

Curriculum of Diploma Programme

in

Agricultural Engineering



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

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

Semester – VI

Teaching & Learning Scheme

Course Codes	Category of course	CourseTitles	Teaching & Learning Scheme (Hours/Week)					Total Credits (C)
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	
			L	T				
2411601	PCC	Agribusiness Management	02	01	-	02	05	04
2411602	PCC	Post-Harvest and Food Packaging Technology	03	-	04	02	09	06
2411603	PEC	Programme Electives* -Any one	03	-	04	02	09	06
2400604	OEC	Open Electives**/ COE (Advanced -Any One)	03	-	04	02	09	06
2411605	PSI	Major Project (Common for All Programmes)	-	-	08	04	12	06
2400408	NRC	Employability skills Development (Common for All Programmes)	01	-	-	-	01	01
2400009	NRC	Open Educational Resources	01	-	-	-	01	01
Total			13	1	20	12	46	30

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

Legend:

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

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

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

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

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

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

*: Organic farming and sustainable Agriculture/ Precision Agriculture and system management/ Watershed planning and management

** : 3D Printing and Design / Artificial Intelligence/ Drone Technology/ Electric Vehicle/ Industrial Automation / Internet of Things (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)	
2411601	PCC	Agribusiness Management	30	70	20	30	-	-	150
2411602	PCC	Post-Harvest and Food Packaging Technology	30	70	20	30	20	30	200
2411603	PEC	Programme Electives* -Any one	30	70	20	30	20	30	200
2400604	OEC	Open Electives**/ COE (Advanced -Any One)	30	70	20	30	20	30	200
2411605	PSI	Major Project (Common for All Programmes)	-	-	20	30	50	100	200
2400408	NRC	Employability skills Development (Common for All Programmes)	25	-	-	-	-	-	25
2400009	NRC	Open Educational Resources	25	-	-	-	-	-	25
Total			145	280	125	150	110	190	1000

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

Legend:

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

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

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

*: Organic farming and sustainable Agriculture/ Precision Agriculture and system management/ Watershed planning and management

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

Note: ETA & ELA are to be carried out at the end of the term/ semester.

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

- A) **Course Code** : 2411601(T2411601/S2411601)
 B) **Course Title** : Agri-Business Management
 C) **Pre- requisite Course(s)** :
 D) **Rationale** :

Today there is drastic change in the meaning of agriculture. It has more complex and evolved in to agribusiness and has become a vast and complex system that reaches far beyond the farm to include all those who are involved in bringing food and fiber to consumers. Agribusiness include not only those that farm the land but also the people and firms that provide the inputs, process the output, manufacture the food products and transport and sell the food products to consumers. Therefore, it is directly related to industry, commerce and trade, Industry is concerned with the production of commodities and materials while commerce and trade are concerned with their distribution. Agriculture Business Management course is designed to give students the knowledge and skills they need to work in the agricultural industry.

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

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

- CO-1 Use agricultural policies, control and regulations.
 CO-2 Apply management functions for efficient and effective functioning of agribusiness.
 CO-3 Develop marketing plan for an existing or new agricultural product or service
 CO-4 Use financial statements and accounting information to take effective decision.
 CO-5 Use agricultural and animal laws for effective management of agri-businesses for sustainability
 CO-6 Develop Project proposal, organize and manage agribusiness projects efficiently Effectively

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

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2411601	Agri-business Management	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)

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H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
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		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2411601	Agribusiness Management	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)

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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: T2411601**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Identify different sectors involved in the given agribusiness</p> <p><i>TSO 1b.</i> Compare the govt polices related to farm supplies, farm production, agro processing, agricultural marketing, agricultural finance in agri-business.</p> <p><i>TSO 1c.</i> Explain different types of agro based industries.</p> <p><i>TSO 1d.</i> Identify different types of Govt. financial supports for different agro based industries.</p> <p><i>TSO 1e.</i> Identify the linkages among subsectors for the given agribusiness</p>	<p>Unit-1.0 Introduction to agri-business management</p> <p>1.1 Objectives and role agribusiness management, economic challenges</p> <p>1.2 Components of agribusiness sector</p> <p>1.3 Classification of agro-based industries, types of agro-based industries</p> <p>1.4 Linkages among sub-sectors of the Agribusiness sector</p> <p>1.5 Agribusiness Decision making process, Input – output decisions</p> <p>1.6 Governments policy related to farm supplies, farm production, agro processing, agricultural marketing, agricultural finance in agri-business.</p> <p>1.7 Government intervention in financial support for agri-business.</p> <p>1.8 Policy controls and regulations in agro-industries</p> <p>1.9 Impact of liberalization, privatization and globalization on Agri business sector,</p> <p>1.10New dimensions in Agri business environment and policy</p>	<p>CO1</p>
<p><i>TSO 2a.</i> Explain different types of planning</p> <p><i>TSO 2b.</i> Prepare implementation plan for the given situation</p> <p><i>TSO 2c.</i> Apply motivation techniques to motivate the staff</p> <p><i>TSO 2d.</i> Apply directing and control techniques effectively smooth functioning of agribusiness activities.</p> <p><i>TSO 2e.</i> Perform SWOT and PEST analysis</p> <p><i>TSO 2f.</i> Describe the roles and functions of different financial institutions</p>	<p>Unit-2.0 Management functions in Agri-business</p> <p>2.1 Planning and its role, types of planning</p> <p>2.2 Different steps involved in planning.</p> <p>2.3 Preparation of plan.</p> <p>2.4 Importance of organization, types of organization and role of directing in agri-business.</p> <p>2.5 Models of motivation and its importance.</p> <p>2.6 Controlling and its role.</p> <p>2.7 SWOT and PEST analysis.</p> <p>2.8 Functions of financial institutions- NABARD, NCDC, NDDB, NCUI, APEDA, ICAR, NAFED, FCI, CWC, NHM, CFTRI, EPO</p>	<p>CO2</p>
<p><i>TSO 3a.</i> Identify and define the given market.</p> <p><i>TSO 3b.</i> Perform competitive marketing analysis</p> <p><i>TSO 3c.</i> Analyze market opportunities</p> <p><i>TSO 3d.</i> perform a three-year financial evaluation of the action plan</p> <p><i>TSO 3e.</i> Develop marketing plan for the given agricultural situation</p> <p><i>TSO 3f.</i> Assess financial viability</p>	<p>Unit-3.0 Retail Agribusiness Sales</p> <p>3.1 Concepts and principles of Marketing</p> <p>3.2 Components of market and its functions.</p> <p>3.3 Market segmentation, Four P's of Marketing Mix and consumer behavior analysis.</p> <p>3.4 Analytical tools in developing a marketing plan for an existing or new agricultural product or service.</p>	<p>CO3</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	3.5 Selling Environments 3.6 Relationship Building, Customer Satisfaction 3.7 Pre-Sale, Sales Presentation 3.8 Retail Promotional Tools & Advertising 3.9 Customer Transactions 3.10 Retail Operations	
<i>TSO.4a</i> Prepare agricultural financial statements <i>TSO.4b</i> Analyze the given agricultural financial statements <i>TSO.4c</i> Prepare agricultural budgets <i>TSO.4d</i> Analyze the given accounting information for fraud and internal control <i>TSO.4e</i> Create external financial reporting document	Unit -4.0 Financial Management 4.1 Principles and concepts of preparing agricultural financial statements. 4.2 Analysis of agricultural financial statements 4.3 Analysis of financial statement elements: assets, liabilities, stockholders' equity, revenues, and expenses 4.4 Management of agricultural enterprises. 4.5 Introduction to financial and managerial accounting, financial accounting cycle 4.6 Use of accounting information for fraud, and internal controls. 4.7 Leasing, purchasing, borrowing, and lending decisions in agriculture. 4.8 Agricultural budget, risk management and mitigation, and loan structuring, Insurance needs in agribusiness	CO4
<i>TSO 5a.</i> Identify legal problems in the given situation <i>TSO 5b.</i> Explain different types of contracts <i>TSO 5c.</i> Prepare contract for the given situation <i>TSO 5d.</i> Analyze the given contract <i>TSO 5e.</i> Explain the laws governing for buying agricultural land in the given state. <i>TSO 5f.</i> Follow basic animal laws while using animals for agricultural purpose.	Unit-5.0 Agricultural Law 5.1 Legal problems of farm and agribusiness management. 5.2 Principles of contracts, negligence, debt instruments and commercial transactions of the farm and agribusiness organization. 5.3 State and federal laws regulating the farm and agribusiness sector 5.4 Buying agricultural land 5.5 Basic animal laws including state and federal regulation of agricultural sector.	CO5
<i>TSO 6a.</i> Explain different types of agricultural projects. <i>TSO 6b.</i> Describe the phases of project cycles. <i>TSO 6c.</i> Measure the feasibility of the given project <i>TSO 6d.</i> Prepare project report <i>TSO 6e.</i> Create a roadmap for agricultural enterprise	Unit-6.0 Agri-business Projects 6.1 Concept, characteristics of projects, types of projects agricultural projects. 6.2 project identification, Phases in project cycle of Agri-business 6.3 Measures to check feasibility of project- market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis. 6.4 Project evaluation techniques-discounted/non-discounted cash flows; Net present values, profitability index, Internal rate of returns; Cost benefits ratio; Accounting rate of return, Payback period 6.5 Project implementation; Cost overrun, Project control and information system. 6.6 Preparation of project report	CO6

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	6.7 Sample projects on Water resource development projects, Agricultural development projects, watershed development projects, biogas plant projects etc.	

