\_files/201146.pdf](https://www.bhphotovideo.com/lit_files/201146.pdf)
7. [http://tricopter.hu/docs/cc3d\\_manual.pdf](http://tricopter.hu/docs/cc3d_manual.pdf)

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- A) **Course Code** : 2400604E(T2400604E/P2400604E/S2400604E)  
 B) **Course Title** : 3D Printing and Design (Advanced)  
 C) **Pre- requisite Course(s)** : 3D Printing and Design (Basic)  
 D) **Rationale** :

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

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

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

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

- F) **Suggested Course Articulation Matrix (CAM):**

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

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

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

- G) **Teaching & Learning Scheme:**

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

CI:

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

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

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

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

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

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

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

## H) Assessment Scheme:

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

### Legend:

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

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

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

### Note:

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

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

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

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

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

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

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

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

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

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

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

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

b. **Micro Projects:**

1. Prepare a list of solid, liquid and powder form 3D printing raw materials stating their cost, colour opacity, flexibility and weight per unit volume.
2. Download 5 videos of 3D printing of different components using FDM, SLA and SLS each. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
3. Prepare a report on post processing steps and techniques used for 3D printed components using FDM, SLA, SLS.
4. Prepare a report to compare FDM, SLA, SLS based 3D printing process on the basis of cost, surface finish, printer setting time, printing time and post processing time and cost involved.
5. Download 5 videos of 3D printing processes **other than** FDM, SLA and SLS. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
6. Download 1 video related to inspection and testing of 3D printed components using different techniques like Visual inspection, Scanning Electron Microscopy (SEM), CT system, X-ray, Penetration testing, Infrared thermography, Leak or pressure testing for complex structures, Eddy current, Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength, Metallography

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

**c. Other Activities:**

1. Seminar Topics:

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

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

3. Self-Learning Topics:

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

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

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

**Legend:**

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

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

#: Mentioned under point-(O)

**Note:**

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

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

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

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

**O) Suggested Assessment Table for Laboratory (Practical):**

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

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	High end computers	Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10	All
2.	Parametric Computer Aided Design software	CATIA/Solid works/NX/Creo <b>OR</b> Available with CoE	1 to 5
3.	FDM based 3D printer	Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 <b>OR</b> Available with CoE	1,4,5,6
4.	SLA based 3D printer	Printing Technology: SLA, 145 x 145 x 175mm build volume, Common layer thickness 25–100 µm, Dimensional Accuracy ± 0.5% (lower limit: ±0.10 mm), cure time of only 1-3s per layer, Material type: UV-sensitive liquid resin, Curing unit.	2,4,5,6
5.	SLS based 3D printer	Printing Technology: SLS., Build Volume: 130 x 130 x 180 mm, Recommended min. wall thickness: 0.8 mm, Powder Diameter: 60 Microns, Material Type: Nylon, TPU, Light Source: Laser Diode	3,4,5,6
6.	3D Printing Material	ABS/PLA, Resin based Photosensitive material, Polymer/metal/ceramic powder <b>OR</b> Available with CoE	1,2,3,4,5,6
7.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab <b>OR</b> Available with CoE	1 to 6
8.	3D Scanner and Processing software	Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software <b>OR</b> Available with CoE	6
9.	Post processing equipments and tools	Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper, Chemicals, Etching agents etc.	7
10.	Inspection and Testing devices	<ul style="list-style-type: none"> <li>• Visual inspection,</li> <li>Devices related to: <ul style="list-style-type: none"> <li>• Scanning electron microscopy (SEM), CT system, X-ray,</li> <li>• Penetration testing,</li> <li>• Infrared thermography,</li> <li>• Leak or pressure testing for complex structures,</li> <li>• Eddy current,</li> <li>• Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength</li> <li>• Metallography (Microstructure testing)</li> </ul> </li> </ul>	8

**R) Suggested Learning Resources:****(a) Books:**

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

**(b) Online Educational Resources:**

1. [https://onlinecourses.nptel.ac.in/noc21\\_me115/preview](https://onlinecourses.nptel.ac.in/noc21_me115/preview)
2. <https://archive.nptel.ac.in/courses/112/104/112104265/>
3. <https://bigrep.com/post-processing/>
4. <https://www.mdpi.com/2227-7080/9/3/61>
5. <https://all3dp.com/2/best-3d-printing-books/>
6. <https://www.youtube.com/watch?v=TQY2lF-sFal>
7. <https://www.youtube.com/watch?v=Oz0PoS5LPxg>
8. <https://www.youtube.com/watch?v=6ejjh0GdyDc>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources 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 Schöffner, Brian Garret, 3D Hubs; 1st edition, 2017
3. <https://www.improprecision.com/inspection-method-for-3d-printed-parts/>
4. 3D Printer Users' Guide
5. 3D Printer Material Handbook
6. Lab Manuals

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- A) **Course Code** : 2400604F(T2400604F/P2400604F/S2400604F)  
 B) **Course Title** : Industrial Automation (Advanced)  
 C) **Pre- requisite Course(s)** : Industrial automation (Basic), Digital Electronics and Basic programming skills

D) **Rationale** :

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

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

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

- CO-1. Apply the principles of communication for industrial automation.  
 CO-2. Test the output of the PLC ladder logic programs for the given application  
 CO-3. Maintain PLC systems  
 CO-4. Use SCADA for supervisory control and for acquiring data from the field.  
 CO-5. Develop simple automation systems

F) **Suggested Course Articulation Matrix (CAM):**

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

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

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

**G) Teaching & Learning Scheme:**

Legend:

CI:

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

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

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

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

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

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

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

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

**H) Assessment Scheme:**

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

Legend:

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

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

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

**Note:**

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.1a Describe how does a PLC communicate?</p> <p>TSO.1b Differentiate between parallel and series communication</p> <p>TSO.1c Describe the data transfer mechanism for the given communication protocols.</p> <p>TSO.1d Describe the given communication protocol used in PLC communication.</p> <p>TSO.1e Summarize PLC to PLC communication procedure</p> <p>TSO.1f Describe the common procedure to interface the PLC with other given hardware.</p>	<p><b>Unit-1.0 Industrial automation communication and Interfacing</b></p> <p>1.1 Analog and Digital Communications on Plant Floors</p> <p>1.2 Introduction to Industrial Networking</p> <p>1.3 RS232-422-485 standards for data communication</p> <p>1.4 Industrial Ethernet</p> <p>1.5 Concept of Fieldbus</p> <p>1.6 MODBUS protocol</p> <p>1.7 Highway Addressable Remote Transducer (HART) Protocol</p> <p>1.8 Interfacing of Programmable Logic Controller with other hardware</p>	CO-1
<p>TSO.2a Specify the proper I/O addressing format of the given PLC.</p> <p>TSO.2b Explain the use of different relay type instructions for the given operation.</p> <p>TSO.2c Describe how a program is executed with the help of Program Scan cycle</p> <p>TSO.2d Develop ladder logic program using arithmetic functions to perform the given operation.</p> <p>TSO.2e Develop ladder logic programs using logical and comparison instructions to perform the given operation</p> <p>TSO.2f Develop ladder logic programs using on delay, off delay and reset/retentive timer in a given PLC to create a delay in operation.</p> <p>TSO.2g Develop ladder logic programs using Up, Down and UP-down counter in a given PLC to count the number of products</p>	<p><b>Unit-2.0 PLC Programming</b></p> <p>2.1 PLC I/O addressing in ladder logic</p> <p>2.2 PLC programming instructions using ladder logic and relay type instructions</p> <p>2.3 Program Scan cycle</p> <p>2.4 PLC arithmetic functions - Addition, subtraction, multiplication, division instructions, increment decrement, trigonometric</p> <p>2.5 PLC logical functions - AND, OR, XOR, NOT functions, PLC compare and convert functions.</p> <p>2.6 Programming Timer –Addressing a timer block, status bits, On delay, Off Delay and reset/retentive timer</p> <p>2.7 Programming Counter- Addressing a counter block, status bits, Up and Down counter, up-down counter, counter examples, register basics</p> <p>2.8 Develop ladder logic for various simple applications</p>	CO-2
<p>TSO.3a Describe Requirements for PLC enclosure.</p> <p>TSO.3b Describe Proper grounding techniques.</p> <p>TSO.3c Describe noise reduction Techniques.</p> <p>TSO.3d Explain preventive maintenance procedure associated with PLC system to reduce environmental impact</p> <p>TSO.3e Identify faults in the given PLC system</p> <p>TSO.3f Explain the procedure for Troubleshooting PLC system</p> <p>TSO.3g Prepare preventive maintenance plan for the PLC system</p>	<p><b>Unit-3.0 Installation and maintenance of PLC systems</b></p> <p>3.1 PLC enclosure, grounding requirements, noise generating inductive devices, leaky inputs and outputs, techniques to reduce electrical noise and leakage.</p> <p>3.2 Introduction to PLC Trouble shooting and maintenance, trouble shooting of hardware and software.</p> <p>3.3 Diagnostic LED Indicators in PLCs</p> <p>3.4 Common problems</p> <ul style="list-style-type: none"> <li>• Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory</li> <li>• External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI),</li> </ul>	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3h Use safety equipment's. TSO.3i Follow safe practices	Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated Circuitry, Field Input and Output Devices, Communication Issues. <ul style="list-style-type: none"> <li>• Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer</li> </ul> 3.5 Troubleshooting of Specific Components of the PLC System <ul style="list-style-type: none"> <li>• Power Supply Troubleshooting</li> <li>• I/O Modules Troubleshooting</li> <li>• Troubleshooting PLC Program Errors</li> <li>• Troubleshooting the Working Environment of a PLC</li> <li>• Replacement of CPU</li> </ul> 3.6 PLC trouble shooting flowchart 3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system. 3.8 Safety procedure and safety equipment's.	
TSO.4.a Describe the function of given element of a SCADA system. TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC). TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application. TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.	<b>Unit-4.0 SCADA and DCS</b>  4.1 Introduction, need, benefits and typical applications of SCADA and DCS 4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA 4.3 Comparison of SCADA with DCS 4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture 4.5 Creating SCADA Screen HMI for simple object, Steps for linking SCADA object (defining Tags and items, creating trends etc.,) with PLC ladder program using OPC, configuring simple applications using SCADA: Traffic light control, water distribution, pipeline control, Power generation, transmission and distribution etc. 4.6 Procedure to maintain the SCADA based PLC system.	<b>CO-3</b>
TSO.5a Identify different components used for automation in the given system TSO.5b Select automation components for a given situation TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible. TSO.5d Prepare plan for sustainable automation as per the requirement.	<b>Unit-5.0 Applications of Industrial Automation</b>  5.1 <b>Manufacturing-</b> Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation. 5.2 <b>Health Care-</b> microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci 5.3 <b>Defense- guided rockets and missiles,</b> counter measures, UAV drones, launcher, radar antenna, engagement control system 5.4 <b>Automobile –Break</b> monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps,	<b>CO-5</b>

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 3.4</i> Test the ground connections of the given PLC.</p> <p><i>LSO 3.5</i> A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output</p> <p><i>LSO 3.6</i> Investigate the cause of Noise in the given PLC</p> <p><i>LSO 3.7</i> PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.</p> <p><i>LSO 3.8</i> Troubleshoot the corrupted PLC memory.</p> <p><i>LSO 3.9</i> Replace CPU and power supply fuses in a given PLC system.</p>			
<p><i>LSO 4.1</i> Download any open source SCADA software and install the same.</p> <p><i>LSO 4.2</i> Interpret the available components in symbol factory of SCADA software</p> <p><i>LSO 4.3</i> Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list)</p> <ol style="list-style-type: none"> <li>i. Turn on and off a tube light using a Switch</li> <li>ii. Apply filling and object size properties to a rectangle, square and round object</li> <li>iii. Move the object, fill the object using slider and meter reading.</li> <li>iv. Apply orientation property to a fan and control its direction using a slider.</li> <li>v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.</li> </ol> <p><i>LSO 4.4</i> Create historical and real time trends for the given automation</p>	14.	Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties	CO4
<p><i>LSO 5.1</i> Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.</p> <p><i>LSO 5.2</i> Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application</p> <p><i>LSO 5.3</i> Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.</p> <p><i>LSO 5.4</i> Develop a Automation system to Open and close the door in the shop</p>	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	CO5

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

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

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

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

**b. Micro Projects:**

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

**c. Other Activities:**

1. Seminar Topics- PLC instructions, Timers and Counters used in a given PLC
2. Seminar Topics- Industrial Applications of PLC and SCADA, AGV, Application of automation in different area, trouble shooting of different types of PLC
3. Visits – Visit any industry with full or semi automation and prepare a report on industrial automation used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.
4. Surveys- Carry out a market/internet survey of PLC and prepare the comparative technical specifications of any one type of PLC (Micro or Mini) of different manufacturer.
5. Product Development- Develop a prototype automatic railway crossing system

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

**d. Self-Learning Topics:**

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

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

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

**Legend:**

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

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

#: Mentioned under point- (O)

