

**Curriculum of Diploma Programme**  
**in**  
**Mining Engineering**



**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				
2447601	PCC	Mine Safety and Rescue Practices	02	01	-	02	05	04
2447602	PCC	Surface Mining	03	-	04	02	09	06
2447603	PCC	Strata Control and Roof Support	02	01	-	02	05	04
2400604	OEC	Open Electives*/ COE (Advanced -Any One)	03	-	04	02	09	06
2447605	PSI	Major Project (Common for all programmes)	-	-	08	04	12	06
2447606	PCC	Application of Drone in Mining Engineering	-	-	04	02	06	03
2400110	NRC	Community/ Society Development (AIML, AE, CSE, ELX (R), CHE, EE, ME, ME (Auto), MIE, FTS, CACDDM, FPP)	01	-	-	-	01	01
<b>Total</b>			<b>11</b>	<b>2</b>	<b>20</b>	<b>14</b>	<b>47</b>	<b>30</b>

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

**Legend:**

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

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

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

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

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

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

\*: 3D Printing & Design/ Artificial Intelligence (AI)/ Industrial Automation & Control Electric Vehicle /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)	
2447601	PCC	Mine Safety and Rescue Practices	30	70	20	30	-	-	150
2447602	PCC	Surface Mining	30	70	20	30	20	30	200
2447603	PCC	Strata Control and Roof Support	30	70	20	30	-	-	150
2400604	OEC	Open Electives*/ COE (Advanced -Any One)	30	70	20	30	20	30	200
2447605	PSI	Major Project (Common for all programmes)	-	-	20	30	50	100	200
2447606	PCC	Application of Drone in Mining Engineering	-	-	20	30	10	15	75
2400110	NRC	Community/ Society Development	25	-	-	-	-	-	25
<b>Total</b>			<b>145</b>	<b>280</b>	<b>120</b>	<b>150</b>	<b>100</b>	<b>175</b>	<b>1000</b>

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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.

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**Note:**

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

- A) **Course Code** : 2447601(T2447601/S2447601)  
 B) **Course Title** : Mine Safety and Rescue Practices  
 C) **Pre- requisite Course(s)** :  
 D) **Rationale** :

The mining industry is one of the industries causing environmental pollution and the possibility of serious accidents. Certain constraints are imposed on the mining industry through regulations to control the safe working and hazards associated with mines. Diploma holders in Mining Engineering are required to become more familiar with the major problems associated with mine workers in relation to comfortable working conditions and various sources of problem causing agents. This course is designed to meet the required level of knowledge along with associated skills related to mine hazards and accidents for safe mining.

- 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 relevant fire extinguisher and Fire stopping for different types of fire in mines.  
**CO-2** Identify the conditions susceptible to spontaneous heating and prevent spontaneous heating in underground mines.  
**CO-3** Adopt suitable preventive measures of fire damp and coal dust explosions in underground mines.  
**CO-4** Prevent inundation and control water logging conditions in mines.  
**CO-5** Perform rescue and recovery work under the given conditions in mines.

- 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 Engineer-ing Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	-	3	2	-	-	2		
CO-2	3	2	-	2	-	-	-		
CO-3	3	3	-	2	3	-	-		
CO-4	3	3	-	2	-	-	-		
CO-5	3	-	3	3	-	3	2		

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

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

## G) Teaching &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)
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2447601	Mine Safety and Rescue Practices	02	01	-	02	05	04

## Legend:

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## H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
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## Note:

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

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

## J) Theory Session Outcomes (TSOs) and Units: T2447601

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Analyze factor responsible for mine fire in a given situation.</p> <p><i>TSO 1b.</i> Use appropriate fire extinguisher under the given conditions.</p> <p><i>TSO 1c.</i> Identify the stages of spontaneous heating in mines.</p> <p><i>TSO 1d.</i> Identify different types of fire stopping used in underground mines.</p> <p><i>TSO 1e.</i> Adopt precaution before reopening of sealed off area.</p> <p><i>TSO 1f.</i> Write some major incidents of fire in Indian coal mines.</p>	<p><b>Unit-1.0 Mine Fires</b></p> <p>1.1 Classification of fires; Causes, detection, monitoring and control of surface and underground fires;</p> <p>1.2 Fire extinguishers, Preventive measures; Fire fighting – direct methods, sealing off and intersection,</p> <p>1.3 Fire stopping: Preparatory, Temporary and Permanent.</p> <p>1.4 Fire fighting organizations Monitoring of atmosphere behind sealed- off areas;</p> <p>1.5 Precautions to be taken before reopening, methods of reopening,</p> <p>1.6 Case histories.</p>	CO-1
<p><i>TSO 2a.</i> Identify various conditions responsible for spontaneous heating.</p> <p><i>TSO 2b.</i> Explain the mechanism of spontaneous heating.</p> <p><i>TSO 2c.</i> Define incubation period and identify coal susceptible to spontaneous heating.</p> <p><i>TSO 2d.</i> Apply required safety measures for prevention of spontaneous heating.</p>	<p><b>Unit-2.0 Spontaneous Heating</b></p> <p>2.1 Physical and chemical characteristics of coal liable to spontaneous heating.</p> <p>2.2 Mechanism, susceptibility indices and stages of spontaneous heating.</p> <p>2.3 Incubation period and its determination, Causes and detection.</p> <p>2.4 Monitoring and control of spontaneous heating in underground mines, on surface and in coal stacks and dumps; Incubation period; Preventive measures.</p>	CO-2
<p><i>TSO 3a.</i> Write different types of explosion occur in underground coal mines.</p> <p><i>TSO 3b.</i> Identify various conditions responsible for firedamp and coal dust explosion.</p> <p><i>TSO 3c.</i> Identify limits of inflammability of various gases in mines.</p> <p><i>TSO 3d.</i> Write qualities of stone dust to using for prevention of coal dust explosion.</p> <p><i>TSO 3e.</i> Use stone dust barriers, water barriers and chemical foam method for prevention of coal dust explosion.</p> <p><i>TSO 3f.</i> Investigate the causes of accident due to explosion.</p>	<p><b>Unit-3.0 Explosion</b></p> <p>3.1 Types of explosion, causes and mechanism of firedamp and coal dust explosions;</p> <p>3.2 Limits of explosibility towards diagram, inflammability and factor affecting these.</p> <p>3.3 Sources of initiation, Preventive measures; Water spraying.</p> <p>3.4 Stone dusting, stone-dust and water barriers; Investigations after an explosion.</p> <p>3.5 Enlist some major explosion in Indian coal mines.</p>	CO-3
<p><i>TSO 4a.</i> Identify the sources of dangerous accumulation of water.</p> <p><i>TSO 4b.</i> Apply suitable preventive measures against inundations in mines under given conditions.</p> <p><i>TSO 4c.</i> Operate various dams to prevent water logging inside mines.</p>	<p><b>Unit-4.0 Mine Inundation</b></p> <p>4.1 Causes of inundation in mines.</p> <p>4.2 Sources of dangerous accumulation of water in mines.</p> <p>4.3 Preventive measures for inundation.</p> <p>4.4 Precautions for approaching water logged areas.</p> <p>4.5 Burnside boring apparatus; Design and construction of bulk head doors.</p>	CO-4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	4.6 Dams – Purpose of dam, Site of dam, Types of dam and their constructional details. 4.7 Enquiry Report Preparation	
<p><i>TSO 5a.</i> Identify various rescue apparatus used for rescue operation in mines.</p> <p><i>TSO 5b.</i> Operate rescue and reviving apparatus used for rescue and recovery operations.</p> <p><i>TSO 5c.</i> Maintain the equipment used in rescue stations.</p> <p><i>TSO 5d.</i> Write the condition to make rescue station.</p> <p><i>TSO 5e.</i> Prepare rescue plan and rescue organization in case of emergency.</p> <p><i>TSO 5f.</i> Write causes and preventive measures of occupational diseases.</p>	<p><b>Unit-5.0 Mine Rescue and Recovery Work</b></p> <p>5.1 Different types of rescue equipment- constructional features, functions and uses;</p> <p>5.2 Test on rescue apparatus; Rescue stations and rescue room; Organisation of rescue work.</p> <p>5.3 Fresh air base and its advancing. Rescue rules. Recovery and first aid appliances; Training of personnel and organization of rescue station;</p> <p>5.4 Rescue and recovery work in connection with mine fire, explosions and other conditions. Safety chamber.</p> <p>5.5 Occupational diseases in mining industry.</p>	<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: (Not Applicable)

L) **Suggested Term Work and Self Learning: S2447601** 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 model of preparatory/temporary/permanent fire stopping.
2. Prepare a report comprises of i) location ii) causes iii) severity iv) preventive measures taken for latest spontaneous heating occurrence in Indian underground mines.
3. Prepare a model of stone dust barrier or water barrier.
4. To make a model of bulkhead door.
5. Prepare a non working model of rescue stations.