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: S2411601** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

1. Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
 - i. Prepare a case study on agro-based industries
 - ii. Different feasibility test for agricultural projects- Balance sheet- different test ratios
 - iii. Analyze the given profit –loss statement in project evaluation, different test ratios
 - iv. Appraisal of given Irrigation project
 - v. Analysis of expenditure and returns from particular project
 - vi. Prepare a report on different scheme and credit facilities available for agribusiness
 - vii. Preparation of report on export and import market

b. Micro Projects:

- i. Preparation of loan proposal for agri-development projects.
- ii. Preparation of project design for new agricultural projects.
- iii. Collect information on marketing of agricultural commodities through online platform
- iv. Visit to 02 agro-based industry and collect information on Year of establishment, Seed, Machinery, Irrigation Set, Fertilizer Cost, Payback period Benefits and returns
- v. Visit to different financing institutions (at least 04) like DCCB, PACS and Commercial banks and prepare a report based on given criteria.

c. Other Activities:

1. Seminar Topics:
 - Study of NABARD and its role in agricultural development.
 - Concepts of market segmentation and its examples.
 - Meaning and concepts of agri-business management.
 - Important functions involved in business management.
2. Visits:
 - Visit nearby input market. Prepare report on same.
 - Visit to product market and prepare report on this.
 - Visit to Financial institution.
3. Self-Learning Topics:
 - Concepts of organization
 - Motivation and its model
 - Planning and its steps

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	10%	15%	-	-	-	-
CO-2	10%	15%	10%	20%	20%	-	-
CO-3	15%	20%	15%	20%	20%	-	-
CO-4	20%	20%	20%	20%	20%	-	-
CO-5	20%	20%	20%	20%	20%	-	-
CO-6	20%	15%	20%	20%	20%	-	-
Total Marks	30	70	20	20	10	-	-
			50				

Legend:

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

** : Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to agri-business management	8	CO1	10	3	3	4
Unit 2.0 Management functions in Agri-business	8	CO2	12	3	4	5
Unit-3.0 Retail Agribusiness sales	8	CO3	12	3	4	5
Unit-4.0 Financial Management	8	CO4	12	3	4	5
Unit-5.0 Agricultural Law	8	CO5	12	4	3	5
Unit-6.0 Agri-business projects	8	CO6	12	4	3	5
Total	48	-	70	20	21	29

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

O) Suggested Assessment Table for Laboratory (Practical): (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.	A Concept of Agribusiness	John H Davis Ray a Goldberg	Martino Fine Books, 2021 ISBN-13 : 978-1684225248
2.	Agribusiness Management	Shivaji Nagpure R.G. Deshmukh	AGROMET Publishers, Nagpur.
3.	Agricultural Finance & Management,	S. Subha Reddy, P. Raghu Ram	Oxford IBH Publishing Co. Pvt. Ltd., New Delhi, 2018, ISBN-13 : 978-8120410220
4.	Agri Business Management	J.S. Amarnath A.P.V. Samvel	Satish Serial Publishing House, 2020, New Delhi, ISBN 13: 9788189304478
5.	Indian Agriculture & Agri-Business Management	Dr. Smita Diwase	KRISHI Resource Management Network, Third Edition, 2017, ISBN-13 : 978- 8190938426

(b) Online Educational Resources:

- 1) <https://www.idp.com/india/subject/farm-and-agribusiness/#:~:text=Agribusiness%20management>
- 2) <https://zalamsyah.files.wordpress.com/2018/02/6-agribusiness-management.pdf>
- 3) https://agri-bm.kkwagh.edu.in/uploads/department_course/ABM_111
- 4) https://www.youtube.com/watch?v=0eGQ6h4MkM8&list=PL_YXsNANo2M5cx56ONWGVyNC4jdleLhfz
- 5) <https://www.youtube.com/watch?v=gPXlgGmXOIY>
- 6) http://eprints.cmfri.org.in/9670/1/Project_appraisal_techniques.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. Handbook on agri-business management.
2. Lab Manuals

- A) **Course Code** : 2411602(T2411602/P2411602/S2411602)
 B) **Course Title** : Post-Harvest and Food Packaging Technology
 C) **Pre- requisite Course(s)** :
 D) **Rationale** :

Post-harvest technology plays a vital role in agriculture. It involves tasks like cleaning, grading, sorting, drying, storing, and milling to enhance the quality and availability of grains. Different drying methods such as solar drying, deep bed dryers, flat bed dryers, and continuous flow dryers are used. It's also crucial to learn about preventing losses during storage and proper packaging of fruits and vegetables. Students will study these aspects and apply their knowledge in farms and industries

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

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

CO-1. Use relevant post-harvest handling process

CO-2. Use relevant measures to reduce the infection, losses and deterioration during storage.

CO-3. Apply relevant measures to increase the post-harvest storage life and quality of fruits, vegetables and crops.

CO-4. Use relevant harvesting and handling techniques to minimize post-harvest losses.

CO-5. Use process and packaging techniques for packaging of fresh fruits and vegetables as well as processed horticulture produce.

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

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	2	-	2	3	-	1		
CO-2	3	2	-	2	3	-	1		
CO-3	3	2	-	2	2	-	1		
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Legend: High (3), Medium (2), Low (1) and No mapping (-)

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Legend:

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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:

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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: T2411602**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain principles and methods of food preservation for the given sample</p> <p><i>TSO 1b.</i> Explain post-harvest handling process for the given perishable items</p> <p><i>TSO 1c.</i> Explain the process of ripening and senescence for the given horticultural crops</p> <p><i>TSO 1d.</i> Apply post-harvest treatment for quality retention of horticultural crops</p> <p><i>TSO 1e.</i> Differentiate primary and secondary post-harvest operation</p> <p><i>TSO 1f.</i> Process the given sample of fruits and vegetables.</p>	<p>Unit I.0- Introduction to Post-Harvest Technology</p> <p>1.1 Introduction, History and role of post-harvest technology</p> <p>1.2 Principles and methods of food preservation.</p> <p>1.3 Post-harvest handling-harvesting, precooling, sorting, grading and packaging of perishables (fruits, vegetables, cereals and pulses)</p> <p>1.4 Food storage systems; ripening and senescence of horticultural crops</p> <p>1.5 Post-harvest treatment for quality retention of horticultural crops; spoilage of fruits & vegetables, methods to reduce decay.</p> <p>1.6 Processing of fruit and vegetables -canning, dehydration, freezing and value-added products</p> <p>1.7 Post-harvest operations- Primary Processing Operation and Secondary Operation</p> <p>1.8 Post -harvest operations like Harvesting, Handling cleaning, grading, sorting, drying, storage, milling, size reduction, expelling, extraction, blending, heat treatment, separation, material handling (transportation, conveying, elevating) and washing</p>	<p>CO1</p>
<p><i>TSO 3a.</i> Explain the principles and process o of drying.</p> <p><i>TSO 3b.</i> Describe different types of drying systems</p> <p><i>TSO 3c.</i> Describe principles and operation of different types of dryers</p> <p><i>TSO 3d.</i> Select relevant dryers for the given requirement</p> <p><i>TSO 3e.</i> Explain the effect of different factors like temperature, moisture changes, influence of moisture content, relative humidity, fungi on the physical properties of the given product</p> <p><i>TSO 3f.</i> Explain effect of fungi, insect and organism on stored grain</p> <p><i>TSO 3g.</i> Select relevant storage structure for the given grains.</p> <p><i>TSO 3h.</i> Describe the principle and operation of the given material conveying systems.</p>	<p>Unit-2.0 Drying and storing of Cereals and Pulses</p> <p>2.1 Importance of drying, principles of drying and factors affecting drying, Moisture content representation, equilibrium moisture content</p> <p>2.2 Drying Characteristics, types of grain drying systems - solar drying system, batch drying system, continuous flow drying system. Precautions during drying.</p> <p>2.3 Principles and operation of different types of dryers- deep bed dryers, flat bed dryers, continuous flow dryers, L.S.V dryers, spray dryer, fluidized bed dryers, rotary dryer, spouted beds, freeze dryer, tray and tunnel dryers</p> <p>2.4 Need and importance of storing, general principles of storage. Temperature and moisture changes during storage, influence of</p>	<p>CO2</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	moisture content, relative humidity, temperature, fungi etc. on stored product. 2.5 Fungi, insect and other organism / Infections associated with stored grains. 2.6 Types of storage structures- Deep and shallow bins, Traditional and modern storage structures. 2.7 Management of storage structures. Losses during storage and their control, space requirement of bag storage structure. 2.8 Types of material conveying Systems- Belt Conveyor, Bucket Elevator, Screw Conveyor, Pneumatic Conveyor	
<p><i>TSO 3a.</i> Describe the effect of different environmental factors on post-harvest life and quality.</p> <p><i>TSO 3b.</i> Apply measures to reduce the effect of ripening and spoilage on the given fruits, vegetables and crops</p> <p><i>TSO 3c.</i> Explain the effect of plant growth regulator on storage life and quality of the given fruits, vegetables and crops.</p> <p><i>TSO 3d.</i> Explain growth and developmental process of the given crops.</p>	<p>Unit 3.0 Pre-Harvest Physiological aspects related to Post Harvest</p> <p>3.1 Introduction, Growth and development - definition, parameters of growth and development.</p> <p>3.2 Role of environmental factors e.g. light, temperature, humidity etc. on physiological processes like photosynthesis and photoperiodism, vernalisation, respiration on post-harvest life and quality.</p> <p>3.3 Physiological changes associated with ripening and seed development and preharvest factors affecting ripening and spoilage.</p> <p>3.4 Influence of plant growth regulators as pre-harvest application on post-harvest storage life and quality.</p> <p>3.5 Growth and developmental processes during stress manipulation of developing crop.</p>	CO3
<p><i>TSO 4a.</i> Explain post-harvest treatment to increase shelf life</p> <p><i>TSO 4b.</i> Describe Physiology and biochemistry of given fruits.</p> <p><i>TSO 4c.</i> Describe different treatments used on fruits and vegetables prior to shipment</p> <p><i>TSO 4d.</i> Select storage conditions for the given fruits and vegetables to reduce physical injuries and disorders, irradiation of fresh produce.</p> <p><i>TSO 4e.</i> Select relevant storage practices for the given fruits and vegetables</p> <p><i>TSO 4f.</i> Select relevant food preservation techniques for the given fruits following food safety standards</p>	<p>Unit 4.0 Post Harvest Technology of Fruits and Vegetables</p> <p>4.1 Introduction, Maturity indices, harvesting practices for specific market requirements,</p> <p>4.2 Influence of pre-harvest practices on post-harvest quality.</p> <p>4.3 Physiology and biochemistry of fruit ripening, enzymatic and textural changes, respiration, and transpiration, ethylene evolution and ethylene management,</p> <p>4.4 Factors leading to post-harvest loss, pre-cooling. Treatments prior to shipment, viz., chlorination, waxing, chemicals, bio control agents and natural plant products.</p> <p>4.5 Storage conditions-temperature, humidity and atmospheric composition; Storage systems ambient temperature storage, ventilated, refrigerated and freezing, MAS, CA storage, physical injuries and disorders, irradiation of fresh produce.</p>	CO4

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	<p>4.6 Storage practices: Controlled atmospheric, Bead atmosphere, hypobaric storage, cool store, zero energy cool chamber, Short, and Long-term humidity-controlled storage chambers</p> <p>4.7 Principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies. Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, processing waste management, food safety standards</p>	
<p><i>TSO 5a.</i> Explain packaging and its types.</p> <p><i>TSO 5b.</i> Describe the different methods of packaging</p> <p><i>TSO 5c.</i> Select packaging material for the given situation.</p> <p><i>TSO 5d.</i> Differentiate modified and controlled atmospheric packaging</p> <p><i>TSO 5e.</i> Explain different export requirements and its control measures</p> <p><i>TSO 5f.</i> Evaluating the suitability and effectiveness of various packaging materials</p> <p><i>TSO 5g.</i> determine optimal choices for preserving freshness and extending shelf life of agricultural products</p> <p><i>TSO 5h.</i> Explain food regulation and standards.</p>	<p>Unit 5.0 Packaging Technology</p> <p>5.1 Introduction to Packaging of fruits and vegetables</p> <p>5.2 Role of packaging in extending shelf life of foods.</p> <p>5.3 Types of Packaging and packaging materials and their characteristics</p> <p>5.4 Concept of modified atmosphere packaging and controlled atmospheric packaging</p> <p>5.5 Need of food packaging,</p> <p>5.6 Packing methods and transport. Export requirements, quarantine requirements, quality management, insect and pest infestation and control measure. Pesticides and fungicide residues.</p> <p>5.7 Maintain the required food regulation and standards such as APEDA, AGMARK, Global GAP</p> <p>5.8 Maintain food safety standards such as HACCP</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: P2411602