**Note:**

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

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

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

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

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

### O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Transfer the control data from PLC to PC and vice versa	CO1	50	40	10
2.	Transfer the control data from PLC to PLC	CO1	50	40	10
3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1	50	40	10
4.	Interface the given PLC with a PC or a Laptop	CO1	50	40	10
5.	Identify Different parts and front panel indicators of a PLC	CO2	50	40	10
6.	Develop Ladder logic program for different arithmetic operations	CO2	50	40	10
7.	Develop Ladder logic program for different logical operations	CO2	50	40	10
8.	Program Latch and Unlatch circuit in a PLC for motor operation	CO2	50	40	10
9.	Create delay in operation using on delay, off delay and retentive timer function in a given PLC	CO2	50	40	10
10.	Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	CO2	50	40	10
11.	Program PLC using ladder logic to control a LED/Lamp	CO2	50	40	10
12.	Program PLC using ladder logic to control a simple traffic light system	CO2	50	40	10
13.	Use hygrometer to measure the humidity inside the panel	CO3	50	40	10
14.	Use thermometer to measure ambient temperature inside the panel	CO3	50	40	10
15.	Use tester to determine the voltage fluctuation at the power supply terminals is within specifications	CO3	50	40	10
16.	A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output	CO3	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
17.	Investigate the cause of Noise in the given PLC	CO3	50	40	10
18.	PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.	CO3	50	40	10
19.	Troubleshoot the corrupted PLC memory.	CO3	50	40	10
20.	Replace CPU and power supply fuses in a given PLC system	CO3	50	40	10
21.	Download any open source SCADA software and install the same.	CO4	50	40	10
22.	Interpret the available components in symbol factory in SCADA software	CO4	50	40	10
23.	Create simple SCADA HMI applications and apply dynamic properties <b>(Any Three)</b> . i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.	CO4	50	40	10
24.	Create historical and real time trends for the given automation	CO4	50	40	10
25.	<b>Select any three of the following: -</b> i. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. ii. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application iii. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. iv. Develop a Automation system to Open and close the door in the shop v. Develop a line following robot with RFID sensor for supplying materials and automating workflow. vi. Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day. vii. Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.	CO5	60	30	10

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

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

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

## R) Suggested Learning Resources:

### (a) Books:

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

### (b) Online Educational Resources:

1. Software: - [www.fossee.com](http://www.fossee.com)
2. Software: - [www.logixpro.com](http://www.logixpro.com)
3. Software: - [www.plctutor.com](http://www.plctutor.com)
4. Software; - [www.ellipse.com](http://www.ellipse.com)
5. PLC lecture: - <https://www.youtube.com/watch?v=pPiXefBO2qo>
6. PLC tutorial: [http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API\\_I\\_C3\\_3\\_ST.pdf](http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API_I_C3_3_ST.pdf)
7. <https://www.youtube.com/watch?v=277wwYWolpw>-PLC system troubleshooting and repair. Industrial control panel. PLC system repair.
8. <https://www.youtube.com/watch?v=5Jmtvrch5Jg>
9. <https://www.youtube.com/watch?v=peyV9bwEaLY>
10. <https://www.youtube.com/watch?v=QdJhRmtKpxk&list=RDCMUcKe36Liq-w5fboMHkq1APZw&index=3>
11. <https://www.youtube.com/watch?v=ygrrRwajz3M>

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

**(c) Others:**

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

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- A) **Course Code** : 2400604G(T2400604G/P2400604G/S2400604G)  
 B) **Course Title** : Electric Vehicle (Advanced)  
 C) **Prerequisite Course(s)** : Electric Vehicle (Basics)  
 D) **Rationale** :

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

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

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

- CO-1** Compute various parameters affecting Vehicle movement.  
**CO-2** Test the operation of the different elements of the Automobile System.  
**CO-3** Test the battery and motor used for Power Transmission in EVs.  
**CO-4** Test electronic control unit system of EVs.  
**CO-5** Interpret the impact of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) during the charging cycle.

- F) **Suggested Course Articulation Matrix (CAM):**

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

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

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

## G) Teaching &amp; Learning Scheme:

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

Legend:  
CI:

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

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

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

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

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

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

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

## H) Assessment Scheme:

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

**Legend:**

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

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

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

**Note:**

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the vehicle movement process TSO 1b. Derive various equations for the movement of Vehicles TSO 1c. Compute different resistances affecting Vehicle movement. TSO 1d. Explain the dynamics of the given type of EV system.	<b>Unit-1.0 Vehicle Dynamics</b>  1.1 Vehicle Movement 1.2 Rolling Resistance: Equation, Coefficient, factor affecting rolling resistance, typical values of rolling resistance 1.3 Grading resistance 1.4 Road resistance 1.5 Acceleration resistance 1.6 Total driving resistance 1.7 Aerodynamic drag: Equation, typical values of the drag coefficient. 1.8 Vehicle dynamics <ul style="list-style-type: none"> <li>• Hybrid and Electric Vehicles</li> <li>• DC Motor Dynamics and Control</li> <li>• AC Motor Dynamics and Control</li> </ul>	<b>CO1</b>
TSO 2 a. Identify the given elements of Automobile Systems. TSO 2 b. Describe the functions of the given elements of Automobile Systems. TSO 2 c. Explain the dynamic characteristics of the Disc Braking System for the given braking steps. TSO 2 d. Describe the Procedure for testing the given AC/DC motors. TSO 2 e. Describe the Procedure of Installation and Testing of the given EV Charging Stations. TSO 2 f. Describe the Procedure for Commissioning EV Charging Stations. TSO 2 g. Explain the functions of the EV Control Unit.	<b>Unit-2.0 Elements of Automobile</b>  2.1 Suspension and Damping systems 2.2 Brake system: Half-step braking, Full step Braking 2.3 Transaxle 2.4 Elements of Noise Vibration and Harshness Control 2.5 Body balancing 2.6 Tyre Technology 2.7 AC/DC motor 2.8 Air-conditioning and Heating System 2.9 Lighting System 2.10 Automotive wiring system 2.11 Earthing and Insulation 2.12 Charging stations – Installation and Commissioning 2.13 Vehicle control unit	<b>CO2</b>
TSO 3a. Compare different power transmission systems in EVs. TSO 3b. List the main Components of the EV Power Train. TSO 3c. Explain the functions of the given EV Power Train component. TSO 3d. Describe the testing procedure of the given EV Power Train component. TSO 3e. Explain the regenerative braking operation in the given EV motor.	<b>Unit-3.0 EV Power Transmission System</b>  <b>3.1 Transmission System:</b> Single and Multi-transmission system <b>3.2 EV Power Train</b> <b>3.3 EV Power Train Components:</b> Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger. <b>3.4 Battery Parameters:</b> Voltage, Current, Charging rate, efficiency, energy density, power density, State of Charge (SoC),	<b>CO3</b>