**c. Other Activities:**

1. Seminar Topics:
  - Mine fire control technology.
  - Causes and preventive measures of spontaneous heating in underground coal mines.
  - Study the stone dust and stone dust barrier to prevent coal dust explosion in underground coal mines.
  - Case study of some major inundation accidents in Indian mines.
  - Technical considerations for the rescue of miners trapped at great depth in mines.
2. Visits: Visit nearby underground coal mines and prepare a detailed report on it.
3. Self-Learning Topics:
  - Study different types of fire and different types of fire extinguisher used to control fires.

- Visit nearby underground mines and study the safety measures applied for prevention of spontaneous heating.
- To study some major explosion occurred in Indian coal mines.
- Study the cause and preventive measures of coal dust in underground coal mines.
- Case study the some major inundation in Indian coal mines.
- Study the different types of rescue apparatus used in nearby mines.
- To watch videos on rescue and recovery work.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	20%	20%	20%	20%	-	-
CO-2	20%	20%	20%	20%	20%	-	-
CO-3	20%	20%	20%	20%	20%	-	-
CO-4	20%	20%	20%	20%	20%	-	-
CO-5	20%	20%	20%	20%	20%	-	-
<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 this 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 Mine Fires	10	CO-1	10	3	3	4
Unit-2.0 Spontaneous Heating	8	CO-2	10	3	2	5
Unit-3.0 Explosion	10	CO-3	20	5	6	9
Unit-4.0 Mine Inundation	10	CO-4	15	5	6	9
Unit-5.0 Rescue and Recovery Work	10	CO-5	15	4	5	6
<b>Total</b>	<b>48</b>	-	<b>70</b>	<b>20</b>	<b>22</b>	<b>33</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): (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: (Not Applicable)****R) Suggested Learning Resources:****(a) Books:**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Mine disasters and mine rescue	M.A. Ramlu	Universities Press, 2 <sup>nd</sup> , ISBN-8173715734
2.	Mine Ventilation vol 2	S.K Ghatak	Lovely Prakshan, 3 <sup>rd</sup> edition 2008.
3.	Elements of Mining Technology Vol.2	D. J. Deshmukh	Denett & Co Nagpur, 9 <sup>th</sup> edition, ISBN-10: 8189904345
4.	Safety in Mines	Prof. B.K. Kejriwal	Lovely Prakashan Dhanbad,
5.	Mining Digest	L.C. Kaku	Lovely Prakashan Dhanbad, ISBN-9788179561515

**(b) Online Educational Resources:**

1. <https://www.thebalancesmb.com/specific-and-non-specific-hazards-in-underground-mines-2367338>
2. <https://www.slideshare.net/mj2611/spontaneous-combustion-of-coal>
3. <https://www.slideshare.net/safdar5647/mine-explosions>  
<https://www.youtube.com/watch?v=daXeesa5LDI>
4. [https://www.researchgate.net/publication/309691264\\_Lessons\\_Learnt\\_from\\_Indian\\_Inundation\\_Disasters\\_An\\_Analysis\\_of\\_Case\\_Studies](https://www.researchgate.net/publication/309691264_Lessons_Learnt_from_Indian_Inundation_Disasters_An_Analysis_of_Case_Studies)
5. [https://www.slideshare.net/kedi85prasad/danger-due-to-fire-innundation?from\\_search=0](https://www.slideshare.net/kedi85prasad/danger-due-to-fire-innundation?from_search=0)

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

**(c) Others:**

1. Revised study material by N.B Krishnamurthy.

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- A) **Course Code** : 2447602(T2447602/P2447602/S2447602)  
 B) **Course Title** : Surface Mining  
 C) **Pre- requisite Course(s)** :  
 D) **Rationale** :

Technology and techniques of extracting minerals from the earth are changing rapidly with recent developments in mining industry. Emphasis is being given for winning of deposits by removing overburden as compared to underground mining by employment of heavy machineries. It is essential to study the technology applied in mining field for extraction of mineral completely by introducing heavy machines & comfortable natural conditions. Surface mining and problems of mined out area is one of the important field of mining/Industry. This course is designed to fulfill the necessary knowledge and associated skills of surface mining.

- 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 basic knowledge of surface mining for understanding, formulating and solve problems related to surface mine.  
**CO-2** Design a layout of mechanized surface mines under the given conditions.  
**CO-3** Select appropriate type of drills and explosives used in surface mines.  
**CO-4** Select appropriate type of surface mining machinery under the given conditions in surface mines.  
**CO-5** Select appropriate method of land reclamation and drainage system in surface mines.

- 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 Engineer-ing Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	-	3	2	-	-	2		
CO-2	3	2	2	2	2	1	3		
CO-3	3	3	3	2	3	-	-		
CO-4	3	3	-	3	-	1	3		
CO-5	3	-	3	3	-	1	2		

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

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## J) Theory Session Outcomes (TSOs) and Units: T2447602

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Apply basic terminology in surface mining operations.</p> <p><i>TSO 1b.</i> Calculate life of surface mine under given condition.</p> <p><i>TSO 1c.</i> Prepare a layout of boxcut on the basis of given conditions.</p> <p><i>TSO 1d.</i> Select appropriate site for waste dump disposal.</p> <p><i>TSO 1e.</i> Analyze advantages and disadvantages of surface mining under the given conditions.</p>	<p><b>Unit-1.0 Introduction</b></p> <p>1.1 Definition of terms related to surface mining – Strip Mining, outcrop, overburden, stripping ratio, break even stripping ratio, economic cut off Ratio, quarriable limit, angle of repose etc.</p> <p>1.2 Basic Parameters: Size of mine area, Pit depth; Annual production and life of mine; Determination of mine parameters.</p> <p>1.3 Phases of surface mining.</p> <p>1.4 Opening up of deposit-Box cut -internal and external box cut, location of Box cut.</p> <p>1.5 Overburden Removal: Systems of overburden removal and disposal; Site selection for disposal, Design of waste dumps, Overcasting, haulage and combination methods.</p> <p>1.6 Advantages and disadvantage of surface mining.</p>	CO-1
<p><i>TSO 2a.</i> Identify the required parameters of designing ultimate pit.</p> <p><i>TSO 2b.</i> Design benches, haul roads and ramps under the given conditions.</p> <p><i>TSO 2c.</i> Write a statutory provision for benches, Haul Road and Ramp.</p> <p><i>TSO 2d.</i> Identify different types of slope failure occurs in surface mines.</p> <p><i>TSO 2e.</i> Adopt measures for stability of slope under given conditions.</p> <p><i>TSO 2f.</i> Solve numerical problems based on slope stabilization.</p>	<p><b>Unit-2.0 Pit Design and Layouts</b></p> <p>2.1 Important parameters of Open pit design; Ultimate pit design</p> <p>2.2 Bench parameters-Bench height, Bench width, Length of blast, Bench slope angle and overall slope angle.</p> <p>2.3 Statutory provisions for benches, Haul Road and Ramp- design &amp; maintenance.</p> <p>2.4 Layouts: Basic layouts for flat, horizontal, inclined and steep deposits; Strip mining layouts; Layout for hilly deposits. Management of layouts (Pushback operation for rearrangement of existing layouts).</p> <p>2.5 Slope stabilization, numerical based on slope stabilization, Slope failures-different types of slope failures.</p>	CO-2
<p><i>TSO 3a.</i> Operate drill machine under given condition.</p> <p><i>TSO 3b.</i> Enlist different types of drill used in opencast metal mines.</p> <p><i>TSO 3c.</i> Compute productivity of drill machine under given condition.</p> <p><i>TSO 3d.</i> Select appropriate type of explosive under given condition.</p> <p><i>TSO 3e.</i> Design drill pattern as per the requirement in opencast mines.</p> <p><i>TSO 3f.</i> Describe different mode of initiation system used in opencast mines.</p>	<p><b>Unit-3.0 Drilling and Blasting</b></p> <p>3.1 Blast hole drilling: Types of drilling equipment, Selection of Drills; Drilling concepts - Operation and performance, Drilling patterns, Inclined drilling, Computation of Productivity of Drill Machines; Control of dust.</p> <p>3.2 Blasting: Choice of explosive; Blast round design, blasting calculation for charges, Mode and points of initiation; Sequence of blasting and delay interval; Multi row blasting, Blast hole deviation, Inclined hole blasting; Fragmentation monitoring; Secondary blasting; Blasting hazards - noise, ground vibration, fly rock, dust &amp; air over pressure and their remedial measures</p>	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<i>TSO 3g.</i> Write caused and remedial measures of accident in opencast mines.	3.3 Accident due to blasting and its remedial measures.	
<p><i>TSO 4a.</i> Select appropriate mining machineries under the given condition in opencast mines.</p> <p><i>TSO 4b.</i> Prepare a plan for application of different machineries for excavation and loading and transportation in opencast mines.</p> <p><i>TSO 4c.</i> Calculate output with shovel- dumper combination, dragline and bucket wheel excavator under the given conditions in opencast mines.</p> <p><i>TSO 4d.</i> Describe belt conveyor used in opencast mining.</p>	<p><b>Unit-4.0 HEMM (Heavy Earth Moving Machinery)</b></p> <p>4.1 Site preparation by- Dozers, Scrapers, Front-End Loaders. Their Construction, Operation, and Applicability.</p> <p>4.2 Loading and Excavation- Shovel, Dragline, Multi Bucket Excavator. Their Construction, Operation, and Applicability.</p> <p>4.3 Calculation of out-put with shovel- dumper combination, bucket wheel excavator &amp; dragline.</p> <p>4.4 Transportation: Rail, Road, Pipe line, Conveyors and aerial ropeway transportation systems; Their Suitability, limitations and comparative study; Computation of Their Productivity,</p> <p>4.5 Optimization of shovel- dumper combination; Computerized truck dispatch system; construction and safety measures, Steep angle conveyor, high angle conveyor, in pit crushing and conveying.</p>	<b>CO-4</b>
<p><i>TSO 5a.</i> Apply land reclamation process in preparation of mine plan.</p> <p><i>TSO 5b.</i> Select appropriate method of land reclamation under the given conditions.</p> <p><i>TSO 5c.</i> Prepare a plan for water drainage system in opencast mining.</p>	<p><b>Unit-5.0 Reclamation and Drainage System</b></p> <p>5.1 Reclamation: Different Types, Applicability, Planning and process, Final closure of mine.</p> <p>5.2 Drainage: Assessment of water make; Drains, sumps and pumping systems; Pre-drainage through diversion channels and boreholes.</p>	<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: P2447602