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Measure the quality parameters of the given agricultural material	1.	Measure the length, width, and thickness of individual grains or seeds using calipers or digital imaging software.	CO1
	2.	Determine the porosity of the given rice sample	CO1
	3.	Determine the angle of repose and coefficient of friction of the given sample	CO1
	4.	Perform handling operations such as sorting, grading, and packaging for the given size and shape of the grains and see the influence of properties in processing and handling operations	CO1
<i>LSO 1.2.</i> Determine the maturity indices of the fruits and vegetables	5.	Determine the maturity indices of the fruits and vegetables by different methods – visual, chemical, computational and physical.	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.3.</i> Perform chemical analysis of given sample	6.	Perform chemical analysis of fruits and vegetables at different stages of maturity and ripening.	CO1
<i>LSO 1.4.</i> Use refractometer or spectrophotometer	7.	Measure the TSS using a refractometer or spectrophotometer, which quantifies the concentration of soluble sugars.	CO1
<i>LSO 1.5.</i> Compare the TSS values between different stages of ripeness or storage conditions to track changes	8.	Compare the TSS values between different stages of ripeness or storage conditions to track changes in sweetness, flavor, and nutritional quality for the given sample of fruits and vegetables	CO1
<i>LSO 2.1.</i> Determine of moisture content of grains by direct and indirect methods.	9.	Use moisture meters to measure the moisture content of given sample of grains	CO2
	10.	Use oven drying to dry the given sample	CO2
	11.	Use solar drying system to dry the given sample	CO2
	12.	Calculate moisture content as a percentage of the wet weight or dry weight of the sample.	CO2
	13.	Evaluate moisture content data to assess the quality, storability, and susceptibility to spoilage of agricultural materials.	CO2
	14.	Implement proper drying and storage practices based on moisture content levels to prevent mold growth, insect infestation, and deterioration for the given sample	CO2
	15.	Determine the drying constant for the given grain	CO2
<i>LSO 2.2.</i> Performance and suitability of different types of dryers for drying agricultural products.	16.	Determine the performance of different types of dryers	CO2
<i>LSO 2.3.</i> Evaluate different domestic grain storage structures to identify the most effective option for preserving grains and ensuring food security in households.	17.	Identify and evaluate different types of domestic grain storage structures for the given different samples of grains.	CO2
<i>LSO 2.4.</i> Use material conveying equipment to optimize transportation efficiency	18.	Operate different material conveying equipment's	CO2
	19.	Determine the conveyance efficiency of bucket elevator and screw conveyor	CO2
<i>LSO 3.1.</i> Use plant growth regulator	20.	Control the sprouting of onion and potato by using plant growth regulator.	CO3
<i>LSO 3.2.</i> Determine the effect of precooling	21.	Compare the effect of precooling on shelf life and quality of fresh fruits and vegetables for the given sample.	CO3
<i>LSO 3.3.</i> Measure psychometric variables	22.	Measure psychometric variables for perishable commodities	CO3
<i>LSO 3.4.</i> Detect various microbes and microorganism	23.	Determine various microbes and microorganism causing spoilage of raw materials and finished product.	CO3
<i>LSO 3.5.</i> Use spectro-photometric	24.	Identify and quantify of pesticide residue using Spectro -photometric techniques	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 4.1.</i> Apply harvesting and handling techniques to reduce post-harvest losses and maintain the quality of fruits and vegetables.	25.	Determine Harvest indices of fruits	CO4
	26.	Determine Morphology, structure and composition of fruit and vegetable	CO4
	27.	Determine Physical qualities of fruits and vegetables	CO4
	28.	Determine textural characteristics, and chemical composition	CO4
	29.	Determine maturity indices of selected fruits and vegetables	CO4
<i>LSO 4.2.</i> Use cooling equipment	30.	Perform precooling of given fruits using given cooling method.	CO4
<i>LSO 4.3.</i> Determine quality of the fruits and vegetables	31.	Sort and grade the given fruits and vegetables using sorting and grading equipment's	CO4
<i>LSO 4.4.</i> Preserve fruits and vegetables	32.	Perform pre-treatments chemicals, wax coating, prepackaging and irradiation on the given samples of fruits and vegetables	CO4
	33.	Determine spoilage causing organisms in the given sample	CO4
	34.	Apply protective skin coating with wax emulsion for pre and post harvesting treatment	CO4
	35.	Determine the effect of enzymes on the blanching of vegetables	CO4
	36.	Chemical analysis for nutritive value of fresh and processed fruits and vegetables.	CO4
<i>LSO 5.1.</i> Determine optimal choices for preserving freshness and extending shelf life of agricultural products.	37.	Identify various packaging materials and their characteristics	CO5
	38.	Measure thickness of paper and paper boards used for packaging using a micrometer or caliper, screw gauge	CO5
	39.	Evaluate the suitability and effectiveness of various packaging materials for their transport worthiness	CO5
	40.	Determine ventilation requirement in packing materials for different fruits and vegetables	CO5
	41.	Determine water vapour transmission rate (WVTR) and Gas transmission rate (GTR) of packaging material	CO5
	42.	Determine the optimum storage conditions of given product	CO5
<i>LSO 5.2.</i> Maintain the required food regulation and food safety standards.	43.	Identify basic taste, odour, texture and color of the given sample.	CO5
	44.	Perform physico-chemical analysis of fresh material and finished product.	CO5

L) **Suggested Term Work and Self Learning: S2411602** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

- i. Explore recent advancements, trends, and challenges in the field post-harvest
- ii. Collect information about new technologies available in food packaging.
- iii. Prepare a case study of a specific agricultural product (e.g., fruits, vegetables, grains) and analyze the post-harvest handling and food packaging techniques employed.
- iv. Explain the function and working of equipment, tools and materials for cleaning, grading, sorting, and packaging fruits and vegetables effectively.
- v. Explain modern packing methods for fruit juices

b. Micro Projects:

- i. Visit to warehouses, Pack houses and cold-storage and prepare a detailed report on the logistics and storage practices in warehouses, packhouses, and cold-storage facilities to understand efficient post-harvest handling and preservation techniques for agricultural produce.
- ii. Organize training sessions and workshops for farmers on best practices in post-harvest handling, including cleaning, grading, sorting, and packaging.
- iii. Devise strategies for post-harvest disease control for the given situation
- iv. Evaluate the impact of the project by assessing changes in post-harvest losses, product quality, marketability, and farmer income.
- v. Organize field days or farmer exchange visits to share experiences and lessons learned from implementing improved post-harvest handling practices.
- vi. Visit nearby food packaging unit (make report regarding different type packaging available in that unit)

c. Other Activities:

1. Seminar Topics:

- Enhancing Post-Harvest Management Practices for Fresh Fruits and Vegetables.
- Locally available storage structure

2. Visits:

- Report on industry visit showcasing various unit operations: cleaning, grading, sorting, drying, and dehydration. Machinery observed includes different cleaner, grader, sorter, dryer, conveyor belt systems, for enhancing efficiency and product quality in food processing.
- Organize a field visit to a local farm, warehouse, or food processing facility to observe firsthand the post-harvest handling and food packaging practices in action.

3. Self-Learning Topics:

- Types of drying methods i.e. sun drying & artificial drying by mechanical means.
- Different properties of packaging materials.

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%	20%	20%
CO-2	20%	15%	20%	20%	20%	20%	20%
CO-3	20%	20%	20%	20%	20%	20%	20%
CO-4	20%	25%	20%	20%	20%	20%	20%
CO-5	25%	25%	20%	20%	20%	20%	20%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

** : Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to post-harvest technology	10	CO1	11	4	3	4
Unit-2.0 Drying and storing of Cereals and Pulses	8	CO2	11	3	3	5
Unit-3.0 Pre-harvest physiological aspects related to post harvest	8	CO3	15	4	5	6
Unit-4.0 Post harvest technology of fruits and vegetables	11	CO4	18	5	6	7
Unit-5.0 Packaging Technology	11	CO5	15	4	5	6
Total	48	-	70	20	22	28

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Measure the length, width, and thickness of individual grains or seeds using calipers or digital imaging software.	CO1	40	50	10
2.	Determine the porosity of the given rice sample	CO1	40	50	10
3.	Determine the angle of repose and coefficient of friction of the given sample	CO1	40	50	10
4.	Perform handling operations such as sorting, grading, and packaging for the given size and shape of the grains and see the influence of properties in processing and handling operations	CO1	40	50	10
5.	Determine the maturity indices of the fruits and vegetables by different methods – visual, chemical, computational and physical.	CO1	40	50	10
6.	Perform chemical analysis of fruits and vegetables at different stages of maturity and ripening.	CO1	40	50	10
7.	Measure the TSS using a refractometer or spectrophotometer, which quantifies the concentration of soluble sugars.	CO1	40	50	10
8.	Compare the TSS values between different stages of ripeness or storage conditions to track changes in sweetness, flavor, and nutritional quality for the given sample of fruits and vegetables	CO1	40	50	10
9.	Use moisture meters to measure the moisture content of given sample of grains	CO2	40	50	10
10.	Use oven drying to dry the given sample	CO2	40	50	10
11.	Use solar drying system to dry the given sample	CO2	40	50	10
12.	Calculate moisture content as a percentage of the wet weight or dry weight of the sample.	CO2	40	50	10
13.	Evaluate moisture content data to assess the quality, storability, and susceptibility to spoilage of agricultural materials.	CO2	40	50	10
14.	Implement proper drying and storage practices based on moisture content levels to prevent mold growth, insect infestation, and deterioration for the given sample	CO2	40	50	10
15.	Determine the drying constant for the given grain	CO2			
16.	Determine the performance of different types of dryers	CO2	40	50	10
17.	Identify and evaluate different types of domestic grain storage structures for the given different samples of grains.	CO2	40	50	10
18.	Operate different material conveying equipment's	CO2	40	50	10
19.	Determine the conveyance efficiency of bucket elevator and screw conveyor				
20.	Control the sprouting of onion and potato by using plant growth regulator.	CO3	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
21.	Compare the effect of precooling on shelf life and quality of fresh fruits and vegetables for the given sample.	CO3	40	50	10
22.	Measure psychometric variables for perishable commodities	CO3	40	50	10
23.	Determine various microbes and microorganism causing spoilage of raw materials and finished product.	CO3	40	50	10
24.	Identify and quantify of pesticide residue using Spectro - photometric techniques	CO3	40	50	10
25.	Determine Harvest indices of fruits	CO4	40	50	10
26.	Determine Morphology, structure and composition of fruit and vegetable	CO4	40	50	10
27.	Determine Physical qualities of fruits and vegetables	CO4	40	50	10
28.	Determine textural characteristics, and chemical composition	CO4	40	50	10
29.	Determine maturity indices of selected fruits and vegetables	CO4	40	50	10
30.	Perform precooling of given fruits using given cooling method.	CO4	40	50	10
31.	Sort and grade the given fruits and vegetables	CO4	40	50	10
32.	Perform pre-treatments chemicals, wax coating, prepackaging and irradiation on the given samples of fruits and vegetables	CO4	40	50	10
33.	Determine spoilage causing organisms in the given sample	CO4	40	50	10
34.	Apply protective skin coating with wax emulsion for pre and post harvesting treatment	CO4	40	50	10
35.	Determine the effect of enzymes on the blanching of vegetables	CO4	40	50	10
36.	Chemical analysis for nutritive value of fresh and processed fruits and vegetables.	CO4	40	50	10
37.	Identify various packaging materials and their characteristics	CO5	40	50	10
38.	Measure thickness of paper and paper boards used for packaging using a micrometer or caliper, screw gauge	CO5	40	50	10
39.	Evaluate the suitability and effectiveness of various packaging materials for their transport worthiness	CO5	40	50	10
40.	Determine ventilation requirement in packing materials for different fruits and vegetables	CO5	40	50	10
41.	Determine water vapour transmission rate (WVTR) and Gas transmission rate (GTR) of packaging material	CO5	40	50	10
42.	Determine the optimum storage conditions of given product	CO5	40	50	10
43.	Identify basic taste, odour, texture and color of the given sample.	CO5	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs	PLA/ELA		
			Performance		Viva- Voce (%)
			PRA* (%)	PDA** (%)	
44.	Perform physico-chemical analysis of fresh material and finished product.	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.	Grain porosity apparatus	Can determine the bulk volume, grain volume, pore volume and effective porosity of interconnected pores of a core sample	2
2.	Hot air oven	Temperature Range: 50-250°C, Capacity: 90L-100L Voltage:220-230 V	10-15
3.	Universal digital moisture meter	Range : 3.5 to 40%, Consistency : ± 0.2 % Principle of measurement : Resistance Temperature Compensation: Automatic with PT-100 temperature sensor. Error Conditions : Under Range, Over Range etc. Display : 2 x16 character alphanumeric LCD display.	10-15
4.	Vernier caliper, screw gauge, micrometer	Measure the length accurately up to 0.1 mm	10-15
5.	Digital imaging software	Digital imaging software	10-15
6.	Working model of Thin layer grain dryer setup	The air temperature range for the drying- 20 and 80 °C. range of RH- 5 and 80 %, air velocity- 0.3 and 2.0 m·s ⁻¹ .	10-15
7.	Working model of LSU dryer setup	LSU is a continuous flow mixing type of dryer. LSU dryer is mainly used to dry the grains	10-15
8.	Weighing balance	Approx. 100kg – 110 kg	All
9.	Conveying equipment's setup	Working models of Belt Conveyor, Bucket Elevator, Screw Conveyor, Pneumatic Conveyor	18,19
10.	Bucket elevator setup	Working model of Bucket elevator to vertically convey granular products.	19
11.	Set of Refractometer	Range : 0-62 % Brix Min. division : 0.2 % Brix Accuracy : + 0.2 % Remark : Without ATC	7,8