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO 3f. Describe the speed control mechanism of the given motor. TSO 3g. Explain various parameters of the given battery. TSO 3h. Select the suitable battery for the given EV application. TSO 3i. Describe the assembling and dismantling procedure of the given battery. TSO 3j. Describe the Mechanism of Gear and Differential Assembly.		Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. <b>3.5</b> Battery Assembly and Dismantling. <b>3.6</b> Gear and Differential Assembly <b>3.7</b> Safe disposal of used battery	
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.		<b>Unit- 4.0 Vehicle Control Unit (VCU)</b>  4.1 <b>Electronic Control Unit:</b> Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	<b>CO4</b>
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.		<b>Unit- 5.0 EV Charging Technologies</b>  5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	<b>CO5</b>

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

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

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	<ul style="list-style-type: none"> <li>Testing of Control Disc Braking system and Control Regenerative Braking system.</li> </ul>	CO2	
LSO 2.3 Test the performance of different types of propulsion motors.	2.	<ul style="list-style-type: none"> <li>Testing of Motors</li> </ul>		
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	<ul style="list-style-type: none"> <li>Testing of the automotive wiring system.</li> </ul>		
LSO 3.1 Test the performance of a new set of batteries and aged batteries.	4.	<ul style="list-style-type: none"> <li>Testing of Batteries used in EVs</li> </ul>	CO2, CO3	

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p>LSO 3.2 Compare the performance of the battery and find the Fuel Gauge after discharging the battery.</p> <p>a. 0% - 100%</p> <p>b. 30% - 100%</p> <p>c. 50% - 100%</p> <p>LSO 3.3 Evaluate the following parameters of the given EV battery.</p> <p>a. Specific power</p> <p>b. Specific energy</p> <p>c. Life span and</p> <p>d. Cost parameters</p> <p>LSO 3.4 Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.</p>			
<p>LSO 3.5 Test the dynamic performance of the given motor;</p> <p>a) Speed and torque spectrum.</p> <p>b) Speed and torque oscillation</p> <p>c) Friction torque friction spectrum.</p> <p>LSO 3.6 Test the following speed-controlled performance characteristics of the given motor;</p> <p>a. Motor voltage over time</p> <p>b. Motor current over time.</p> <p>c. Speed and torque over time.</p> <p>d. Torque over speed.</p> <p>e. Current over speed.</p> <p>f. Electrical input power and the mechanical input power over speed</p>	5.	<ul style="list-style-type: none"> <li>Speed control of Electrical Motors</li> </ul>	
<p>LSO 4.1 Connect the components of the EC Units with EV subsystems.</p> <p>LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.</p>	6.	<ul style="list-style-type: none"> <li>Connection of Electronic Control Unit components</li> <li>Troubleshooting of electronic control unit</li> </ul>	CO4
<p>LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.</p>	7.	<ul style="list-style-type: none"> <li>Impacts of G2V and V2G</li> </ul>	CO 5
<p>LSO 5.2 Prepare a layout of a charging station</p>	8.	<ul style="list-style-type: none"> <li>Demonstration of Charging stations</li> </ul>	

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

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

b. **Micro Projects:**

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

**c. Other Activities:****1. Seminar Topics:**

- Safe disposal process of Used Batteries.
- Charging Technologies used for charging the EV.
- EV power transmission systems.

**2. Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.**3. Self-Learning Topics:**

- Impact of fleet charging of EVs on Power Systems.
- Energy Management in EV.
- Fuel Cell powered bus.
- EV Battery disposal and recycling.
- Mobility and connectors.

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

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

**Legend:**

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

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

# : Mentioned under point- (O)

**Note:**

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

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

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

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

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

### O) Suggested Assessment Table for Laboratory (Practical):

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

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

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

**R) Suggested Learning Resources:****(a) Books:**

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

**(b) Online Educational Resources:**

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

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

**(c) Others:**

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

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- A) **Course Code** : 2400604H(T2400604H/P2400604H/S2400604H)  
 B) **Course Title** : Robotics (Advanced)  
 C) **Pre- requisite Course(s)** : Robotics (Basic)  
 D) **Rationale** :

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

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

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

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

**F) Suggested Course Articulation Matrix (CAM):**

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

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

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

**G) Teaching & Learning Scheme:**

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

**Legend:**

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

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

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

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

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

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

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

**H) Assessment Scheme:**

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

**Legend:**

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

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

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

**Note:**

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

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1e. List safety steps while handling the given robot. TSO 1f. Interface robots with the given welding machine. TSO 1g. Interface robots with the given painting machine. TSO 1h. Interface robots with the given assembly machine.	kinematics for 2 Degrees of Freedom. 1.4 Safety while operating and handling robot  1.5 Robot Industrial applications: <ul style="list-style-type: none"> <li>• Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing</li> <li>• Spray painting Robots, assembly operation, cleaning.</li> </ul>	
TSO 2a. Explain the techniques to control robot motion. TSO 2b. Describe the given robot drive system. TSO 2c. Describe the types of grippers. TSO 2d. Design grippers for specific application. TSO 2e. Test the designed gripper for the application. TSO 2f. Use Bar code technology for robotic applications. TSO 2g. Integrate radio frequency identification technology in robotic applications. TSO 2h. Assemble an automated guided vehicle for the given situation using standard components. TSO 2i. Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components.	<b>Unit– 2.0 Robot Drives, Control and Material Handling</b>  2.1 Controlling the Robot motion. 2.2 Position and velocity sensing devices. 2.3 Drive systems – Hydraulic and Pneumatic drives 2.4 Linear and rotary actuators and control valves 2.5 Electro hydraulic servo valves, electric drives, motors 2.6 End effectors – Vacuum, magnetic and air operated grippers 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS) 2.8 Bar code technology 2.9 Radio frequency identification technology.	<b>CO2, CO3</b>
TSO 3a. Differentiate between various work cell layouts. TSO 3b. Select work cell for specific robot with justification. TSO 3c. Analyse robot cycle time. TSO 3d. Explain industrial applications of robotic cell. TSO 3e. Follow safety procedures in robotic cell.	<b>Unit– 3.0 Robot Cell Design and Application</b>  3.1 Robot work cell design, control and safety 3.2 Robot cell layouts 3.3 Multiple Robots and machine interference 3.4 Robot cycle time analysis 3.5 Industrial application of robotic cells	<b>CO3</b>
TSO 4a. List different programming languages for the robots TSO 4b. Describe artificial intelligence TSO 4c. Write a programme in the required language to operate a robot for the given task. TSO 4d. Optimise robot programming parameters. TSO 4e. Select a robot on the basis of cycle time analysis. TSO 4f. Conduct an economic analysis for use of robots. TSO 4g. Follow testing methods and acceptance rules for industrial robots.	<b>Unit– 4.0 Robot Programming and Economics of Robotization</b>  4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on	<b>CO1, CO4, CO5</b>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	investment method. 4.9 Testing methods and acceptance rules for industrial robots	
TSO 5a. Describe applications of robots in healthcare and medicine. TSO 5b. Describe applications of robots in Construction industry. TSO 5c. Describe applications of robots in Underground coal mining. TSO 5d. Describe applications of robots in utilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	<b>Unit-5.0 Applications in Non-manufacturing Environments</b>  5.1 Applications of Robots in <ul style="list-style-type: none"> <li>● Healthcare and medicine</li> <li>● Construction industry</li> <li>● Underground coal mines</li> <li>● Utilities, military &amp; firefighting operations</li> <li>● Undersea</li> <li>● Space</li> <li>● Logistics,</li> <li>● Retail and Hospitality</li> <li>● Smart Cities</li> <li>● Farming and Agriculture</li> </ul> 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	<b>CO5</b>