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Calculate SR and BESR of given data.</p> <p><i>LSO 1.2.</i> Explain the factor affecting SR and BESR.</p>	1.	Determination of stripping and break-even stripping ratio of given mine data.	CO-1
<i>LSO 2.1.</i> Design a layout of internal and external boxcut in an opencast mine.	2.	Layout of internal and external boxcut in an opencast mine.	CO-1
<p><i>LSO 3.1.</i> Analyze DGMS norms related to haul road and ramp</p> <p><i>LSO 3.2.</i> Construct haul road and ramp as per norms.</p>	3.	Designing of haul road and ramp as per DGMS norm.	CO-2
<p><i>LSO 4.1.</i> Measure strength and porosity of bench rock.</p> <p><i>LSO 4.2.</i> Analyze physical and chemical properties of rock</p>	4.	Factor of Safety (FOS) of overburden bench.	CO-2
<i>LSO 5.1.</i> Compute the productivity of drill machine in an opencast mine.	5.	Use of Drill machine in an opencast mine	CO-3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 6.1.</i> Choose appropriate blast hole parameters and explosive.</p> <p><i>LSO 6.2.</i> Select appropriate initiation devices for deep hole blasting.</p>	6.	Calculation of powder factor and detonation factor of given data.	CO-3
<p><i>LSO 7.1.</i> Choose appropriate type of shovel under given condition.</p> <p><i>LSO 7.2.</i> Calculate productivity of Shovel machine, assume your own data.</p>	7.	Use of Shovel machine in an opencast mine	CO-4
<i>LSO 8.1.</i> Prepare a layout for belt conveyor used in opencast mines.	8.	Use of belt conveyor in an opencast mine	CO-4
<i>LSO 9.1.</i> Prepare a layout for land reclamation of opencast mines.	9.	Process of land reclamation in opencast mines.	CO-5
<i>LSO 10.1.</i> Prepare a water drainage plan for monsoon season in an opencast mine.	10.	Water drainage in an opencast mine.	CO-5

L) **Suggested Term Work and Self Learning: S2447602** 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 model to show different element of box cut.
2. Design a layout of mechanized opencast metal mines.
3. Prepare a layout of single row and multi row blasting.
4. Prepare a model of Shovel/Front end loader/dragline.
5. Design a layout of land reclamation.

c. **Other Activities:**

1. Seminar Topics:

- Opening up deposit by internal box cut.
- Different parameters for pit design and layout.
- Evaluation of drilling and blasting methods used in surface mining.
- Principles of blast round design for single and multi row blasting.
- Optimization of shovel- dumper combination in opencast mining.
- Reclamation of degraded landscapes due to opencast mining.

2. Visits: Visit a nearby opencast mines and prepare a brief report on it.

3. Self-Learning Topics:

- Visit nearby surface mines and study different types of plans used therein.
- Find the measures used for slope stability in civil construction projects.
- Watch surface blasting videos on youtube.
- Find the statutory requirements about storage and transportation of explosives according to regulations.
- Study the machineries used in nearby opencast mines.
- Study the land reclamation method used in nearby opencast mines.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	20%	20%	20%	20%	20%
CO-2	20%	25%	20%	20%	20%	20%	20%
CO-3	20%	25%	20%	20%	20%	20%	20%
CO-4	20%	25%	20%	20%	20%	20%	20%
CO-5	20%	10%	20%	20%	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)
Unit-1.0 Introduction	10	CO1	10	4	3	3
Unit-2.0 Pit Design and Layouts	10	CO2	15	4	4	7
Unit-3.0 Drilling and Blasting	10	CO3	15	4	4	7
Unit-4.0 HEMM	10	CO4	20	5	6	9
Unit-5.0 Reclamation and Drainage System	8	CO5	10	3	3	4
<b>Total</b>	<b>48</b>	<b>-</b>	<b>70</b>	<b>20</b>	<b>20</b>	<b>30</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.	Determination of stripping and break-even stripping ratio of given mine data.	CO1	30	60	10
2.	Layout of internal and external boxcut in an opencast mine.	CO1	40	50	10
3.	Designing of haul road and ramp as per DGMS norm.	CO2	40	50	10
4.	Factor of Safety (FOS) of overburden bench.	CO2	30	60	10
5.	Use of Drill machine in an opencast mine	CO3	30	60	10
6.	Calculation of powder factor and detonation factor of given data.	CO3	30	60	10
7.	Use of Shovel machine in an opencast mine	CO4	30	60	10
8.	Use of belt conveyor in an opencast mine	CO4	40	50	10
9.	Process of land reclamation in opencast mines.	CO5	40	50	10
10.	Water drainage in an opencast mine.	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.	Colorful sketch of Ultimate Pit Design	Showing all bench parameters	1
2.	Model of Boxcut	Showing internal and external boxcut	2
3.	Colorful Sketches of haul road and ramp	Showing single lane and double lane road, ramp etc.	3
4.	Model of Shovel	Model showing boom, bucket, turntable, cabin and crawler mounting chain etc.	7
5.	Model of belt conveyor	Model shows safety features of conveyor, Idlers, structures etc.	8

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Colorful sketch of Ultimate Pit Design	Showing all bench parameters	1
2.	Model of Boxcut	Showing internal and external boxcut	2
3.	Colorful Sketches of haul road and ramp	Showing single lane and double lane road, ramp etc.	3
6.	Model of reclaimed land	Showing use of land i.e. tourism, agriculture, hotel, boating etc.	9
7.	Mine Drainage plan	Plan show all surface features.	10

## R) Suggested Learning Resources:

### (a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Surface Mining	G.B. Mishra	Dhanbad Publishers, Revised edition, 1994
2.	A Handbook on Surface Mining Technology	Dr. Samir K Das	SagardeepPrakashan, Kharagpur 3 <sup>rd</sup> edition ,2006
3.	Opencast Mining	R.T. Deshmukh	M. Publications, Nagpur. Revised edition
4.	Elements of Mining Technology Vil-1	D.J. Deshmukh	Denett & Co, Nagpur, ISBN10 8189904337
5.	Surface and Underground excavation	Ratan Raj Tatiya	CRC press ,2 <sup>nd</sup> Edition, ISBN 9781138496163

### (b) Online Educational Resources:

1. Slope stabilization -<https://www.sciencedirect.com/science/article/pii/S1877705811029997>
2. Land reclamation -<https://www.worldcoal.org/returning-mined-land-productivity-through-reclamation>
3. Explosives used in mines - <https://www.cdc.gov/niosh/mining/userfiles/works/pdfs/acobo.pdf>

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

### (c) Others:

1. Lab Manuals

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- A) **Course Code** : 2447603(T2447603/S2447603)  
 B) **Course Title** : Strata Control and Roof Support  
 C) **Pre- requisite Course(s)** :  
 D) **Rationale** :

Strata control is one of the most important aspects of safety in opencast mines as well as underground mines. This requires understanding the basic concept and principle of support of level control mechanism in mining. It is also important for the students to become fully aware of various level control techniques by applying different types of supports adopted in different situations in the field. This course will enable students to understand the requirements required in this field to function effectively.

- 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 techniques to measure and reduce the ground movement.  
 CO-2 Control surface subsidence and its effects.  
 CO-3 Select appropriate type of support system under given conditions.  
 CO-4 Operate appropriate type of powered support under given condition.  
 CO-5 Apply the concepts of stowing to minimise the damage caused by subsidence.