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
12.	UV/Vis spectrometer	UV/Vis spectrometer with LOW temperature accessories with PC control, Optics Double beam sealed, quartz coated, lens free system, Grating Concave holographic grating with 1030 lines/mm or better Measurement wavelength Range 200 – 1100 nm or better. Stray Radiation/Light Min 0.01 %T, Wavelength Accuracy Minimum +/- 0.1 nm, Wavelength Reproducibility Minimum +/- 0.06 nm , Band-pass/Band width Minimum 4 steps (0.6 to 4nm or better) Photometric Accuracy at 1A Min +/- 0.0	24
13.	Cooling equipment Deep Freezer	Quick Freezer Horizontal model / Vertical model (Temp. upto-20oC) 265/365-liter, capacity inner chamber of stainless steel with built in Digital temperature indicator cum controller having audio visual alarm.	30
14.	Refrigerator	165 lit, 235and 320 lit (capacity) double door type	30
15.	sorting and grading equipment's	For different types of agricultural products	31
16.	Wax coating Machine	Wax coating machine	32,34
17.	Packing materials	Different types of packing materials used for packing agricultural products in small and bulk quantity	37-41

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and edition with isbn
1.	Post-harvest technology of cereal, pulses, oil seeds	A. Chakraverty	Oxford & IBH publication co, 3rd edition (1 january 2019) Isbn-13 : 978-8120409699
2.	Horticultural practices and post- harvest technology	Alokes Das S Mandal, Sudipa Nag	books & allied (p) ltd, 2022 Isbn-13 : 978-8195318971
3.	Postharvest management of fruits and vegetables	Eleni Tsantili Jinhe Bai	Mdpi ag, 2022 Isbn-13 : 978-3036535357
4.	Post-harvest technology & management	Dr Akash Mishra	Publisher : kalyani; 2nd edition, 2020, Asin : b084m23zjd
5.	Unit operation of agro processing engineering	Dr.K.M. Sahay& K.K Singh	Vikas publications, 2 nd ed. 2004 ISBN-13 : 978-8125911425
6.	Post-harvest technology and value addition of fruits and vegetables	K Prakash S Chandraprabha	Lap lambert academic publishing, 2020 ISBN-13 : 978-6202563857
7.	Post-harvest technology of tropical fruits and vegetables	Surajit T.K. Bose Mitra	Astral publishing, 2023 ISBN-13 : 978-9354614293
8.	Food packaging: principles and practice	Gordon L. Robertson Gordon Robertson	Taylor and Francis books India pvt. Ltd.; 3rd edition, 2024 ISBN-13 : 978-1032789996

(b) Online Educational Resources:

1. <http://ecoursesonline.iasri.res.in/>
2. <http://ecoursesonline.iasri.res.in/course/view.php?id=28>

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

- A) **Course Code** : 2411603A(T2411603A/P2411603A/S2411603A)
 B) **Course Title** : Organic Farming for Sustainable Agriculture
 C) **Pre- requisite Course(s)** :
 D) **Rationale** :

Organic farming is a method of farming system which principally meant at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health. Organic farming protects soil life by avoiding the use of synthetic fertilizers and pesticides to maintain the physical, chemical, and biological properties of soil, thus abating chemical soil disturbance. In this course students will learn how to excludes the use of synthetic inputs and to maximize the rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection

- E) **Course Outcomes (COs):** The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos.

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

- CO-1** Use organic methods and techniques to improve soil health and fertility
CO-2 Integrate pest management (IPM) strategies for minimizing pest and disease damage.
CO-3 Use crop production techniques effectively and efficiently
CO-4 Apply principles of organic crop production and livestock production and standards.
CO-5 Apply agroecology principles and their application in sustainable agriculture.

F) Suggested Course Articulation Matrix (CAM):

Course Outcome	Programme Outcomes (POs)							Programmes 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	-	1		
CO-2	3	2	1	1	1	-	1		
CO-3	3	2	1	1	1	-	1		
CO-4	3	2	1	1	1	-	1		
CO-5	3	2	1	-	1	-	1		

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2411603A	Organic Farming for Sustainable Agriculture	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)	
2411603A	Organic Farming for Sustainable Agriculture	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: T2411603A**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Apply principles and practices of organic farming in the situation.</p> <p><i>TSO 1b.</i> Explain historical context and evolution of organic agriculture.</p> <p><i>TSO 1c.</i> Describe the significance of organic farming in achieving sustainability and environmental conservation</p> <p><i>TSO 1d.</i> Assess soil health and fertility.</p> <p><i>TSO 1e.</i> Explain the importance of soil organic matter and microbiology in soil health.</p> <p><i>TSO 1f.</i> Explain the procedure of composting technique and vermicomposting technique</p> <p><i>TSO 1g.</i> Interpret the soil test results and recommend it for organic amendments</p>	<p>Unit -1.0 Introduction to Organic farming</p> <p>1.1 Organic Farming: Introduction and Status and History and evolution of organic farming and its components</p> <p>1.2 Organic farming Concepts, principles and practices.</p> <p>1.3 Importance of organic farming in sustainable agriculture and climate change</p> <p>1.4 Soil health and fertility management in organic farming.</p> <p>1.5 Vermicompost Production Technology and its quality</p> <p>1.6 Composting techniques and compost tea preparation.</p> <p>1.7 SWOT Analysis of Organic Farming</p>	CO1
<p><i>TSO 2a.</i> Describe common pests and diseases</p> <p><i>TSO 2b.</i> Identify beneficial insects in organic farming systems.</p> <p><i>TSO 2c.</i> apply pest management strategies for pest and disease control.</p> <p><i>TSO 2d.</i> Explain non-chemical methods for managing pests and diseases organically.</p> <p><i>TSO 2e.</i> Explain Crop rotation and polyculture techniques</p>	<p>Unit- 2.0 Organic Pest and Disease Management</p> <p>2.1 Introduction to Pest and Disease Management.</p> <p>2.2 Integrated Pest Management (IPM) in organic farming.</p> <p>2.3 Beneficial insects and companion planting.</p> <p>2.4 Non-chemical methods for pest control</p> <p>2.5 Disease management in organic systems.</p> <p>2.6 Level "C" Pest and Disease Management</p> <p>2.7 Crop rotation and polyculture techniques.</p>	CO2
<p><i>TSO 3a.</i> select organic seeds</p> <p><i>TSO 3b.</i> Explain the process of organic seed selection, propagation, and nursery management.</p> <p><i>TSO 3c.</i> Apply transplanting and direct seeding techniques suitable for given organic crop production.</p> <p><i>TSO 3d.</i> Describe weed management strategies.</p> <p><i>TSO 3e.</i> Explain the importance of crop rotation in organic farming</p> <p><i>TSO 3f.</i> Develop plan for crop planning and rotation design.</p> <p><i>TSO 3g.</i> Implement mulching practices effectively</p> <p><i>TSO 3h.</i> Compare the effectiveness of techniques such as contour plowing, terracing, cover</p>	<p>Unit- 3.0 Organic Crop Production Techniques</p> <p>3.1 Transition to organic crop production.</p> <p>3.2 Seed selection, saving, and propagation in organic farming.</p> <p>3.3 Transplanting and direct seeding methods.</p> <p>3.4 Nursery management.</p> <p>3.5 Weed management strategies in organic farming.</p> <p>3.6 Mulching techniques and weed suppression.</p> <p>3.7 Crop planning and rotation design in organic system.</p> <p>3.8 Integrated Farming System and Urban Agriculture.</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
cropping, and mulching in reducing soil erosion.	3.9 Quality of Organic Food.	
<p><i>TSO.4a</i> Manage organic vegetables, field crops, plantation crops effectively and efficiently.</p> <p><i>TSO.4b</i> Explain organic standards and practices for livestock production.</p> <p><i>TSO.4c</i> Describe animal welfare standards and ethical considerations in organic animal husbandry.</p> <p><i>TSO.4d</i> Choose relevant organic feeding, housing, and healthcare practices for the given livestock.</p> <p><i>TSO.4e</i> Explain the procedure of getting organic certification.</p> <p><i>TSO.4f</i> Maintain records and documents necessary for organic certification</p>	<p>Unit -4.0 Organic Crop and livestock Management.</p> <p>4.1 Organic Vegetable Crop Management.</p> <p>4.2 Organic Field Crop Management (Pulse and Oilseed Crop).</p> <p>4.3 Organic Plantation Crop Management.</p> <p>4.4 Organic livestock production.</p> <p>4.5 Animal welfare standards in organic farming.</p> <p>4.6 Feeding and nutrition in organic animal husbandry</p> <p>4.7 Disease prevention and treatment without antibiotics.</p> <p>4.8 Housing and pasture management for organic livestock.</p> <p>4.9 Organic certification process and standards.</p> <p>4.10 Record-keeping and documentation requirements</p>	CO4
<p>Practical demonstration: setting up agroforestry plots</p> <p><i>TSO 5a.</i> Apply the principles of agroecology and sustainable agriculture.</p> <p><i>TSO 5b.</i> Apply sustainable water management techniques and climate-smart agriculture practices for the given situation.</p> <p><i>TSO 5c.</i> Apply agroforestry systems and soil conservation techniques for sustainable land management.</p> <p><i>TSO 5d.</i> Explain government policies and regulations related to organic farming and sustainable agriculture.</p>	<p>Unit- 5.0 Sustainable Agriculture and Agroecology</p> <p>5.1 Agroecology principles and applications.</p> <p>5.2 Sustainable water management techniques.</p> <p>5.3 Climate-smart agriculture practices</p> <p>5.4 Agroforestry systems and their benefits.</p> <p>5.5 Soil conservation and erosion control methods.</p> <p>5.6 Key Indicators of Sustainable Agriculture.</p> <p>5.7 Government policies supporting organic farming.</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: P2411603A