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

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

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

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

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

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

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

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

**c. Other Activities:**

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

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

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

**Legend:**

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

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

# : Mentioned under point-(O)

**Note:**

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

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

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

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

**O) Suggested Assessment Table for Laboratory (Practical):**

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

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
1.	6 Axis Articulated Robot (Material Handling)- 1 No	<ul style="list-style-type: none"> <li>• Articulated Type</li> <li>• Controlled axis: 6-axes (J1, J2, J3, J4, J5, J6)</li> <li>• Reach: 717 mm</li> <li>• Installation Floor, Upside-down (Angle mount)</li> <li>• Motion range (Maximum Speed) <ul style="list-style-type: none"> <li>• J1 Axis Rotation 7.85 rad/s</li> <li>• J2 Axis Rotation 6.63 rad/s</li> <li>• J3 Axis Rotation 9.08 rad/s</li> <li>• J4 Axis Rotation 9.60 rad/s</li> <li>• J5 Axis Rotation 9.51 rad/s</li> <li>• J6 Axis Rotation 17.45 rad/s</li> </ul> </li> <li>• Max. load capacity Wrist: 4Kg</li> <li>• Allowable Load moment 16.6 N-m at wrist J4 Axis, J5 Axis, J6 Axis</li> <li>• Allowable Load inertia).47 kg-m<sup>2</sup> at wrist J4 Axis J5 Axis, J6 Axis</li> <li>• Repeatability: +/- 0.05mm</li> <li>• Mass: 21 Kg Minimum</li> <li>• Installation environment: Ambient temperature: 0 – 45°C</li> <li>• Ambient humidity: Normally 75%RH or less. No dew, nor frost allowed.</li> <li>• Vibration Acceleration: 4.9 m/s<sup>2</sup> (0.5G or less)</li> </ul>	1, 2, 3, 12
2.	6 Axis Articulated Robot (General Purpose-Welding, Assembly, Drilling) - 1 No	<p>Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic</p> <p>Weight of robot: 50 Kg. Accuracy: ±0.3 Repeatability: ±0.2 Tip Velocity range: 500 mm / min Pay load capacity: 2 kg (including gripper) J1 - Waist: ± 140° J2 - Shoulder: - 100 - 60° J3 - Elbow: - 70 + 10° J4 - Wrist rotate: ± 70° J5 - Wrist pitch: ± 35° J6 - Wrist roll: ± 180° External I/O 8 Programmable digital inputs 8 Programmable digital outputs</p>	8, 9, 14
3.	A mounted vision system with software (Free open source Robot simulation software)	<p>Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or I2C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from -40°C to 125°C (Analog Devices ADT7302)</p>	3, 4, 5, 11
4.	6-axis Robotics Trainer	<p>Programmable robotic arm with an interactive front panel. Software to demonstrate functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM</p>	3, 4, 5, 13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		processors; Record and Play capability; Optional interfacing with PLC; Touch operated ON/OFF Switch; Auto set to home position; Applications can be developed; Data acquisition using USB	
5.	E-Yantra Firebird kit	<ul style="list-style-type: none"> <li>• Fire Bird V 2560 Robot</li> <li>• Spark V Robot</li> <li>• Fire Bird V P89V51RD2 adapter card</li> <li>• Fire Bird V LPC2148 adapter card</li> <li>• LSM303 3 axis digital accelerometer and 3 axes magnetometers</li> <li>• L3G4200 3 axis digital gyroscope</li> <li>• Gyroscope, accelerometer and GPS interfacing module for the robot</li> <li>• GPS receiver</li> <li>• Zigbee Modules 100m range</li> <li>• Zigbee Modules Adapter</li> <li>• Metal-gear Servo Motors</li> <li>• Servo Motor Based Gripper kit for the Fire Bird V robot</li> <li>• Sharp infrared range sensor (10cm to 500cm)</li> <li>• Arduino Uno/Nano</li> <li>• Hexapod</li> <li>• 16 Programming Software (AVR studio, Keil, AVR Boot loader, Flash Magic)</li> </ul>	1, 3, 5, 6, 7, 10
6.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	2, 8, 10
7.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc.	4
8.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4, 10
9.	Raspberry Pi kit	1.2GHz quad-core Broadcom BCM2837 CPU with 1GB DDR2 RAM with in-built Wi-Fi & Bluetooth Video Core IV 3D graphics core 40 pin extended pins - with 27 GPIO pins Micro SD slot Multiple ports: Four USB ports, full sized HDMI, four pole stereo output and composite video port, CSI camera port and DSI display port 10/100 BaseT Ethernet Micro-USB, power source 5V, 2A	7, 9

## R) Suggested Learning Resources:

### (a) Books:

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

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

**(b) Online Educational Resources:**

1. <https://web.iitd.ac.in/~saha/ethiopia/appln.pdf>
2. <https://nptel.ac.in/courses/112105249>
3. <https://www.robotsscience.com/industrial/industrial-robots-types-applications-benefits-and-future/>
4. [https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL\\_APPLNS-converted.pdf](https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL_APPLNS-converted.pdf)
5. <https://forcedesign.biz/blog/5-common-industrial-robot-applications>
6. <https://www.hitechnectar.com/blogs/top-industrial-robotics-applications-role-of-robots-in-manufacturing/> <http://www.robotics.org/>
7. [https://en.wikipedia.org/wiki/Industrial\\_robot](https://en.wikipedia.org/wiki/Industrial_robot)
8. <https://www.youtube.com/watch?v=fH4VwTgfyRQ>
9. [https://www.youtube.com/watch?v=aW\\_BM\\_S0z4k](https://www.youtube.com/watch?v=aW_BM_S0z4k)
10. <https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud>
11. <https://robots.ieee.org/robots/?t=all>
12. [https://www.youtube.com/watch?v=fc\\_Cynqr6jM](https://www.youtube.com/watch?v=fc_Cynqr6jM)

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

**(c) Others:****1. Learning Packages:**

- <https://www.edx.org/learn/robotics>
- <https://www.coursera.org/courses?query=robotics>
- <https://www.udemy.com/topic/robotics/>
- <https://library.e.abb.com/public/9a0dacfddec8aa03dc12578ca003bfd2a/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](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** : 2400604I(T2400604I/P2400604I/S2400604I)  
 B) **Course Title** : Transformer Manufacturing and Repairing (Advanced)  
 C) **Pre- requisite Course(s)** : Transformer Manufacturing and Repairing (Basic)  
 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 advanced course will help the students understand the concepts of manufacturing and repair of transformers at par with the industries. The knowledge gained through this course will help the students choose their career in transformer manufacturing and repair.