- 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 Engineer-ing Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	-	3	2	-	-	2		
CO-2	3	2	-	2	-	-	-		
CO-3	3	3	-	2	3	-	-		
CO-4	3	3	-	2	-	-	-		
CO-5	3	-	3	3	-	3	2		

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

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

## G) Teaching &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				
2447603	Strata Control and Roof Support	02	01	-	02	05	04

## Legend:

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

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

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

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

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

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

**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)		Internal	External	Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2447603	Strata Control and Roof Support	30	70	20	30	-	-	150

## Legend:

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

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

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

## Note:

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

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

## J) Theory Session Outcomes (TSOs) and Units: T2447603

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Apply the concepts of ground movement to reduce accidents caused due to strata movement.</p> <p><i>TSO 1b.</i> Describe rock pressure redistribution due to narrow and wide excavation.</p> <p><i>TSO 1c.</i> Explain causes of roof and floor failure in bord and pillar mining.</p> <p><i>TSO 1d.</i> Measure the strata movement by suitable instrument.</p> <p><i>TSO 1e.</i> Identify different types of roof and their behavior.</p>	<p><b>Unit-1.0 Strata and Ground Movements</b></p> <p>1.1 Strata conditions before and after mining operations – Theories of mechanics of Strata behaviour.</p> <p>1.2 Strata pressure redistribution in and around Bord and pillar and longwall workings.</p> <p>1.3 Surface Movements and Deformation during Bord and pillar and Longwall Mining.</p> <p>1.4 Measurement of strata movement- Wire extensometer, Load cell, Convergence indicator.</p> <p>1.1 Types of roof and examination of roof, rock burst and coal bumps.</p>	CO1
<p><i>TSO 2a.</i> Write causes of subsidence.</p> <p><i>TSO 2b.</i> Describe theory of subsidence.</p> <p><i>TSO 2c.</i> Identify lateral and vertical movement of strata due to subsidence.</p> <p><i>TSO 2d.</i> Identify safe zone of mines from angle of draw and angle of fracture.</p> <p><i>TSO 2e.</i> Apply techniques to protect surface features from subsidence.</p>	<p><b>Unit-2.0 Subsidence</b></p> <p>2.1 Causes and impact, Mechanics and theory of subsidence,</p> <p>2.2 Angle of draw and angle of fracture, factors affecting subsidence, Protective measures, Subsidence measurements,</p> <p>2.3 Estimation of vertical and lateral movements, Subsidence monitoring and prediction, Sub-critical, critical and super-critical widths of extraction.</p>	CO2
<p><i>TSO 3a.</i> Classify different types of support used in mines.</p> <p><i>TSO 3b.</i> Use roof bolting and cable bolting in underground mines.</p> <p><i>TSO 3c.</i> Use different support system at different places in underground mines.</p> <p><i>TSO 3d.</i> Frame Systematic support rule and support plan.</p> <p><i>TSO 3e.</i> Describe prop support withdrawal.</p>	<p><b>Unit-3.0 Supports</b></p> <p>3.1 Classification of Supports- Timber support, Steel supports and its behavior with change in stress condition.</p> <p>3.2 Roof Bolting and Cable Bolting, Roof stitching and side stitching, Rigid and Yielding props, constructional details of Friction and Hydraulic props,</p> <p>3.3 Supporting under different Conditions - Roadways, Crossing, Junctions, Depillaring area.</p> <p>3.4 Systematic Support Rules(SSR) and Support plan,</p> <p>3.5 Sylvester support withdrawal.</p>	CO3
<p><i>TSO 4a.</i> Apply principles of operation of powered support.</p> <p><i>TSO 4b.</i> Identify different types of powered support used in mines.</p> <p><i>TSO 4c.</i> Select suitable type of powered support used in underground mines.</p> <p><i>TSO 4d.</i> Differentiate various types of powered support.</p> <p><i>TSO 4e.</i> Describe Power pack system of powered support.</p>	<p><b>Unit-4.0 Powered Support</b></p> <p>4.1 Principle of operation of power support</p> <p>4.2 Classification of power support- Frame support, Chock support, Shield support, Chock Shield support,</p> <p>4.3 Characteristic curves and performance of powered support.</p> <p>4.4 Power pack system and hydraulic fluids.</p> <p>4.5 Merits and demerits of powered support.</p>	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 5a.</i> Write different types of stowing methods.</p> <p><i>TSO 5b.</i> Explain the working procedure of various stowing methods.</p> <p><i>TSO 5c.</i> Identify the problems related to stowing methods and suggest methods to resolve them.</p> <p><i>TSO 5d.</i> Draw a hydraulic profile of hydraulic stowing.</p> <p><i>TSO 5e.</i> Suggest measures to reduce cost incurred due to Pipe wear and Pipe jams.</p>	<p><b>Unit-5.0 Stowing</b></p> <p>5.1 Classification of stowing- Hand Packing, Hydraulic stowing, Pneumatic Stowing, Mechanical Stowing.</p> <p>5.2 Relative merits and demerits of different types of stowing methods.</p> <p>5.3 Hydraulic profile</p> <p>5.4 Face arrangements</p> <p>5.5 Pipe wear, pipe jams and Pipe joint.</p>	CO5

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

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

L) **Suggested Term Work and Self Learning: S2447603** 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 working model of roof monitoring convergence system used in underground coal mines.
2. Carry out subsidence survey in nearby mines.
3. Prepare a model of wooden chock support.
4. Make a model of any one type of powered support used in longwall mining.
5. Prepare a model of surface arrangement of hydraulic stowing.

c. **Other Activities:**

1. Seminar Topics:

- Strata pressure redistribution in Bord and pillar and longwall workings.
- Impact of subsidence on important surface building, railway lines etc.
- Conventional wooden support used in underground coal mines in India.
- Adapting the Powered Roof Support to Diverse Mining and Geological Conditions.
- Study of hydraulic stowing.

2. Visits: Visit nearby mines having hydraulic stowing and prepare a report on it.

3. Self-Learning Topics:

- Study Strata behavior due to mining activity.
- Obtain the report of subsidence occurred in the Nearby mines and study the methods adopted for its control.
- Study a difference between wooden support and steel support.
- To watch videos on support used in underground coal mines.
- Study the powered support used in longwall mining.
- Watch videos of working operation of powered support used in mines.
- Find alternate materials which can be used in barricading in hydraulic stowing.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	20%	20%	20%	-	-
CO-2	20%	15%	20%	20%	20%	-	-
CO-3	20%	20%	20%	20%	20%	-	-
CO-4	20%	20%	20%	20%	20%	-	-
CO-5	20%	30%	20%	20%	20%	-	-
<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 this 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 Strata and Ground Movements	8	CO-1	10	4	3	3
Unit-2.0 Subsidence	10	CO-2	10	3	4	3
Unit-3.0 Supports	10	CO-3	15	4	5	6
Unit-4.0 Powered support	10	CO-4	15	4	3	8
Unit-5.0 Stowing	10	CO-5	20	5	5	10
<b>Total</b>	<b>48</b>	-	<b>70</b>	<b>20</b>	<b>20</b>	<b>30</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): (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: (Not Applicable)****R) Suggested Learning Resources:****(a) Books:**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Elements of mining technology vol 3	D.J. Deshmukh	Denett& co. Nagpur, 8 <sup>th</sup> edition, ISBN-8189904353
2.	Modern Coal Mining Practices	R.D. Singh	New age international London, ISBN-8122409741
3.	Strata Control in Deep Mines	J. Dubinski, A. Kidybinski	A A Balkema Publishers, ISBN-10 : 9061911249
4.	Strata Mechanics in Coal Mining	Michael L. Jeremic	A A Balkema Publishers, 1st Edition ISBN-9061915562

**(b) Online Educational Resources:**

1. <https://scienceandtech.cmpdi.co.in/PDF%20Files/Strata%20Control.pdf>
2. [https://www.resourcesandenergy.nsw.gov.au/\\_\\_data/assets/pdf\\_file/0003/543945/NSW-code-of-practice-Strata-control-in-underground-coal-mines.pdf](https://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0003/543945/NSW-code-of-practice-Strata-control-in-underground-coal-mines.pdf)
3. [https://www.academia.edu/22903280/STRATA\\_CONTROL\\_PREPARATION\\_CLASSES](https://www.academia.edu/22903280/STRATA_CONTROL_PREPARATION_CLASSES)
4. [https://www.academia.edu/53364215/Determination\\_of\\_the\\_stress\\_state\\_in\\_a\\_rock\\_mass\\_subjected\\_to\\_excavation?uc-g-sw=22903280](https://www.academia.edu/53364215/Determination_of_the_stress_state_in_a_rock_mass_subjected_to_excavation?uc-g-sw=22903280)
5. [https://www.youtube.com/watch?v=VoGXfqa\\_\\_v0](https://www.youtube.com/watch?v=VoGXfqa__v0)
6. [https://www.youtube.com/watch?v=WmwEB4DY\\_jc&t=126s](https://www.youtube.com/watch?v=WmwEB4DY_jc&t=126s)

**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: -**

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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 (Advance) 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)	
<b>2400604B</b>	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 visualization- symbols</p>	CO-5