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Determine the properties and nutrient content of the soil	1.	Determine pH, nutrient levels (NPK), organic matter content in the given soil	CO1
	2.	Conduct texture analysis and assess organic matter content.	CO1
	3.	Determining nutrient levels of the given soil	CO1
LSO 1.2 Use microscope	4.	Determine soil microbial population using microscope	CO1
LSO 1.3 Prepare organic material compost	5.	Prepare compost of organic materials to produce nutrient-rich soil.	CO1
	6.	Monitor compost temperature, moisture levels, and microbial activity over time	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.4 Prepare vermicompost	7.	Prepare vermicompost for the given land	CO1
LSO 2.1. Apply homemade organic pest	8.	Identify common pests and beneficial insects	CO2
	9.	Prepare and apply homemade organic pest control solutions (e.g., neem oil spray, garlic spray etc)	CO2
	10.	Set up pest monitoring traps	CO2
LSO 3.1 Seed germination test	11.	Assess the seed viability and vigor of the given seeds.	CO3
	12.	Perform transplanting seedlings and direct seeding in prepared plots	CO3
LSO 3.2 Set up an experiment to study the effects of crop rotation on soil health and crop yield.	13.	Implement crop rotation plan	CO3
	14.	measure soil properties over time, and compare yields of rotated crops with those of monoculture systems	CO3
LSO 4.1 Perform animal health assessment	15.	Determine the body condition, scoring and parasite examination on the given live stock	CO4
LSO 4.2 Perform feeding trails	16.	formulate organic feed rations for different livestock species.	CO4
LSO 5.1. Soil erosion simulation	17.	Construct erosion plots and observing the effects of different soil conservation techniques.	CO5
LSO 5.2. Construct a demonstration plot to integrate trees and shrubs in agriculture system	18.	Practice alley cropping, windbreaks, and silvopasture and Determine its effect on soil fertility, biodiversity, and microclimate	CO5
	19.	Set up an experiment to apply water-saving techniques such as drip irrigation, rainwater harvesting, and soil moisture monitoring	CO5
	20.	Determine water usage, soil moisture levels, and plant growth under different irrigation regimes.	CO5

L) Suggested Term Work and Self-Learning: S2411603A 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.

- i. Prepare a report on the principles and practices of organic farming including discussion soil health, pest and disease management, and biodiversity conservation.
- ii. Develop a crop rotation plan for a hypothetical organic farm. Consider factors such as soil fertility, pest management, and crop diversity.
- iii. Design an integrated pest management (IPM) strategy for an organic farm. Identify preventive measures, cultural practices, and biological controls to minimize pest and disease damage.
- iv. Discuss the principles of agroecology and how they align with organic farming practices to create sustainable agricultural systems.

b. Micro Projects:

- i. Analyze a successful organic farming case study from a specific region or farm. Assess the strategies employed, challenges faced, and outcomes achieved.
- ii. Visit an organic farm or community garden and prepare a detailed report including the farming methods observed, interactions with farmers, and insights gained.
- iii. Visit an organic livestock farm and prepare a detailed report including the Housing and pasture management for organic livestock, interactions with farmers, and insights gained.
- iv. Conduct a market analysis of organic produce in a selected region. Identify consumer trends, market demand, and distribution channels. Develop a marketing plan for promoting organic products.
- v. Evaluate government policies and regulations related to organic farming and their effectiveness in promoting sustainable agriculture and suggest potential improvements.

c. Other Activities:

1. Seminar Topics:

- Urban Agriculture and Organic Farming
- Agroecology and Organic Farming:
- Regenerative Agriculture

2. **Visits:** Visit nearby organic farms/ gardens/ kitchen gardens/livestock farm. Prepare a report of the visit with comments regenerative farming, biodiversity conservation, pest management etc.

3. Self-Learning Topics:

- The Economics of Organic Farming
- Biodiversity Conservation on Organic Farms

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 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%	20%	20%
CO-2	20%	20%	20%	20%	20%	20%	20%
CO-3	20%	20%	20%	20%	20%	20%	20%
CO-4	20%	20%	20%	20%	20%	20%	20%
CO-5	20%	20%	20%	20%	20%	20%	20%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

**.: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.

- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

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

Unit Title and Number	Total Classroom Instruction Hours (CI)	Relevant Cos Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit -1.0 Introduction to Organic farming	8	CO1	13	4	4	5
Unit- 2.0 Organic Pest and Disease Management	9	CO2	14	4	4	6
Unit -3.0 Organic Crop Production Techniques	10	CO3	15	4	4	7
Unit- 4.0 Organic Crop and livestock Management.	12	CO4	15	4	4	7
Unit -5.0 Sustainable Agriculture and Agroecology	9	CO5	13	4	2	7
Total	48	-	70	20	18	32

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine pH, nutrient levels (NPK), organic matter content in the given soil	CO1	40	50	10
2.	Conduct texture analysis and assess organic matter content.	CO1	40	50	10
3.	Determining nutrient levels of the given soil	CO1	40	50	10
4.	Determine soil microbial population using microscope	CO1	40	50	10
5.	Prepare compost of organic materials to produce nutrient-rich soil.	CO1	40	50	10
6.	Monitor compost temperature, moisture levels, and microbial activity over time	CO1	40	50	10
7.	Prepare vermicompost for the given land	CO1	40	50	10
8.	Identify common pests and beneficial insects	CO2	40	50	10
9.	Prepare and apply homemade organic pest control solutions (e.g., neem oil spray, garlic spray etc)	CO2	40	50	10
10.	Set up pest monitoring traps	CO2	40	50	10

S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
11.	Assess the seed viability and vigor of the given seeds.	CO3	40	50	10
12.	Perform transplanting seedlings and direct seeding in prepared plots	CO3	40	50	10
13.	Implement crop rotation plan	CO3	40	50	10
14.	Measure soil properties over time, and compare yields of rotated crops with those of monoculture systems	CO3	40	50	10
15.	Determine the body condition, scoring and parasite examination on the given live stock	CO4	40	50	10
16.	formulate organic feed rations for different livestock species.	CO4	40	50	10
17.	Construct erosion plots and observing the effects of different soil conservation techniques.	CO5	40	50	10
18.	Practice alley cropping, windbreaks, and silvopasture and determine its effect on soil fertility, biodiversity, and microclimate	CO5	40	50	10
19.	Set up an experiment to apply water-saving techniques such as drip irrigation, rainwater harvesting, and soil moisture monitoring	CO5	40	50	10
20.	Determine water usage, soil moisture levels, and plant growth under different irrigation regimes.	CO5	40	50	10

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.	Soil PH & Moisture Meter	For soil pH testing, and measuring moisture in soil	1, 20,19
2.	Soil Testing Kits	Including kits for testing nitrogen (N), phosphorus (P), potassium (K), and organic matter content	2,3,18
3.	Microscopes	For examining soil microorganisms, plant pathogens, and beneficial insects.	4
4.	Sprayers	For applying organic pest control solutions and foliar fertilizers	9
5.	Seed Germination Trays	For conducting seed germination tests.	11
6.	Potting Mix	Organic potting mix for starting seeds and transplanting seedlings	12
7.	Compost Bins	For composting organic materials and creating compost tea	5,6

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
8.	Vermicomposting Bins	For vermicomposting with earthworms	7
9.	Animal Health Kits	Including tools for animal health assessment, such as thermometers, scales, and fecal egg counting kits	15
10.	Feeding Equipment	Including feeders and waterers for livestock.	16
11.	Erosion Simulation Equipment	Such as erosion plots, rainfall simulators, and sediment traps.	17,18
12.	Models of drip irrigation, rain water harvesting,	Models of drip irrigation, rain water harvesting,	19
13.	Safety Gear	Including gloves, goggles, and aprons for handling chemicals and conducting experiments safely	All

R) Suggested Learning Resources:

a) Books:

Sr. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Organic Farming Manual: A Comprehensive Guide to Starting and Running A Certified Organic Farm	Ann Larkin Hansen	Storey Publishing LLC, 2010 ISBN-13 : 978-1603424790
2.	The Complete Book on Organic Farming and Production of Organic Compost	NPCS Board of Consultants & Engineers	ASIA PACIFIC BUSINESS PRESS Inc.; 2nd Ed. 2021 ISBN-13 : 978-8194099529
3.	The Complete Technology Book on Pesticides, Insecticides, Fungicides and Herbicides (Agrochemicals) with Formulae, Manufacturing Process, Machinery & Equipment	Dr. Himadri Panda	Niir Project Consultancy Services; 2nd Revised Edition, 2022 ISBN-13 : 978-8195577538
4	The Complete Technology Book on Vermiculture and Vermicompost (Earthworm) with Manufacturing Process, Machinery Equipment Details & Plant Layout	Dr. Himadri Panda	Asia Pacific Business Press Inc. 2022 ISBN-13 : 978-8195370146
5	The Complete Technology Book on Biofertilizer and Organic Farming	Dr. Himadri Panda	NIIR Project Consultancy Services; 3rd ed. 2022 ISBN-13 : 978-9381039076

(b) Online Educational Resources:

- 1) Rodale Institute: The Rodale Institute is a leading research organization dedicated to organic agriculture. Their website features research publications, educational materials, and resources for farmers interested in transitioning to organic practices.
- 2) International Federation of Organic Agriculture Movements (IFOAM)- IFOAM is a global network of organic farming organizations. Their website provides information about organic farming principles, standards, advocacy efforts, and events worldwide.
- 3) NPTEL

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: -

- A) **Course Code** : 2411603B(T2411603B/P2411603B/S2411603B)
 B) **Course Title** : Precision Agriculture and System Management
 C) **Pre- requisite Course(s)** :
 D) **Rationale** :

This course provides an overview of the principles of precision agriculture with focus on prescriptive agriculture and the ability to effectively execute input management plans using today's technologies. After completion of this course, students will be skilled in applying various advanced irrigation technologies to increase the field efficiency. Interested students can start consultancy services in this area.