- 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-11** Analyze the materials used in transformer manufacturing.  
**CO-12** Assemble the transformer based on specific requirements.  
**CO-13** Design using software based on specific requirements.  
**CO-14** Analyze the working conditions of transformers.  
**CO-15** Apply the concepts for practical use.

- 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		
CO-2	3	3	2	2	2	-	3		
CO-3	3	2	2	2	-	-	3		
CO-4	3	1	1	1	1	-	3		
CO-5	3	2	3	3	3	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)					Total Credits (C)
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	
		L	T				
2400604	Transformer Manufacturing and Repairing (Advanced)	03	-	04	02	09	06

**Legend:**

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

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

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

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

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

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

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

**H) Assessment Scheme:**

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

**Legend:**

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

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

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

**Note:**

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- 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.

**III) 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: T2400604I

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.3.</i> Knowledge of knowing the various components of a power transformer. <i>LSO 1.4.</i> Explain the use of those components in the power transformer.	1.	Dismantling a power transformer and understanding various components.	CO1
<i>LSO 2.1.</i> Design a transformer using computer programming considering various aspects.	2.	Designing a transformer using computer programming.	CO1
<i>LSO 3.3.</i> Use of a commercial software to design a transformer.	3.	Application of software for transformer design.	CO1
<i>LSO 4.4.</i> Understand the breakdown voltage (BDV) of transformer oil.	4.	Breakdown voltage test of transformer oil.	CO2
<i>LSO 5.1.</i> Explain the practical applications of power transformers. <i>LSO 5.2.</i> Knowledge of various transformers used in substations.	5.	Substation visit to see the application of power transformers.	CO3, CO4, CO5

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

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

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

**11. Micro Projects:**

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

**12. Other Activities:**

## 1. Seminar Topics:

- Silicon Steel in Transformer Manufacturing.
- Impact of Environmental Factors on Transformer Design.
- Introduction to CAD in Transformer Design.
- Cost Estimation and Analysis in Transformer Design Using CAD.
- Impact of Environmental Conditions on Transformer Monitoring.
- Oil Quality Analysis in Transformer Maintenance.
- Designing Transformers for Industrial Applications.

## 2. Visits:

- Visit to nearby transformer manufacturing station. Prepare report of visit with special comments on transformer winding technique, winding material and insulating material used.
- Visit to nearby transformer manufacturing station. Prepare report of visit with manufacturing process, different stages of production, and the quality control measures and technologies involved in transformer manufacturing.

## 3. Self-learning topics:

- Types of insulation materials used in transformers (e.g., paper, pressboard, synthetic materials, and mineral oil)
- Nanomaterials in Transformer Construction.
- Thermal management in transformer design.
- Vibration of transformer.
- Smart transformer used in smart grid.

**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%
<b>Total Marks</b>	<b>30</b>	<b>70</b>	<b>20</b>	<b>20</b>	<b>10</b>	<b>20</b>	<b>30</b>
			<b>50</b>				

**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 Transformer Materials	8	CO1	10	3	3	4
Unit-2.0 Transformer Design	12	CO1, CO2	10	3	2	5
Unit-3.0 Transformer Design-Using CAD	12	CO3, CO4	10	5	2	3
Unit-4.0 Transformer Condition Monitoring	8	CO3, CO4	20	5	6	9
Unit-5.0 Transformer Design - Practical Applications	8	CO4, CO5	20	4	6	10
<b>Total</b>	<b>48</b>	-	<b>70</b>	<b>20</b>	<b>19</b>	<b>31</b>

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):**

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
15.	Dismantling a power transformer and understanding various components.	CO1	30	60	10
16.	Designing a transformer using computer programming.	CO1	40	50	10
17.	Application of software for transformer design.	CO1	30	60	10
18.	Breakdown voltage test of transformer oil.	CO2	30	60	10
19.	Substation visit to see the application of power transformers.	CO3, CO4, 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.	Transformer, Multi-meter, LCR Meter	3 Phase Transformer, Multi-meter, LCR Meter, Tools to dismantle transformer.	Dismantling a power transformer and understanding various components.
2.	MATLAB, PC	MATLAB Software and Desktop PC (As per requirement).	Designing a transformer using computer programming
3.		Machine Design Software and Desktop PC (As per requirement).	Application of software for transformer design.
4.	Transformer Oil Testing Kit	Transformer oil testing kit, transformer oil,	Breakdown voltage test of transformer oil.
5.	Equipment for a prototype substation	Power transformer, circuit breaker, relay, Insulator, Isolator, Bus-bar, capacitor bank, Fuse, current transformer, potential transformer.	Substation visit to see the application of power transformers

**R) Suggested Learning Resources:****(d) Books:**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Transformer Engineering Design and Practice	S.V.Kulkarni, S.A.Khaparde	CBS Publishers, 2004 ISBN: 9780824757281, 0824757289
2.	Design of Transformers	Indrajit Dasgupta	Tata McGraw Hill India, 2002 ISBN: 0071331352, 9780071331357
3	Principles of Electrical Machine Design With Computer Programs	S. K. Sen	Oxford & IBH Publishing Company Pvt. Limited, 2006. ISBN: 9788120415218, 8120415213

**(b) Online Educational Resources:**

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

**(c) Others:**

\*\*\*\*\*

- A) **Course Code** : 2400604J(T2400604J/P2400604J/S2400604J)  
 B) **Course Title** : Optical Fiber and 5G Communication (Advance)  
 C) **Pre- requisite Course(s)** : Optical Fiber and 5G Communication (Basics)  
 D) **Rationale** :

A course on Optical Fiber and 5G Communication (Advance) is essential to understand the 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 5G networks, which is going to be an integral part of the wireless communication infrastructures fields, students gain comprehensive insights into how advanced communication systems operate and interact, preparing them for careers in telecommunications and networking.