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
	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 using perceptron	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)
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 line with the targeted COs.

b. **Micro Projects:**

Use python programming for the solutions of Microproject problems

1. (a) Create a Bar plot to get the frequency of the three species of the Iris data.  
(b) Create a Pie plot to get the frequency of the three species of the Iris data.  
(c) Write a Python program to create a graph to find relationship between the sepal length and width.
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)
<b>Unit-1.0.</b> Introduction to Machine Learning	08	CO1	11	5	4	2
<b>Unit-2.0.</b> Supervised and Unsupervised Learning	10	CO2	18	5	6	7
<b>Unit-3.0.</b> Introduction to Neural Networks	10	CO3	17	5	7	5
<b>Unit-4.0.</b> Neural Networks Models and Learning Methods	10	CO4	14	3	3	8
<b>Unit-5.0.</b> 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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
3.	Jupyter Notebook	Download from <a href="https://jupyter.org/">https://jupyter.org/</a>	S. No. 1 to 10
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
6.	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

### (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>	<p><b>CO-1 and CO-5</b></p>
<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. Python Advance: -</b></p> <p>2.1 Python Do &amp; while loops</p> <p>2.2 Python break, continue, pass statements</p> <p>2.2 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>	<p><b>CO-1 and CO5</b></p>
<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>	<p><b>CO-1, CO-2 and CO-5</b></p>
<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 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>	<p><b>CO-1 and CO-4</b></p>
<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><b>Unit. 5 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>	<p><b>CO-4 and CO-5</b></p>

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		2.6 Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use. 2.7 Create a Class with instance attributes 2.8 Create a Vehicle class without any variables and methods 2.9 Write a Python function to find the Max of three numbers. 2.10 Write a Python program to reverse a string.	
LSO 3.1 Signup for free cloud storage LSO 3.2 Store data into cloud and retrieve it.	3.	3.1 Create a free cloud account 3.2 Store data on cloud and retrieve it	CO-3
LSO 4.1 Design various types of network cables LSO 4.2 Connect computer in LAN. LSO 4.3 Connect devices using wireless network LSO 4.4 Connect machine with machine LSO 4.5 Connect devices using IEEE 802 LSO 4.6 Connect devices using LPWAN LSO 4.7 Connect devices using RFID	4	4.1 Explain 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

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
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
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	
8	Arduino development board	Arduino Uno and Arduino Nano.	
6	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

**(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](https://www.freestudy.co.uk/mech%20prin%20h2/stress.pdf)
4. [www.engineerstudent.co.uk/stress\\_and\\_strain.html](https://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

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- 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 &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				
2400604D	Drone Technology (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)	
2400604D	Drone Technology (Advanced)	30	70	20	30	20	30	200

## Legend:

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

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

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

## Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	<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	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
	3.7 GPS interface with FCB 3.8 Safety features of advance FCB	
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	<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>	CO-4
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	<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>	CO-5

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

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

<b>Practical/Lab Session Outcomes (LSOs)</b>	<b>S. No.</b>	<b>Laboratory Experiment/Practical Titles</b>	<b>Relevant COs Number(s)</b>
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.	<b>CO-1</b>
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	<b>CO-1</b>
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).	<b>CO-2, CO-4</b>
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.	<b>CO-2</b>
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.	<b>CO-2, CO-3</b>
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.	<b>CO-2</b>
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.	<b>CO-2</b>
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).	<b>CO-3</b>
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.	<b>CO-3, CO-2</b>
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	<b>CO-3, CO-2</b>
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.	<b>CO-3, CO-2</b>
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	<b>CO-4</b>

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

**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)
Unit 1.0 Engineering mechanics for Drone Technology	8	CO-1	12	04	04	04
Unit 2.0 Drone frame and components	10	CO-2	14	04	04	06
Unit 3.0 Advance Flight Controller Board	12	CO-3	16	04	06	06
Unit 4.0 Maintenance and assembling of drone	10	CO-4	16	04	06	06
Unit 5.0 Advance Drone Application	8	CO-5	12	04	04	04
<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 transeiver.	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
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.

**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

**(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:**

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

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

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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><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><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> <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>	CO1
<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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<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><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><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 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>	<p>CO1, CO2, CO3, CO4, CO5</p>

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

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: T2400604E**

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

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

SN	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

**(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 Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. <https://www.improrecision.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 &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				
2400604F	Industrial Automation (Advanced)	03	-	04	02	09	06

## Legend:

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

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

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

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

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

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

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

## H) Assessment Scheme:

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

## Legend:

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

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

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

## Note:

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

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3d Explain preventive maintenance procedure associated with PLC system to reduce environmental impact TSO.3e Identify faults in the given PLC system TSO.3f Explain the procedure for Troubleshooting PLC system TSO.3g Prepare preventive maintenance plan for the PLC system TSO.3h Use safety equipment's. TSO.3i Follow safe practices	3.3 Diagnostic LED Indicators in PLCs 3.4 Common problems <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), 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.</li> <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,	<b>CO-5</b>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	<p>AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci</p> <p>5.3 <b>Defense- guided rockets and missiles</b>, counter measures, UAV drones, launcher, radar antenna, engagement control system</p> <p>5.4 <b>Automobile –Break monitoring system</b>, 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, Intelligent Parking Assist System, Driverless/Autonomous Cars</p> <p>5.5 <b>Agriculture-</b> harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor</p> <p>5.6 <b>Mining-</b> Mine planning system, mine picture compilation, mine control system, seismic imagining, laser imaging, Rig control system, automated drilling, automated exploration, automated truck</p>	

**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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<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 <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 <i>LSO 3.4</i> Test the ground connections of the given PLC. <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 <i>LSO 3.6</i> Investigate the cause of Noise in the given PLC <i>LSO 3.7</i> PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure. <i>LSO 3.8</i> Troubleshoot the corrupted PLC memory. <i>LSO 3.9</i> Replace CPU and power supply fuses in a given PLC system.	13.	Troubleshooting of PLC system	CO3
<i>LSO 4.1</i> Download any opensource SCADA software and install the same. <i>LSO 4.2</i> Interpret the available components in symbol factory of SCADA software <i>LSO 4.3</i> Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list) <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> <i>LSO 4.4</i> Create historical and real time trends for the given automation	14.	Develop simple SCADA HMI applications using any one opensource SCADA software and apply dynamic properties	CO4
<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. <i>LSO 5.2</i> Build an electronic device that can remotely control home appliances with your Bluetooth-enabled	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>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> <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)
<b>Unit-1.0</b> 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

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
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
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
24	<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	CO5	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
	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.				

**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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
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 -0.1degree centigrade, humidity measurement resolution -0.1%RH, minimum operating temperature - -10 to -20-degree centigrade, Maximum operating temperature +45 to +50 degree centigrade	13

## 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

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

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO 3j.	Describe the Mechanism of Gear and Differential Assembly.		
TSO 4a. TSO 4b. TSO 4c. TSO 4d. TSO 4e.	Describe the Vehicle Control Unit (VCU). Describe the functions of the given component of the Electronic Control Unit. Describe the connections of the given control unit with the EV sub-system. Explain the Interaction of Controller Area Network Communication with VCU. 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. TSO 5b. TSO 5c. TSO 5d. TSO 5e.	Explain the Classification of Charging Technologies. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. Describe the testing procedure of the given Bi-directional charging systems. Explain the Energy Management Strategies in the EV. 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 LSO 2.2	Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. 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 LSO 3.2 LSO 3.3	Test the performance of a new set of batteries and aged batteries. Compare the performance of the battery and find the Fuel Gauge after discharging the battery. a. 0% - 100% b. 30% - 100% c. 50% - 100% Evaluate the following parameters of the given EV battery. a. Specific power	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)
b. Specific energy c. Life span and d. Cost parameters  LSO 3.4 Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.			
LSO 3.5 Test the dynamic performance of the given motor; a) Speed and torque spectrum. b) Speed and torque oscillation c) Friction torque friction spectrum.  LSO 3.6 Test the following speed-controlled performance characteristics of the given motor; a. Motor voltage over time b. Motor current over time. c. Speed and torque over time. d. Torque over speed. e. Current over speed. f. Electrical input power and the mechanical input power over speed	5.	<ul style="list-style-type: none"> <li>Speed control of Electrical Motors</li> </ul>	
LSO 4.1 Connect the components of the EC Units with EV subsystems. LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.	6.	<ul style="list-style-type: none"> <li>Connection of Electronic Control Unit components</li> <li>Troubleshooting of electronic control unit</li> </ul>	CO4
LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	<ul style="list-style-type: none"> <li>Impacts of G2V and V2G</li> </ul>	CO 5
LSO 5.2 Prepare a layout of a charging station	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.