- E) **Course Outcomes (COs):** The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following field-oriented COs associated with the above-mentioned competency:

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

- CO-1** Develop plan for application of precision agriculture techniques.
CO-2 Use different global positioning systems.
CO-3 Use sensors as per requirement.
CO-4 Analyse different types of data from the agricultural field
CO-5 Integrate PA technology into agriculture farm.

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

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

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

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

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2411603B	Precision Agriculture and System Management	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2411603B	Precision Agriculture and System Management	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2411603B

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain various tools used in precision farming.</p> <p><i>TSO 1a.</i> Describe the impact of map scale on farm management</p> <p><i>TSO 1b.</i> Describe coordinates, projection, datum's and resolution</p> <p><i>TSO 1c.</i> Describe various techniques of precision agriculture</p> <p><i>TSO 1d.</i> Identify and analyze the Issues and concerns related to the given farm</p> <p><i>TSO 1e.</i> Describe the pros and cons of GPS, GIS, and VRT in farm management and record keeping in precision agriculture</p> <p><i>TSO 1f.</i> Apply precision agriculture farming techniques on the given farm.</p>	<p>Unit-1.0 Introduction to precision agriculture</p> <p>1.1 Importance of Precision Agriculture, functional requirements of precision agriculture, mapping in farming for decision making</p> <p>1.2 Benefits of Precision Agriculture</p> <p>1.3 Precision agriculture: concepts and techniques</p> <p>1.4 Geographical concepts of PA- Coordinate systems, Scales, Projection, Resolution</p> <p>1.5 Geographical Position System- GIS, GPS, IDI, remote sensing & VRA in precision agriculture.</p> <p>1.6 Issues and concerns for Indian agriculture;</p>	CO1
<p><i>TSO 2a.</i> Explain the relationship between GPS and GIS</p> <p><i>TSO 2b.</i> Explain ground base and space-based correction system</p> <p><i>TSO 2c.</i> Explain the steps to collect data through geo-referencing, GPS, satellites and drones</p> <p><i>TSO 2d.</i> Explain the working and operation of GPS, satellites and drones, GIS and IDI device.</p> <p><i>TSO 2e.</i> Explain the procedure to record the crop scouting data using geo-mapping, sensors, integrated electronic communications and variable rate technology</p> <p><i>TSO 2f.</i> Analyze the image/data obtained from satellite imagery</p> <p><i>TSO 2g.</i> Select GIS, GPS and Remote sensing tools for spatiotemporal study.</p> <p><i>TSO 2h.</i> Explain the function and working of various agricultural drone</p> <p><i>TSO 2i.</i> Plan a route in the given area allowing the drones to follow the automated flight path created by the relevant flight planning software</p> <p><i>TSO 2j.</i> Select drone as per the requirement</p>	<p>Unit-2.0 Tools of Precision Agriculture</p> <p>2.1 Introduction to Global navigation and position systems used in agriculture</p> <p>2.2 Geographical Position System- GPS Basics (Space Segment, Receiver Segment, Control Segment), Error and correction, Function and usage of GPS</p> <p>2.3 Introduction to GIS-Basics of GIS, Function of GIS, Use of GIS for decisions</p> <p>2.4 IDI devices usage in Precision Agriculture-Yield monitor, VR Application (fertilizers, seed, chemicals)</p> <p>2.5 Remote sensing-Aerial and satellite imagery, Above ground (non-contact) sensors</p> <p>2.6 Drones- function of drone, types of drone, Surveillance drones, Digital imaging, Crop damage identification, Surveys & Mapping of Geographical Areas, DGCA Drone Law</p> <p>2.7 Ground-based and space-based correction systems,</p> <p>2.8 levels of accuracy, factors affecting accuracy</p> <p>2.9 manual guidance and auto guidance</p>	CO2
<p><i>TSO 3a.</i> select the relevant field devices for the given farm</p> <p><i>TSO 3b.</i> Explain operation and working of the given sensors</p> <p><i>TSO 3c.</i> Plan for identification for the appropriate locations in the field for the installation of field data recorders and remote sensors</p> <p><i>TSO 3d.</i> Explain the procedure of calibration for the given sensors per the manufacturers' instructions</p>	<p>Unit 3.0 Sensors for smart farming</p> <p>3.1 Introduction to agricultural sensors, working and function of sensors, advantages and disadvantages</p> <p>3.2 Types of sensors</p> <p>3.3 Optical Sensors -Soil moisture sensors, Soil temperature sensors, Leaf wetness sensors</p> <p>3.4 Agricultural Weather Stations -Micro-climate sensors, Air humidity sensors, Windspeed and</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 3e.</i> Select relevant mobile application and/or computer software for the collection and analysis of data</p> <p><i>TSO 3f.</i> Use IoT based platform</p>	<p>direction sensors, Rainfall sensors, Temperature sensors,</p> <p>3.5 Location Sensors</p> <p>3.6 Electro-chemical sensors-Pesticide sensor, Nutrient sensor, Volatile organic compound sensor</p> <p>3.7 Mechanical Sensors and Mass flow sensors</p> <p>3.8 Acoustic based sensors</p> <p>3.9 Electromagnetic sensors</p> <p>3.10 Light detection and ranging (LIDAR)</p> <p>3.11 FPGA (Field programmable gate array) based sensors</p> <p>3.12 Ultrasonic ranging sensors</p> <p>3.13 Flexible and wearable sensors, Battery-free and self-powered sensors,</p> <p>3.14 IoT-based intelligence platform</p>	
<p><i>TSO.4a</i> Explain the procedure for data Collection using geo-referencing, GPS, satellites and drones</p> <p><i>TSO.4b</i> Explain grid sampling and yield monitor.</p> <p><i>TSO.4c</i> Analyze the given soil data.</p> <p><i>TSO.4d</i> Prepare a plan to set the relevant field devices, such as smart sensors, field data recorders, GPS receivers, etc., for recording the relevant data from agricultural fields</p> <p><i>TSO.4e</i> Explain the methods of data analysis</p> <p><i>TSO.4f</i> Perform the data analysis of the given sample data of the agriculture farm.</p> <p><i>TSO.4g</i> Analyze the given soil map</p> <p><i>TSO.4h</i> Explain the given maps and charts of the given agriculture product.</p>	<p>Unit 4.0-Processes of Precision Agriculture</p> <p>4.1 Data collection</p> <ul style="list-style-type: none"> • Methods of data collection (traditional and new) • Data Collection by Grid Sampling • Collecting Data by Yield Monitor • Remote Sensing • Use of sensors for data collection <p>4.2 Data analysis</p> <ul style="list-style-type: none"> • Concepts of data analysis • Resolution • Surface analysis <p>4.3 Analysis application</p> <ul style="list-style-type: none"> • Interpretive products (map, charts, application map etc) 	CO4
<p><i>TSO 5a.</i> Describe the methods of record keeping</p> <p><i>TSO 5b.</i> Develop a plan for to test soil sample using geospatial technology</p> <p><i>TSO 5c.</i> Analyze Soil formation and change across landscapes</p> <p><i>TSO 5d.</i> Interpret the given soil map and yield map</p> <p><i>TSO 5e.</i> Describe soil and water spatial variability</p> <p><i>TSO 5f.</i> Describe Nutrient spatial variability</p> <p><i>TSO 5g.</i> Describe Crop spatial variability</p> <p><i>TSO 5h.</i> Explain the steps to reduce negative environmental impact in the given area.</p>	<p>Unit 5.0-Precision Agriculture technology integration</p> <p>5.1 Recordkeeping and its types</p> <p>5.2 Soil and water spatial variability -Soil formation and change across landscapes, soil mapping technology and utility, precision land management, irrigation and drainage</p> <p>5.3 Nutrient spatial variability -Grid and zone sampling approaches, developing management zones, nutrient-specific sensors, equipment for nutrient VRT</p> <p>5.4 Crop spatial variability-Yield monitors for grain and non-grain crops, calibration of monitors, data cleaning, yield map interpretation, yield stability, crop quality sensors</p> <p>5.5 Reduce negative environmental impact</p> <p>5.6 Crop/technology cost optimization</p>	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2411603B

Practical/Lab Session Outcomes (LSOs)	Sr. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 1.1.</i> Identify Geographical Position System	1.	Identify different types of geographical Position System like GIS, GPS, IDI, remote sensing & VRA in precision agriculture.	CO1
<i>LSO 2.1.</i> Collect and analyze the data	2.	Collect data and record site-specific information through geo-referencing, GPS via an interface with the satellites and drones for the given farm.	CO2
	3.	Collect geo-referenced data with the help of GPS receivers mounted on the farm machineries	CO2
<i>LSO 2.2.</i> Use GPS and GIS-based sensors, drones and satellite imagery	4.	Use GPS and GIS-based sensors, drones and satellite imagery, to get a 3-Dimensional (3D) analysis of the field.	CO2
	5.	Set up the GPS-based vehicle guidance system along with the relevant mechanical controls	CO2
	6.	Set the drone appropriately to ensure it takes and captures the required images using the attached camera	CO2
<i>LSO 2.3.</i> Use GPS and GIS-based sensors, drones and satellite imagery to monitor the properties of soil, crop, whether etc in the farm.	7.	Determine information regarding moisture stress, disease, structural anomalies, nutrient levels, and the yield health of the soil with the help of high-resolution satellite imagery	CO2
	8.	monitor the effects of weather; crop growth and yield; weed and pest/ insect infestation; trespassing into the field by animals, preying by birds and record the data by Operating drones	CO2
	9.	Determine the composition of soil in the cultivated region using GPS and GIS-based sensors, drones and satellite imagery	CO2
<i>LSO 3.1.</i> Identify the location and mount the relevant sensors to collect the data	10.	Identify the appropriate locations and Install and prepare data recorders and remote sensors	CO3
	11.	Attach/mount the smart sensors and GPS receivers to farm machineries such as tractors, fertilizer/pesticide sprayers, and combine harvesters, following the manufacturers' instructions	CO3
<i>LSO 3.2.</i> Record the crop scouting data	12.	Record the crop scouting data using geo-mapping, sensors, integrated electronic communications and variable rate technology	CO3
<i>LSO 3.3.</i> Calibrate the sensors	13.	calibrate a variety of given sensors as per the manufacturers' instructions	CO3
<i>LSO 3.4.</i> Use agricultural software	14.	set up the relevant mobile application and/or computer software for the collection and analysis of data	CO3
<i>LSO 3.5.</i> Use electro chemical sensors	15.	Monitor the levels of phosphorous, potassium, calcium, sodium, nitrogen, copper, iron, alkaline and acids in the soil with the help of electrochemical sensors	CO4