- 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-16 Analyze various 5G radio-access technologies.  
 CO-17 Identify different components of GSM architecture.  
 CO-18 Describe the channel and channel behavior of the wireless channel.  
 CO-19 Analyze different mitigation techniques.  
 CO-20 Summarize different emerging technologies for next generation communication networks.

- 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	2	2	2	2	-		
CO-3	3	2	2	2	3	2	-		
CO-4	3	3	-	2	-	-	-		
CO-5	3	-	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				
2400604J	Optical Fiber and 5G Communication (Advance)	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)	
2400604J	Optical Fiber and 5G Communication (Advance)	30	70	20	30	20	30	200

**Legend:**

PTA: Progressive Theory Assessment in classroom (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:**

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- 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.

**IV) 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: T2400604J**

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.5.</i> Noise Modelling and its effect on Wireless Data Transmission	1.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	<b>CO1</b>
<i>LSO 2.2.</i> Effect of fading on wireless data transmission in terms of outage probability	2.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	<b>CO2</b>
<i>LSO 3.4.</i> Capacity of Wireless Channel (AWGN v/s Fading)	3.	Comparative Study of Channel Capacity: AWGN versus Fading Channels	<b>CO3</b>
<i>LSO 4.5.</i> Implementation of receiver diversity technique.	4.	Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication	<b>CO4</b>
<i>LSO 5.3.</i> Implementation of transmitter diversity technique.	5.	Practical Implementation and Performance Analysis of Transmitter Diversity Techniques	<b>CO4</b>
<i>LSO 6.1</i> Implement the (2X2) of MIMO system.	6.	Design and Implementation of MIMO Technology	<b>CO4</b>
<i>LSO 7.1</i> Implement of OFDM system and test the performance.	7.	Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems	<b>CO5</b>

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

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

#### 14. Micro Projects:

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

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

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

## 2. Path loss models for Aerial Communication Network

**Task:** Research and adapt existing path loss models for aerial networks, develop tailored models for scenarios like drones, validate with field or simulation data, compare model performance, and document findings with recommendations for network design.

## 3. Resource allocation for 5G communication Network

**Task:** Identify challenges in 5G resource allocation, develop an optimization strategy, simulate the strategy's effectiveness, implement it in a test environment, and analyze results to enhance resource allocation and network performance.

## 4. LEO Satellite based IoT communication

**Task:** Research LEO satellite technologies for IoT, design a communication system using LEO satellites, simulate system performance, conduct a cost-benefit analysis compared to other methods and prepare a brief report of the same.

## 5. QoS requirements for Tactile Internet

**Task:** Define QoS requirements for tactile internet applications, develop a QoS framework, test the framework in various scenarios, evaluate its performance, and prepare a report with recommendations for meeting QoS standards in tactile internet networks.

### 15. Other Activities:

16. Seminar Topics: Some of the suggested seminar topics are

- i. "Advancements in 5G Technology and beyond"
- ii. "The Future of Wireless Communication: 5G and Beyond"
- iii. "Integrating Haptics with 5G Networks: Opportunities and Challenges"
- iv. "Security Strategies for 5G Networks: Ensuring Robust Protection"
- v. "AR/VR-enabled Systems in 5G: Innovations and Implementation"

17. 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%
<b>Total Marks</b>	<b>30</b>	<b>70</b>	<b>20</b>	<b>20</b>	<b>10</b>	<b>20</b>	<b>30</b>
			<b>50</b>				

**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 5G Radio Access Technology	8	CO1	12	4	4	4
Unit-2.0 Study of GSM Architecture	8	CO2	12	4	4	4
Unit-3.0 Channel and channel behavior	8	CO3	12	4	4	4
Unit-4.0 Mitigation Techniques	12	CO3	14	4	4	6
Unit-5.0 Advanced Optical Fiber Communication and Emerging Technologies	12	CO2	20	6	6	8
<b>Total</b>	<b>48</b>	<b>-</b>	<b>70</b>	<b>22</b>	<b>22</b>	<b>26</b>

**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):** Kindly change this table as per the list of experiment in the above list

Sl. No	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
20.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	CO1	30	60	10
21.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	CO2	40	50	10
22.	Comparative Study of Channel Capacity: AWGN versus Fading Channels	CO3	30	60	10
23.	Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication	CO4	30	60	10
24.	Practical Implementation and Performance Analysis of Transmitter Diversity Techniques	CO4	30	60	10
25.	Design and Implementation of MIMO Technology	CO4	30	60	10
26.	Development and Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems	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:**

Please insert laboratory equipment in this format

Sl. No.	Name of Equipment, Tools, and Software	Relevant Experiment/ Practical Number
1.	Software-Defined Radio (SDR) kit : Allows for the implementation and testing of 5G communication protocols.	All
2.	5G NR Testbed: Complete test setups for developing and testing 5G NR systems.	All
3.	Vector Signal Analyzer (VSA) and Vector Signal Generator (VSG): For generating and analyzing complex modulated signals used in 5G communication.	All
4.	MIMO (Multiple Input Multiple Output) Test System (2X2, and more): For testing MIMO technology, which is essential for 5G networks.	All
5.	MATLAB/Mathematica	All

**R) Suggested Learning Resources:**

**(a) Books**

Here are some essential books for Optical Fiber and 5G Communication.

Sl. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Millimeter Wave Wireless Communications	Theodore S. Rappaport, Robert W. Heath Jr., Robert C. Daniels, and James N. Murdock	Cambridge University Press, 2024. ISBN 9781009489836
2.	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
3.	Wireless Communications	Andreas F. Molisch,	John Wiley & Sons, 2012. ISBN: 8126542322
4.	Wireless Communications	Andrea Goldsmith	Cambridge University Press, 2005. ISBN: 9780511841224

**(b) Online Educational Resources:**

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

1. Prof. Aditya K. Jagannatham– NPTEL **Principles of Modern CDMA/ MIMO/ OFDM Wireless Communications**
2. **Coursera** - Post Graduate Certificate in 5G Technology and IoT: This program covers the essentials of 4G and 5G systems, including key technical advancements and challenges. It also delves into topics such as massive MIMO, OFDM, and mm Wave communication, providing a solid foundation in modern wireless communication (Coursera).

3. **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).
4. **Coursera - 5G for Everyone:** Gain an in-depth understanding of how 5G is revolutionizing the way we do business in the 2020s with technologies that make 5G possible, including mm Wave, Massive MIMO, RAN, and more. Learn how companies can use 5G Private Networks and Industrial IoT to transform the way they operate daily. Gain the base-level knowledge of 5G you need to continue your wireless education and advance in the rapidly growing field of wireless technology.