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Vehicle Dynamics	8	CO1	12	4	5	3
Unit-2.0 Elements of Automobile.	10	CO2	15	5	6	4
Unit-3.0 EV Power Transmission System.	14	CO3	20	4	10	6
Unit-4.0 Vehicle Control Unit (VCU)	10	CO4	15	4	6	5
Unit-5.0 Charging Technologies	6	CO5	8	3	3	2
<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		60	30	10
6.	Connection of Electronic Control Unit components	CO4	60	30	10
7.	Troubleshooting of electronic control unit				
8.	Impacts of G2V and V2G	CO 5	30	60	10
9.	Demonstration of Charging stations		70	20	10

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Disc Braking and Regenerative braking system test rig	Test rig equipment for Demonstration of Disc Braking and Regenerative Braking system operation.	1
2.	Disc Braking System	Test rig / Software for testing the performance of the disc braking system in Half step and Full step braking mode.	1
3.	Induction motor	Induction motor For EV applications with testing kit	2,5
4.	Switched reluctance motor	Switched reluctance motor for EV applications with testing kit	2,5
5.	Permanent magnet (PM) DC motors	Permanent magnet (PM) DC motors for EV applications with testing kit	2,5

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

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
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

**(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 &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				
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.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4f. Conduct an economic analysis for use of robots. TSO 4g. Follow testing methods and acceptance rules for industrial robots.	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 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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
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
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 14.1 Develop a program for an industrial application. LSO 14.2 Execute 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

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
2.	6 Axis Articulated Robot (General Purpose-Welding, Assembly, Drilling) - 1 No	Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic Weight of robot: 50 Kg. Accuracy: $\pm 0.3$ Repeatability: $\pm 0.2$ Tip Velocity range: 500 mm / min Pay load capacity: 2 kg (including gripper) J1 - Waist: $\pm 140^\circ$ J2 - Shoulder: -100 - $60^\circ$ J3 - Elbow: -70 + $10^\circ$ J4 - Wrist rotate: $\pm 70^\circ$ J5 - Wrist pitch: $\pm 35^\circ$ J6 - Wrist roll: $\pm 180^\circ$ External I/O 8 Programmable digital inputs 8 Programmable digital outputs	8, 9, 14
3.	A mounted vision system with software (Free open source Robot simulation software)	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70x10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from $-40^\circ\text{C}$ to $125^\circ\text{C}$ (Analog Devices ADT7302)	3, 4, 5, 11
4.	6-axis Robotics Trainer	Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM 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	3, 4, 5, 13
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

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

### (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/>  
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-1** Analyze the materials used in transformer manufacturing.  
**CO-2** Assemble the transformer based on specific requirements.  
**CO-3** Design using software based on specific requirements.  
**CO-4** Analyze the working conditions of transformers.  
**CO-5** 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.

- 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: T2400604I**

<b>Major Theory Session Outcomes (TSOs)</b>	<b>Units</b>	<b>Relevant COs Number(s)</b>
<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>	<b>CO1</b>
<p><i>TSO 2a.</i> Explain the basic concept of transformer design.</p> <p><i>TSO 2b.</i> List the various parameters to be considered during design.</p> <p><i>TSO 2c.</i> Choose the number of turns, the core diameter.</p> <p><i>TSO 2d.</i> Select the winding wires and strips.</p> <p><i>TSO 2e.</i> Choose the size of HV and LV conductors.</p>	<p><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>	<b>CO1, CO2</b>
<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>	<b>CO3, CO4</b>
<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>	<b>CO3, CO4</b>
<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>	<b>CO4, 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: P2400604I**

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

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

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

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

a.

**b. Micro Projects:**

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

## c. 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.

d.

## 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.

e.

## 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** (%)	
1.	Dismantling a power transformer and understanding various components.	CO1	30	60	10
2.	Designing a transformer using computer programming.	CO1	40	50	10
3.	Application of software for transformer design.	CO1	30	60	10
4.	Breakdown voltage test of transformer oil.	CO2	30	60	10
5.	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:****(a) 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-6 Analyze various 5G radio-access technologies.  
 CO-7 Identify different components of GSM architecture.  
 CO-8 Describe the channel and channel behavior of the wireless channel.  
 CO-9 Analyze different mitigation techniques.  
 CO-10 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.

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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.
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**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: 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 hands-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 2f.</i> Describe the architecture and key components of basic GSM (Global System for Mobile Communications) networks.</p> <p><i>TSO 2g.</i> List the components of the GSM(LTE) system.</p> <p><i>TSO 2h.</i> Describe the working of the various components and their functions of the given type of wireless communication network</p> <p><i>TSO 2i.</i> Analyze the functions of base station subsystems (BS)</p>	<p><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>	CO5

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

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

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

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

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

**g. 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.

### h. Other Activities:

- i. 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"
- j. 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** (%)	
6.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	CO1	30	60	10
7.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	CO2	40	50	10
8.	Comparative Study of Channel Capacity: AWGN versus Fading Channels	CO3	30	60	10
9.	Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication	CO4	30	60	10
10.	Practical Implementation and Performance Analysis of Transmitter Diversity Techniques	CO4	30	60	10
11.	Design and Implementation of MIMO Technology	CO4	30	60	10
12.	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** : 2447605(P2447605/S2447605)  
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 sessional work 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.

A) **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				
2447605	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)	
2447605	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)

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PLA:	Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
TWA:	Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

**Note:**

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

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

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

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

The following steps are undertaken under the major project-

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

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

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

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

**1.1 Unique Features of Major Project:**

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

- Innovativeness
- Creativity
- Originality
- Pro-activeness
- Initiativeness
- Cost Effectiveness
- Resourcefulness
- Development of Soft Skills/Generic Skills
- Ethical Issues
- Environmental Considerations
- Simulated/Automated Industry's/Improvised Process
- Application or Utility in the World of Work.
- Relevance to the Curriculum
- Mapping of Outcomes of Project with Pos and PSOs (if applicable)

- Feasibility of Implementation of the Project

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

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

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

### 2.1 Project Report Writing:

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

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

### 2.2 Presentation & Discussion:

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

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

### 2.3 Project's Potential:

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

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

## J) Assessment of the Major Project:

For objective, valid and reliable assessment, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared. Even the students may be encouraged 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

\*\*\*\*\*

- B) **Course Code** : 2447606(P2447606/S2447606)  
 C) **Course Title** : Application of Drones in Mining Engineering  
 D) **Pre-requisite Course(s)** :  
 E) **Rationale** :

The application of drones in mining engineering revolutionizes traditional practices by increasing efficiency, safety and accuracy. Drones facilitate aerial surveys, allowing comprehensive mapping of mining sites, identifying potential risks and optimizing resource extraction. They enable real-time monitoring of operations, reducing downtime and increasing productivity. Additionally, drones equipped with various sensors can be used for data collection on terrain, geology and environmental factors and sustainable mining practices. Therefore, their integration streamlines operations, reduces costs and improves safety standards in the mining industry. This course will help students to learn about the applications of drones in mining engineering.

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

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

**CO-1:** Use drones safely and efficiently in various mining 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
<b>CO-1</b>	3	-	1	3	2	1	2		

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

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

**G) Teaching & Learning Scheme:**

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2447606	Application of Drones in Mining Engineering	-	-	04	02	06	03

**Legend:**

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

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

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

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

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

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

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

**H) Assessment Scheme:**

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2447606	Application of Drones in Mining Engineering	-	-	20	30	10	15	75

**Legend:**

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

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

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

**Note:**

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

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

## J) Theory Session Outcomes (TSOs) and Units: (Not Applicable)

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2447606

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Choose the drone based on given mining application</p> <p><i>LSO 1.2.</i> Check the drone components and batteries for operation.</p>	1.	1. Selection of suitable Drone and its checking	CO-1
<p><i>LSO 2.1.</i> Perform real-time monitoring and inspection of mine shafts using sensors installed in drones.</p> <p><i>LSO 2.2.</i> Perform real-time monitoring and inspection of underground mining equipment.</p> <p><i>LSO 2.3.</i> Perform real-time monitoring and inspection of detonation surveillance in underground mines.</p> <p><i>LSO 2.4.</i> Perform real-time monitoring and inspection of detonation surveillance in opencast mines.</p> <p><i>LSO 2.5.</i> Perform real-time rock fragmentation analysis over the blasted muck-pile in surface mines.</p>	2.	<p>1. Drone applications in surface mining</p> <p>2. Drone applications in in underground mining</p> <p>3. Drone applications in for mineral exploration</p> <p>4. Drone applications in survey work</p> <p>5. Drone applications in Production Mapping, Stockpile Management.</p> <p>6. Drone applications in Drilling and blasting management</p>	CO-1
<p><i>LSO 3.1.</i> Carry out aerial mapping of Greenfield mining project sites.</p> <p><i>LSO 3.2.</i> Estimate transport routes for surface mine transportation by photogrammetric methods using flights.</p> <p><i>LSO 3.3.</i> Determine air-space requirements at mining site using flights.</p> <p><i>LSO 3.4.</i> Evaluate forecast weather by using flight.</p>	3.	<p>1. Basic principles of flight Fundamentals of flight</p> <p>2. Utilizing Pre-flight Checklists</p> <p>3. Determining Airspace Requirements</p> <p>4. Evaluating Forecast Weather</p> <p>5. Performing a Site Evaluation</p> <p>6. Flight Hazards</p>	CO-1
<p><i>LSO 4.1.</i> Perform volumetric calculations of mines out bench.</p> <p><i>LSO 4.2.</i> Carry out mining explorations using 3D models</p> <p><i>LSO 4.3.</i> Perform monitoring and inspection of tailings dams.</p> <p><i>LSO 4.4.</i> Perform real-time monitoring and inspection of opencast mine slopes.</p> <p><i>LSO 4.5.</i> Perform data analysis for Digital Terrain Modelling.</p>	4.	<p>1. Elements of Image &amp; Video Interpretation</p> <p>2. Photogrammetry</p> <p>3. Types of Image &amp; Video Data</p> <p>4. Analysis Volume Outputs Orthophoto, DTM, DSM, 3d model, calculations Volume Height Data Digitization.</p> <p>5. Performing Volumetric Calculations</p> <p>6. Cut, Fill, and Volumetric Measurement Calculation</p> <p>7. Lowest Point and Best Fit Base Planes</p>	CO-1
<p><i>LSO 5.1.</i> Carry out common setting of camera using proper imaginary for analysis.</p>	5	<p>1. Environmental Impacts</p> <p>2. Image Framing</p> <p>3. Common Camera Settings</p> <p>4. Specialty Camera Settings</p>	CO-1

L) **Suggested Term Work and Self Learning: S2447606** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

1. Prepare report on Legal Aspects of Drone in Mining comprising of the following-

- i) International Rules, Regulations, Standards & Practices
- ii) Civil Aviation Requirements, AIPs, NOTAM
- iii) Classification & Categorization of drones
- iv) Type Certification of Drones
- v) Registration, Sale & De Registration of Drones
- vi) Operations of Drones
- vii) ATC Procedures
- viii) Dos and Don'ts
- ix) Remote Pilot Certificate

b. **Micro Projects:**

1. Download minimum four videos on drone applications in mining engineering and watch them.
2. After watching the downloaded video, prepare a report describing the type of drone used along with the process used for the mining applications shown.

c. **Other Activities:**

1. **Seminar Topics:**

- History of Drone, Drone regulations and their comparison.
- Software Development in Drone Technology.

2. **Self-Learning Topics:**

- Study on Stakeholders & their laws [Basic] Drone Rules 2021
- Drone technology for mines
- Drone data analysis.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
Assignments			Micro Projects	Other Activities*			
CO-1	-	-	20	20	10	10	15
<b>Total Marks</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: (Not Applicable)**

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

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Choose the drone based on given mining application	CO-1	50	40	10
2.	Check the drone components and batteries for operation.	CO-1	50	40	10
3.	Perform real-time monitoring and inspection of mine shafts using sensors installed in drones.	CO-1	40	50	10
4.	Perform real-time monitoring and inspection of underground mining equipment.	CO-1	50	40	10
5.	Perform real-time monitoring and inspection of detonation surveillance in underground mines.	CO-1	50	40	10
6.	Perform real-time monitoring and inspection of detonation surveillance in opencast mines.	CO-1	40	50	10
7.	Perform real-time rock fragmentation analysis over the blasted muck-pile in surface mines.	CO-1	50	40	10
8.	Carry out aerial mapping of Greenfield mining project sites.	CO-1	50	40	10
9.	Estimate transport routes for surface mine transportation by photogrammetric methods using flights.	CO-1	50	40	10
10.	Determine air-space requirements at mining site using flights.	CO-1	40	50	10
11.	Evaluate forecast weather by using flight.	CO-1	50	40	10
12.	Perform volumetric calculations of mines out bench.	CO-1	50	40	10
13.	Perform data analysis for Digital Terrain Modelling.	CO-1	40	50	10
14.	Carry out mining explorations using 3D models	CO-1	50	40	10
15.	Perform monitoring and inspection of tailings dams.	CO-1	50	40	10
16.	Perform real-time monitoring and inspection of opencast mine slopes.	CO-1	40	50	10
17.	Carry out common setting of camera using proper imaginary for analysis.	CO-1	50	40	10

**Legend:**

PRA\*: Process Assessment  
PDA\*\*: Product Assessment

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

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are

Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications /Features	Relevant Experiment/ Practical Number
1.	Equipment for Aerial imagery	Specifications: High-resolution aerial imagery captured from satellites, manned aircraft, or UAVs. Quantity: Sufficient imagery coverage to support the creation and validation of the DTM.	All the experiments 1-17
2.	Battery Chargers and Power Supplies	Sufficient reliable supply of batteries and battery chargers to ensure uninterrupted operation during inspections	
3.	Battery Packs and Charging Stations	Specifications: Lithium polymer (LiPo) battery packs and charging stations for powering the UAV during flight operations. Quantity: Sufficient battery packs and charging stations to support continuous flight operations.	
4.	Communication Equipment	To ensure real-time monitoring, reliable communication equipment to transmit data between the drones and the monitoring station. This could include the following: <ul style="list-style-type: none"> <li>• Long-range radio communication systems.</li> <li>• Cellular or satellite communication systems for remote areas.</li> <li>• Mesh networking systems for creating ad-hoc communication networks within the mine.</li> <li>• Underground radio communication systems: Provide seamless communication between drone operators, mine personnel, and control centers.</li> <li>• Mesh networking devices: Create ad-hoc communication networks within the underground mine to ensure connectivity in remote areas.</li> <li>• Quantity may be decided based on the range and coverage area of the flights, preferably 1 or more communication devices.</li> </ul>	
5.	Computing Hardware	Specifications: High-performance computers or servers with sufficient processing power and memory to handle large datasets. Quantity: 1 or more depending on the scale and complexity of the DTM analysis tasks.	
6.	Drones	Drones capable of flying inside mine shafts. These drones should ideally be equipped with powerful motors, reliable navigation systems, and durable construction to withstand the harsh conditions of a mine environment. Examples include : <ul style="list-style-type: none"> <li>• DJI Matrice 300 RTK</li> <li>• Flyability Elios 2</li> <li>• Kespry Mining Drone</li> </ul>	
7.	Drones	Drones designed specifically for confined spaces and underground operations are essential. These drones should be equipped with advanced navigation systems, obstacle detection capabilities, and rugged construction. Examples include: <ul style="list-style-type: none"> <li>• Elios 2 by Flyability: A collision-tolerant drone designed for indoor and confined space inspections.</li> <li>• DJI Matrice 300 RTK: This drone offers advanced obstacle avoidance and precise positioning capabilities, suitable for navigating tight spaces in underground mines.</li> </ul>	

S. No.	Name of Equipment, Tools and Software	Broad Specifications /Features	Relevant Experiment/ Practical Number
		<ul style="list-style-type: none"> <li>Kespry Mining Drone: Designed for aerial surveying and mapping in mining environments, it can be adapted for underground inspections.</li> </ul>	
8.	Data Transmission Equipment	Specifications: High-speed internet connection or dedicated communication network for transmitting data from sensors to processing units	
9.	Data Storage and Processing Equipment	To store and process the data collected by the drones. This could include high-capacity hard drives or cloud storage solutions, as well as powerful computers or servers for data processing and analysis. This equipment for storing and processing sensor data collected during detonation surveillance is necessary. This could include high-capacity hard drives, cloud storage solutions, and powerful computers or servers for data analysis.	
10.	Data Processing and photogrammetry software	Specifications: Software for processing aerial imagery, generating orthomosaics, and creating digital surface models (DSMs). Quantity: Licenses for photogrammetry software capable of handling large datasets and generating accurate 3D models.	
11.	Detonation Surveillance Sensors	Specialized sensors are required to monitor detonation activities and ensure safe blasting operations in underground mines. These sensors should be capable of detecting and recording parameters such as vibration, pressure, sound, and gas emissions during detonations. Examples include: <ul style="list-style-type: none"> <li>Seismic sensors: Detect ground vibrations caused by detonations and assess their impact on surrounding structures.</li> <li>Acoustic sensors: Capture sound waves generated by blasts and analyze their frequency and intensity.</li> <li>Gas sensors: Monitor gas emissions such as methane, carbon monoxide, and nitrogen dioxide to ensure safe working conditions after detonations</li> </ul>	
12.	Unmanned Aerial Vehicle	Specifications: Long flight endurance, stable flight characteristics, payload capacity to carry sensors. Quantity: 1 UAV (either fixed-wing or rotary-wing), depending on the size and complexity of the project site.	
13	Equipment for Field Surveying	Specifications: Total station, GNSS receivers, or other surveying equipment for ground truthing and validation. Quantity: Optional, depending on the need for ground-based validation of DTM data.	
14	Global Navigation Satellite System	Specifications: High accuracy positioning, real-time kinematic (RTK) capability for ground control and georeferencing. Quantity: 1 or more units for accurate georeferencing of LiDAR data and aerial imagery.	
15	High-resolution Digital Cameras	Specifications: High-resolution imaging, preferably with infrared capability for night vision. Quantity: 1 or more units strategically placed for comprehensive coverage.	
16	LiDAR Scanner	Specifications: High-speed scanning capability, long-range detection, high accuracy. Quantity: 1 unit per scanning location or depending on the size of the mine site.	
17	Maintenance Tools and Spare Parts	To ensure the drones remain operational, a supply of maintenance tools and spare parts for repairing any damage or wear and tear that may occur during inspections.	
18	RTK Base Station (Optional)	Specifications: Provides real-time corrections to the GNSS data for centimeter-level accuracy. Quantity: 1 RTK base station if RTK corrections are required for improved positional accuracy.	
19	Sensors	Various sensors are required to collect data during the inspection process. The choice of sensors depends on the specific requirements	