**MIT OCW - Principles of Wireless Communications:** This course is an introduction to the design, analysis, and fundamental limits of wireless transmission systems. Topics to be covered include: wireless channel and system models; fading and diversity; resource management and power control; multiple-antenna and MIMO systems; space-time codes and decoding algorithms; multiple-access techniques and multiuser detection; broadcast codes and precoding; cellular and ad-hoc network topologies; OFDM and ultrawideband systems; and architectural issues.

**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. Lab Manuals

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- A) **Course Code** : 2437605(P2437605/S2437605)  
B) **Course Title** : Major Project  
C) **Pre- requisite Course(s)** :  
D) **Rationale** :

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

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

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

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

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

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

- CO-1** Integrate the knowledge (K), skills (S), attitudes (A) developed, in a new task or problem identified in the form of project work.
- CO-2** Develop higher level of cognitive, psychomotor and affective domain skills relevant to the course/programme.
- CO-3** Solve the industrial/real world problems/tasks by Integrating the generic skills/soft skills/employable skills with relevant technical skills.
- CO-4** Develop the capabilities and skills of innovativeness, creativity, resourcefulness, time management, problem solving abilities, interpersonal skills, pro-activeness, cost effectiveness, environment consideration and sustainability.
- CO-5** Prepare the project report.

## F) Suggested Course Articulation Matrix (CAM):

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

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

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

## G) Teaching &amp; 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				
2437605	Major Project	-	-	08	04	12	06

Legend:

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

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

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

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

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

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

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

## H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2437605	Major Project	-	-	20	30	50	100	200

**Legend:**

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)  
PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)  
TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

**Note:**

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

**I) Suggested Implementation of Major Project:**

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

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

The following steps are undertaken under the major project-

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

**1.0 Design, Development and Execution of Major Project:**

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

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

**1.1 Unique Features of Major Project:**

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

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

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

## 2.0 Quality of Project Report Writing and its Presentation:

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

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

## 2.1 Project Report Writing:

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

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

## 2.2 Presentation & Discussion:

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

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

## 2.3 Project's Potential:

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

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

**J) Assessment of the Major Project:**

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

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

**Assessment Scheme for Major Project**

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

\*\*\*\*\*

- A) **Course Code** : 2400408 (T2400408)  
 B) **Course Title** : Employability Skills Development (Common for all Programmes)  
 C) **Pre- requisite Course(s)** :  
 D) **Rationale** :

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

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

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

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

- F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ 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		
CO-2	3	-	-	-	2	2	3		
CO-3	3	-	-	3	3	2	2		

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

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

- G) **Teaching & Learning Scheme:**

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400408	Employability Skills Development	01	-	-	-	01	01

**Legend:**

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

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

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

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

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

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

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

**H) Assessment Scheme:**

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400408	Employability Skills Development	25	--	--	--	--	--	25

**Legend:**

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

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

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

**Note:**

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

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

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

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

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

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

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

**a. Assignments:**

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

**b. Micro Projects:**

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

**c. Other Activities:**

## 1. Seminar Topics:

- Emotional Intelligence.
- 21<sup>st</sup> Century Skills.
- Multitasking

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

## 3. Self-Learning Topics:

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

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

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

**Legend:**

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

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

# : Mentioned under point-(O)

**Note:**

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

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

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

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

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

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

**R) Suggested Learning Resources:**

**(a) Books:**

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

**(b) Online Educational Resources:**

1. **4-Year Plan for Career Success:**  
[https://eng.umd.edu/sites/clark.umd.edu/files/4%20Year%20Plan%20For%20Career%20Success\\_Categorized\\_1.pdf](https://eng.umd.edu/sites/clark.umd.edu/files/4%20Year%20Plan%20For%20Career%20Success_Categorized_1.pdf)
2. **AREER DEVELOPMENT GUIDE**  
[https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/career\\_development\\_guide\\_may\\_2014.pdf](https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/career_development_guide_may_2014.pdf)
3. **Tips for successful career planning** [tips://www.aryacollege.in/tips-for-successful-career-planning-in-2021/](https://www.aryacollege.in/tips-for-successful-career-planning-in-2021/)
4. **Career Planning – Complete Guide** <https://www.mygreatlearning.com/blog/what-is-career-planning/>
5. **Build Resume:** <https://www.themuse.com/advice/how-to-make-a-resume-examples>
6. **Build Resume** <https://resumegenius.com/blog/resume-help/how-to-write-a-resume>
7. **Body Language:** <https://ubiquity.acm.org/article.cfm?id=3447263>
8. **Group Discussions:** <https://brightspeaking.com/en/how-to-effectively-participate-in-a-group-discussion/>
9. **Carrier planning & goal setting:** <https://www.hays.com.au/career-advice/career-development/setting-career-goals>
10. **Carrier planning & goal setting:** <https://www.thebalancemoney.com/step-by-step-guide-to-setting-career-goals-2059883>
11. **Collaboration & teamwork:** <https://www.indeed.com/career-advice/career-development/teamwork-and-collaboration>
12. **Interview skills:** <https://www.youtube.com/watch?v=IKCTS9dY4h4>

**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** : 2400009(T2400009)  
 B) **Course Title** : Open Educational Resources (OER)  
 (FTS, CHE, CSE, EE, ME, ME (Auto), MIE, ELX, AIML, CRE, CACDDM, FPP, GT)  
 C) **Pre- requisite Course(s)** :  
 D) **Rationale** :

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

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

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

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

**CO-1** Use Open Educational Resources (OER) after their evaluation

**CO-2** Use copyright material appropriately.

**CO-3** Implement suitable Creative Common License.

- F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ 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	-	3		
CO-2	-	2	-	-	3	-	3		
CO-3	-	3	-	-	3	-	3		

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

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

## G) Teaching &amp; Learning Scheme:

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

## Legend:

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

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

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

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

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

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

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

## H) H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400009	Open Educational Resources	25	-	-	-	-	-	25

## Legend:

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

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

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

## Note:

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

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

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

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

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

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

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

**a. Assignments:**

**Related to Open Educational Resources – CO1**

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

**Related to Copyright – CO2**

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

**Related to Creative Common Licenses – CO3**

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

**b. Micro Projects:**

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

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

**c. Other Activities:**

1. Seminar Topics:

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

2. Self-Learning Topics:

- Open Licensing and Copyright: Understanding the Legal Framework for OER
- Creative Commons and the future of Copyright
- Copyright and Open Access Publishing
- Copyright and Software

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

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

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

**M) Suggested Learning Resources:**

**(a) Books:**

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

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

**(b) Online Educational Resources:**

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

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

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