S. No.	Name of Equipment, Tools and Software	Broad Specifications /Features	Relevant Experiment/ Practical Number
		<p>of the mine and the data needed. Some common types of sensors include:</p> <ul style="list-style-type: none"> <li>• Lidar sensors: For creating 3D maps of the mine shafts and identifying structural issues.</li> <li>• Thermal cameras: For detecting hotspots, such as overheating equipment or potential fire hazards.</li> <li>• Gas sensors: For detecting the presence of harmful gases, such as methane or carbon monoxide.</li> <li>• Multi-spectral or hyperspectral cameras: For identifying mineral deposits or analyzing vegetation health.</li> <li>• RGB cameras: For capturing high-resolution images and videos for visual inspection.</li> </ul>	
20	Weather Sensors	<p>Specifications: Various sensors for measuring temperature, humidity, pressure, wind speed and direction, precipitation, visibility, and other atmospheric parameters.</p> <p>Quantity: Multiple sensors integrated into the aircraft, including anemometers, barometers, thermometers, hygrometers, and precipitation gauges.</p>	
21	Safety Equipment	<p>Due to hazardous nature of mine environments, safety equipment is paramount. This could include Personal Protective Equipment (PPE) for operators, emergency response kits, and safety barriers or warning signs for restricting access to active work areas. This includes personal protective equipment (PPE) for operators, emergency response kits, and safety barriers to restrict access to blast zones.</p> <ul style="list-style-type: none"> <li>• Specifications: Safety equipment including life jackets, survival kits, emergency beacons, and first aid supplies.</li> <li>• Quantity: Adequate safety equipment for all personnel involved in flight operations.</li> <li>• Specifications: Personal protective equipment (PPE) for personnel involved in field data collection or processing activities.</li> <li>• Quantity: Adequate PPE for all personnel working in potentially hazardous environments.</li> </ul>	
22	Miscellaneous items:	<ul style="list-style-type: none"> <li>• Drone Frame : Tricopter/Quadcopter/Hexacopter</li> <li>• Propellers: 10X4.5 CW/Others</li> <li>• Speed Sensor: 3.3 or 5.0Vdc</li> <li>• Distance Sensor: 5Voltoperatingvoltage</li> <li>• Gyrosensor and Accelerometer: 5Volt operating voltage</li> <li>• Barometer: Altitude tracking, temp range from 25°C to 40°C</li> <li>• TOF Sensor: Accurate ranging up to 4m, Fast ranging frequencyupto50</li> <li>• Battery: LithiumPolymerBattery,2200mAH/others</li> <li>• Motor : BLDC,1000kvor1000RPM/volt</li> <li>• Electronic speed Controller (ESC) : 30Amp,2-4sor cell</li> <li>• Flight Controller Unit : KK2.1.5/ArdupilotAPM2.8/Pixhawk/others</li> <li>• Transmitter and Receiver for radio signal : 4channels/6Channels,2.4GHz&amp;5.8GHz</li> <li>• Drone Simulator Software: RC flight simulator</li> <li>• Python Software: Hardwarerequired-Morethan4GBRAM,64-bitCPUpreferable</li> </ul>	

**Note:** The above list is suggestive, as all items related to drones can be purchased strictly as per the latest rules and guidelines laid down by the concerned government agencies with the latest items depending on the requirement of the course.

## R) Suggested Learning Resources:

### (a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Getting Started with Drones: Build and Customize Your Own Quadcopter	Terry Kilby & Belinda Kilby	Shroff/MakerMedia, First edition 2016, ISBN-978-9352133147
2.	DIY Drone and Quadcopter Projects: A Collection of Drone-Based Essays, Tutorials, and Projects	Editors- Shroff	Maker Media; First edition 2016, ISBN-978-9352133994
3.	The Complete Guide to Drones	Adam Juniper	Ilex Press, Extended 2nd Edition, 2018 ISBN-9781781575383
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.	Principles of Mine Planning, Design, and Scheduling	Jayanta Bhattacharya:	CRC Press, ISBN-13-979-8184242163, 1st edition 2003
6.	Introduction to Mineralogy and Petrology	Swapan Kumar Haldar	Elsevier, ISBN: 9780128205853 and eBook ISBN: 9780323851367
7.	Unmanned Aerial Vehicles: Embedded Control	Anwar Kh. Abdulghafor and Abdulmotaleb El Saddik:	Wiley-ISTE, ISBN: 978-1-848-21127-8, May 2010
8.	Remote Sensing and GIS	Basudeb Bhatta:	Oxford University Press, ISBN: 9780199496648, Edition 2021

**(b) Online Educational Resources:**

1. <https://nptel.ac.in/courses/101104073>
2. [https://en.wikipedia.org/wiki/Unmanned\\_aerial\\_vehicle](https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle)
3. <https://www.scienceabc.com/innovation/what-is-drone-technology.html>
4. <https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or-how-does-drone-technology-work/>
5. <https://www.youtube.com/watch?v=OWaXIK9sHeE>
6. [https://books.google.co.in/books?id=2M0hEAAAQBAJ&printsec=copyright&redir\\_esc=y#v=onepage&q&f=false](https://books.google.co.in/books?id=2M0hEAAAQBAJ&printsec=copyright&redir_esc=y#v=onepage&q&f=false)

**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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals
5. Industry Webinars and talks
6. Open Access Research Papers & Reports

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- A) **Course Code** : 2400110(T2400110)
- B) **Course Title** : Community/ Society Development  
(AIML, AE, CSE, ELX (R), CHE, EE, ME, ME (Auto), MIE, FTS, CACDDM, FPP)
- C) **Pre- requisite Course(s)** :
- D) **Rationale** :

Community development is a process in which community members collectively generate solutions to common problems/concerns for improvement in the quality of life of the people. The course in community and society development is essential so that students can be prepared for taking up activities for the welfare and social well-being of the community and society around them. This course has been designed to develop requisite competencies and skills in students so that they can address social problems, develop sustainable solutions that are tailored to local needs and resources, engage with local communities and civil society organizations to promote people's participation in decision-making and accountability, and apply them to community development.

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

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

- CO-1** Identify the issues and problems faced by local communities/societies that can be addressed through community development schemes for sustainable development.
- CO-2** Prepare an action plan for an identified issue under community development scheme for a selected area.

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

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	2	1	1	3	2	2		
CO-2	3	2	1	1	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)		Notional Hours (TW/ Activities+ SL)	Total Hours (CI+TW/ Activities)	Total Credits (C)
		L	T			
2400110	Community/ Society 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.

## S) 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)	
2400110	Community/ Society 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.

H) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (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.

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

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

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

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

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

**b. Micro Projects:**

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

**c. Other Activities:**

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

2. Visits: Visit to nearby village may be arranged and students may be asked to prepare list of development activities in different Discipline.
3. Self-Learning Topics:
  - Community Development programmes in India after independence.
  - Schemes of GOI for Community /society Development.

**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, 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.

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

**M) Suggested Learning Resources:**

**(a) Books and Reports:**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Module on Rural Development: Indian Context	IGNOU, New Delhi	Published by IGNOU, New Delhi
2.	Module on Rural Development Programmes	IGNOU, New Delhi	Published by IGNOU, New Delhi
3.	Module on Rural development planning and management	IGNOU, New Delhi	Published by IGNOU, New Delhi
4.	India's Developing Villages	G R Madan	Allied Publishers, 1990
5.	Five year plans, Plan Documents, Policy and Reports	Planning Commission of India publications	Planning Commission of India
6.	Scheme of Community Development through Polytechnics	Ministry of Human Resource Development, Shastri Bhavan ,New Delhi	Ministry of Human Resource Development, Govt of India, New Delhi

**(b) Online Educational Resources:**

1. [https://www.google.co.in/books/edition/Rural\\_Development/hABduOX-X-gC?hl=en&gbpv=1&dq=rural+development+latest+books&printsec=frontcover](https://www.google.co.in/books/edition/Rural_Development/hABduOX-X-gC?hl=en&gbpv=1&dq=rural+development+latest+books&printsec=frontcover)
2. <https://www.india.gov.in/my-government/documents/plan-document>
3. <https://www.india.gov.in/website-planning-commission>

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

**(c) Others:**

1. Project Reports Available in the office of CEO, Zila Parishad of the District.
2. Schemes of various departments of Bihar Government for Community/Social Development

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