Practical/Lab Session Outcomes (LSOs)	Sr. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 4.1.</i> Use field data recorders and basic Geographic Information Systems (GIS)	16.	Collect information about soil or field attributes, yield data, or field boundaries using field data recorders and basic Geographic Information Systems (GIS)	CO4
<i>LSO 4.2.</i> Use geo-mapping technology	17.	Collect the relevant information regarding the soil, topography, terrain, moisture levels, organic matter, nitrogen and pH using the geo-mapping technology	CO4
<i>LSO 4.3.</i> Use soil Electrical Conductivity (EC) sensors or Electro-Magnetic (EM) sensors	18.	Map the soil properties, such as soil organic matter, clay, soluble salts, etc. using soil Electrical Conductivity (EC) sensors or Electro-Magnetic (EM) sensors	CO4
<i>LSO 4.4.</i> Carry out zone sampling	19.	Carry out zone soil sampling to determine the patterns of residual crop nutrients in the soil	CO4
<i>LSO 4.5.</i> Use dielectric soil moisture sensors, such as water-potential sensor and tensiometer	20.	monitor the moisture levels of the soil and its moisture-holding capacity at different sites in the field using the relevant dielectric soil moisture sensors, such as water-potential sensor and tensiometer sensor	CO4
<i>LSO 5.1.</i> Select GIS, GPS and Remote sensing tools for spatiotemporal study.	21.	Use of GIS, GPS and Remote sensing tools for spatiotemporal study of crop cultivation under protected cultivation.	CO5
<i>LSO 5.2.</i> Use geospatial technology	22.	Develop soil sampling grids using geospatial technology for testing nitrogen, phosphorus, potassium content, pH, and micronutrients in the soil	CO5
<i>LSO 5.3.</i> Estimate cost of protected cultivation system.	23.	Estimate the cost of different systems installed with basic components and systems for precision farming systems.	CO5

L) Suggested Term Work and Self Learning: S2411603B Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

- i. Collect the essential information's required for installation of protected cultivation structures. (Collect information from field, library and internet). Prepare a report and submit as assignment online.
- ii. Collect information about sensors (soil, temperature) required for protected cultivation and its availability (collect information from distributors, internet, literatures) compile information for further installation in fields and upload it on social media profile.
- iii. Develop a plan for installation/mounting of relevant precision agriculture equipment's and sensors to collect the data.
- iv. Analyze the given data and submit the report
- v. Use agriculture software to analyze the given data

b. Micro Projects:

- i. Design an automated irrigation system for protected cultivation system
- ii. Develop plan and Install precision agricultural equipment's and sensors in the given farm to collect the relevant data

- iii. Use drone to collect the relevant data from the farm and submit the report
- iv. Use GIS and GPS technology to collect the relevant data and submit the report
- v. Identify the different sources of micro nutrients essential for crops under precision farming systems (Collect information from literature and market, prepare chart and submit the report).
- vi. Determine the crop water requirement and irrigation system operation schedule for selected crop under protected cultivation structures (*Use required field data and library resources for solving equations of crop water requirement*) and submit online as assignment.

c. Other Activities:

1. Seminar Topics:

- Use of nanotechnology in precision agriculture
- Integrating Precision Farming Facilities into the IoT

2. Visits:

- Arrange field visit for study of different components and systems for protected cultivation structures installed in field.
- Arrange visit to automated irrigation unit in precision farming systems for practical knowledge of students.
- Arrange site visit of any previous installed protected cultivation structures for crop cultivation in nearby sites.

3. Self-Learning Topics:

- Prepare a flex chart to explain any one method of greenhouse cooling/Heating for greenhouse installation (*Prepare from market and submit it as assignment*).
- Determine cost estimate of different systems installed with basic components and systems for precision farming systems.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	15%	10%	-	-	10%	20%
CO-2	25%	22%	25%	25%	-	25%	20%
CO-3	25%	22%	25%	25%	33%	25%	20%
CO-4	20%	21%	20%	25%	33%	20%	20%
CO-5	20%	20%	20%	25%	34%	20%	20%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Precision Agriculture	8	CO1	10	4	3	3
Unit-2.0 Tools of Precision Agriculture.	10	CO2	15	4	5	6
Unit-3.0 Sensors for smart farming	11	CO3	15	4	5	6
Unit-4.0 Processes of Precision Agriculture	10	CO4	15	4	5	6
Unit-5.0 Precision Agriculture technology integration.	9	CO5	15	4	5	6
Total	48	-	70	20	23	27

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify Geographical Position System like GIS, GPS, IDI, remote sensing &VRA in precision agriculture.	CO1	40	50	10
2.	Collect data and record site-specific information through geo-referencing, GPS via an interface with the satellites and drones for the given farm.	CO2	40	50	10
3.	Collect geo-referenced data with the help of GPS receivers mounted on the farm machineries	CO2	40	50	10
4.	use geo-mapping, sensors, integrated electronic communications and variable rate technology to record the crop scouting data	CO2	40	50	10
5.	Use GPS and GIS-based sensors, drones and satellite imagery, to get a 3-Dimensional (3D) analysis of the field.	CO2	40	50	10
6.	Set up the GPS-based vehicle guidance system along with the relevant mechanical controls	CO2	40	50	10
7.	Set the drone appropriately to ensure it takes and captures the required images using the attached camera	CO2	40	50	10
8.	Determine information regarding moisture stress, disease, structural anomalies, nutrient levels, and the yield health of the soil with the help of high-resolution satellite imagery	CO2	40	50	10
9.	monitor the effects of weather; crop growth and yield; weed and pest/ insect infestation; trespassing into the field by animals, preying by birds and record the data by Operating drones	CO2	40	50	10
10.	Determine the composition of soil in the cultivated region using GPS and GIS-based sensors, drones and satellite imagery	CO2	40	50	10
11.	Identify the appropriate locations and Install and prepare data recorders and remote sensors	CO3	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
12.	Attach/mount the smart sensors and GPS receivers to farm machineries such as tractors, fertilizer/pesticide sprayers, and combine harvesters, following the manufacturers' instructions	CO3	40	50	10
13.	Record the crop scouting data using geo-mapping, sensors, integrated electronic communications and variable rate technology	CO3	40	50	10
14.	Calibrate a variety of given sensors as per the manufacturers' instructions	CO3	40	50	10
15.	Set up the relevant mobile application and/or computer software for the collection and analysis of data	CO3	40	50	10
16.	Monitor the levels of phosphorous, potassium, calcium, sodium, nitrogen, copper, iron, alkaline and acids in the soil with the help of electrochemical sensors	CO4	40	50	10
17.	Collect information about soil or field attributes, yield data, or field boundaries using field data recorders and basic Geographic Information Systems (GIS)	CO4	40	50	10
18.	Collect the relevant information regarding the soil, topography, terrain, moisture levels, organic matter, nitrogen and pH using the geo-mapping technology	CO4	40	50	10
19.	Map the soil properties, such as soil organic matter, clay, soluble salts, etc. using soil Electrical Conductivity (EC) sensors or Electro-Magnetic (EM) sensors	CO4	40	50	10
20.	Carry out zone soil sampling to determine the patterns of residual crop nutrients in the soil	CO4	40	50	10
21.	monitor the moisture levels of the soil and its moisture-holding capacity at different sites in the field using the relevant dielectric soil moisture sensors, such as water-potential sensor and tensiometer sensor	CO4	40	50	10
22.	Use of GIS, GPS and Remote sensing tools for spatiotemporal study of crop cultivation under protected cultivation.	CO5	40	50	10
23.	Develop soil sampling grids using geospatial technology for testing nitrogen, phosphorus, potassium content, pH, and micronutrients in the soil	CO5	40	50	10
24.	Estimate the cost of different systems installed with basic components and systems for precision farming systems.	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.	GPS, GIS	-	1,2, 3,4,5,6,11,16,17,21,22
2.	Drone	Different types of agricultural drones	1,2, 6,8,9,17,21,22
3.	Satellite imagery	-	1, 2,4,7,9,17,21,22
4.	Remote sensors	-	10
5.	Data recorder	-	10,16
6.	Smart sensors kits	Different type of sensors- Soil sensors, Optical sensors, Location sensors, Acoustic sensors, Light detection and ranging (LIDAR), FPGA (Field programmable gate array) based sensors, Ultrasonic ranging sensors, Micro-climate sensors, Air humidity sensors, Windspeed and direction sensors, Rainfall sensors, Temperature sensors, Flexible and wearable sensors Electrical Conductivity (EC) sensors, Electro-Magnetic (EM) sensors, dielectric soil moisture sensors ,water-potential sensor ,tensiometer Electrochemical sensors	All
7.	Agriculture software	-	14

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

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Sensing Approaches for Precision Agriculture	Alexandre Escola Ruth Kerry	Springer Nature Switzerland AG; 1st ed. 2021, ISBN-13 : 978-3030784300
2.	Geostatistical Applications for Precision Agriculture	Margaret A. Oliver	Springer; 2010th edition, ISBN-13 : 978-9048191321
3.	Sensing Technologies for Precision Irrigation	Dubravko Čulibrk Dejan Vukobratovic Vladan Minic Marta Alonso Fernandez	Springer-Verlag New York Inc.; 2014th edition, ISBN-13 : 978-1461483281
4.	Geo-informatics and Nanotechnology for Precision Farming	Gandhi N	LAP Lambert Academic Publishing, 2022 ISBN-13 : 978-6205507780
5.	Methodologies Used in Remote Sensing Data Analysis and Remote Sensors for Precision Agriculture	Jiyul Chang Sigfredo Fuentes	Mdpi AG , 2023 ISBN-10 : 3036566147
6.	Geoinformatics for Precision Farming: A Digital Revolution in Agriculture	Archana Priyadharshini Sambasiva Roa, S. Ambika A. Andrewsvimal	Press Media Pvt Ltd, 2023 ISBN-13 : 979-8890660831
7.	Sensing Approaches for Precision Agriculture (Progress in Precision Agriculture)	Alexandre Escola Ruth Kerry	Springer Nature Switzerland AG; 1st ed. 2021 edition, ISBN-13 : 978-3030784300

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
8.	HANDBOOK OF PRECISION AGRICULTURE	Charles Luxemburg	ARSLER, 2015, ISBN-13 : 978-1680942576
9.	A Textbook on Precision Agriculture Technology	Kishore Chandra Swain	New Age Publications, New Delhi, 2020, ISBN - 9789388879576

(b) Online Educational Resources:

- 1) https://krishi.icar.gov.in/jspui/bitstream/123456789/33996/1/Precision%20Agriculture%20in%20India_a_%20Opportunities%20and%20Challenges.pdf- Precision Agriculture in India: Opportunities and Challenges
- 2) <https://naas.org.in/News/NN22032022.pdf>- Precision Agriculture in India: A Perspective-
<https://www.ceew.in/publications/sustainable-agriculture-india/precision-farming-> Precision Farming in India
- 3) <https://shyamalasubarna.com/scope-of-precision-agriculture-in-india-2/> -Scope of Precision Agriculture in India
- 4) https://www.researchgate.net/publication/257035629_Precision_Agriculture_in_India_Opportunities_and_Challenges- Precision Agriculture in India: Opportunities and Challenges
- 5) <https://www.sciencedirect.com/science/article/pii/S1002007109000173>- Adoption of precision agriculture technologies in India and in some developing countries: Scope, present status and strategies
- 6) <https://www.thepharmajournal.com/archives/2023/vol12issue7S/PartG/S-12-7-68-849.pdf>- Precision farming: Emerging technology in Indian agriculture-brief review
- 7) https://mpra.ub.unimuenchen.de/73233/1/MPRA_paper_73233.pdf- Practicing Precision Agriculture in Dharmapuri District of Tamil Nadu: A Case Study
- 8) <https://www.scribd.com/doc/27774940/Assignment-205-Precision-Farming>- Precision Farming
- 9) <https://www.mdpi.com/2072-4292/12/19/3136> -Applications of Remote Sensing in Precision Agriculture: A Review
- 10) https://www.irjmets.com/uploadedfiles/paper/volume2/issue_9_september_2020/3926/1628083155.pdf- Precision Agriculture: A Review on its Techniques and Technologies-
- 11) <https://www.sciencedirect.com/science/article/pii/S2215017X16301400> -Nanotechnology: The new perspective in precision agriculture
- 12) <https://www.mdpi.com/2076-3417/10/3/813> -A Context-Aware Middleware Cloud Approach for Integrating Precision Farming Facilities into the IoT toward Agriculture 4.0
- 13) <https://www.thepharmajournal.com/archives/2021/vol10issue6S/PartD/S-10-5-44-916.pdf>- Precision farming: Challenges of Indian agriculture

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

- A) **Course Code** : 2411603C(T2411603C/P2411603C/S2411603C)
 B) **Course Title** : Watershed Planning and Management
 C) **Pre- requisite Course(s)** : Soil and Water Conservation
 D) **Rationale** :

The objectives of watershed planning and management are: to increase infiltration into soil, to control damaging excess runoff and to manage and utilize runoff for useful purposes. It also aims to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. It basically refers to the efficient management and conservation of surface and groundwater resources. It involves the prevention of runoff and storage and recharge of groundwater through various methods like percolation tanks, recharge wells etc. With the emerging concept now it should be **Bio-Industrial Watershed Management** as all activities are associated with its water footprint. The knowledge gained through this course will help the students to take up and execute the projects of natural resource management on watershed basis.

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

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

- CO-1** Develop concept of watershed and skills to delineate and prioritize a watershed.
CO-2 Prepare water budget and skill to assess water & sediment yield of a watershed.
CO-3 Formulate hydrologic and hydraulic design of appropriate structures in a watershed.
CO-4 Develop watershed management plan.
CO-5 Analysis of social and economical aspects in a watershed.

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

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

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

G) Teaching & Learning Scheme:

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				
2411603C	Watershed Planning and Management	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2411603C	Watershed Planning and Management	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

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

J) **Theory Session Outcomes (TSOs) and Units: T2411603C**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain watershed and objectives of watershed management.</p> <p><i>TSO 1b.</i> Explain reasons for deterioration of watershed and discussion on problems and prospects of watershed management.</p> <p><i>TSO 1c.</i> Explain steps of watershed management</p> <p><i>TSO 1d.</i> Explain linear, areal and relief aspects of watershed</p> <p><i>TSO 1e.</i> Explain delineation and prioritization of watersheds</p> <p><i>TSO 1f.</i> Explain watershed codification</p> <p><i>TSO 1g.</i> Explain topographical survey, soil characteristics, vegetative cover and land use in a watershed</p> <p><i>TSO 1h.</i> Explain concept of aerial photography and remote sensing</p>	<p>Unit-1.0 Concept of Watershed</p> <p>1.1 Introduction to Watershed and concept of bio-industrial watershed</p> <p>1.2 Concept, Scope and Importance of Watershed Management</p> <p>1.3 Watershed management - problems and prospects</p> <p>1.4 Morphometric analysis of watershed</p> <p>1.5 Delineation and Codification of watershed using remote sensing, GPS and GIS</p> <p>1.6 Factors affecting watershed management</p>	<p>CO1</p>
<p><i>TSO 2a.</i> Explain the importance of hydrologic data in watershed planning</p> <p><i>TSO 2b.</i> Explain the concept of water budgeting</p> <p><i>TSO 2c.</i> Explain various components of watershed hydrology for water budgeting.</p> <p><i>TSO 2d.</i> Explain the sources of sediment, sedimentation of reservoirs and its control</p> <p><i>TSO 2e.</i> Explain estimation of sediment flow rates</p> <p><i>TSO 2f.</i> Explain sediment yield index for prioritization of watershed</p> <p><i>TSO 2g.</i> Explain different sediment yield models.</p>	<p>Unit-2.0 Water Budgeting and Yield of a Watershed</p> <p>2.1 Hydrologic data for watershed planning</p> <p>2.2 Water budgeting in a watershed</p> <p>2.3 Water yield assessment and measurement from a watershed</p> <p>2.4 Sediment yield estimation and measurement from a watershed</p> <p>2.5 Sediment yield index and sediment yield of a watershed</p>	<p>CO2</p>
<p><i>TSO 3a.</i> Explain the functional requirement of structures in a watershed.</p> <p><i>TSO 3b.</i> Explain the procedure for design flood estimation and dimensions of structure</p> <p><i>TSO 3c.</i> Explain the softwares for analysis of hydrologic parameters</p>	<p>Unit-3.0 Hydrologic and Hydraulic Design</p> <p>3.1 Hydrologic and hydraulic design of earthen embankments and diversion structures</p> <p>3.2 Design of water harvesting tanks and ponds</p> <p>3.3 Rainwater conservation technologies - in-situ and storage</p>	<p>CO3</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 3d.</i> Quantitative familiarization with design of structures through worked examples (Numerical)</p> <p><i>TSO 3e.</i> Explain - in-situ and storage water harvesting techniques and recycling.</p>		
<p><i>TSO 4a.</i> Explain Integrated watershed management</p> <p><i>TSO 4b.</i> Explain dry farming techniques - inter-terrace and inter-bund land management.</p> <p><i>TSO 4c.</i> Explain the watershed management practices and technologies</p> <p><i>TSO 4d.</i> Explain Planning and formulation of project proposal</p> <p><i>TSO 4e.</i> Explain the procedure of evaluation and monitoring of watershed programmes</p>	<p>Unit-4.0 Watershed Management Plan.</p> <p>4.1 Concept & components of arable lands - agriculture and horticulture and non-arable lands - forestry, fishery and animal husbandry.</p> <p>4.2 Effect of cropping systems, land management and cultural practices on watershed hydrology.</p> <p>4.3 People's participation in watershed management programmes</p> <p>4.4 Optimal land use models</p> <p>4.5 Watershed planning based on land capability classes</p> <p>4.6 Evaluation and monitoring of watershed programmes</p>	CO4
<p><i>TSO 5a.</i> Explain the socio factors affecting the watershed management programmes</p> <p><i>TSO 5b.</i> Explain the role of watershed associations, user groups and self-help groups.</p> <p><i>TSO 5c.</i> Explain the Operational Guidelines and role of different stakeholders in execution of watershed programme</p> <p><i>TSO 5d.</i> Explain the Indicators of Success</p> <p><i>TSO 5e.</i> Work out the benefit cost ratio of a watershed programme</p>	<p>Unit-5.0 Social and Economical Analysis</p> <p>5.1 Present land use practices and socio-economic factors</p> <p>5.2 Watershed programme execution</p> <p>5.3 Follow-up practices and maintenance of watershed works</p> <p>5.4 Cost benefits analysis of watershed programmes</p> <p>5.5 Case studies of successful watershed planning and management.</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: P2411603C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Use toposheets to critically observe the contour and streams</p> <p><i>LSO 1.2.</i> Demarcate the area into different mini, milli, and micro watershed area and the hydrologic response units</p>	1.	Exercises on delineation of watersheds using toposheets.	CO1
<p><i>LSO 2.1.</i> Survey and prepare contour map of a given area</p>	2.	Field surveying and preparation of watershed map.	CO1
<p><i>LSO 3.1.</i> Use GPS, GIS and remote sensing for delineation of Watershed</p>	3.	Quantitative analysis of watershed characteristics and parameters.	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 3.2.</i> Explore the Major watershed characteristics, viz; Size, Shape, Slope, Soils and geology, Land use, Land cover, Form factor, Bifurcation ratio, Drainage density and Time of concentration			
<i>LSO 4.1.</i> Analysis of hydro-meteorological data on different time steps and seasonal analysis for watershed planning <i>LSO 4.2.</i> Practice on softwares for analysis of hydrologic parameters of watershed	4.	Analysis of hydro-meteorological data for planning watershed management	CO2
<i>LSO 5.1.</i> Analysis of different components of hydrologic cycle for a watershed and perform water budgeting <i>LSO 5.2.</i> Solving numerical on water budgeting	5.	Water budgeting of watersheds.	CO2
<i>LSO 6.1.</i> Worked examples on sediment yield index and prioritize watersheds for restorative measures.	6.	Exploring sediment yield index for prioritization of watersheds.	CO2
<i>LSO 7.1.</i> Worked examples on design of watershed development structures, viz. earthen embankments, ponds and diversion structures	7.	Study of basic functional requirement of structures for watershed development - 1	CO3
<i>LSO 8.1.</i> Worked examples on design of watershed development structures, viz. contour trenches, nalla bandhan, water harvesting structures, Gabions etc.	8.	Study of basic functional requirement of structures for watershed development - 2	CO3
<i>LSO 9.1.</i> Explore institutional arrangement, explore role of women in watershed management, role of research and extension institutions, role of users' group in watershed, explore motivation and participation of community <i>LSO 9.2.</i> Prepare social and resource map	9.	Development of Watershed Management Work Plan - 1	CO4
<i>LSO 10.1.</i> Ensure peoples' participation through participatory tools and techniques, exercises on PRA <i>LSO 10.2.</i> Prioritization of watershed activities and constraint analysis	10.	Development of Watershed Management Work Plan - 2	CO4
<i>LSO 11.1.</i> Sharing of common property resources for equitable distribution of benefits <i>LSO 11.2.</i> Indicators of success	11.	Techno-socio-economic viability of watershed projects - 1	CO5
<i>LSO 12.1</i> Estimating and costing of watershed works <i>LSO 12.2</i> Visit to watershed development project areas.	12.	Techno-socio-economic viability of watershed projects - 2	CO5

L) **Suggested Term Work and Self Learning: S2411603C** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

1. Perform delineation of mini-watershed, milli-watershed, micro-watershed and hydrologic response unit inside the concerned watershed.
2. Using **one truck sand**, prepare a 3D model of a watershed and grow crops/trees, install/construct appropriate structures in a suitable site as per the guidelines. (Group Task). Once completed lets dismantle everything and repeat with new ideas. Now, try completing in at the earliest possible time.
3. Prepare land use/land cover under 2 above as per the land capability classification.

c. Other Activities:

1. Seminar Topics:
 - Morphometric analysis of a watershed
 - Land use capability classification.
 - Design of watershed development structures
 - Success story of a watershed development work
 - Role of stakeholders in success of a watershed development programme
2. Visits: Field visit nearby watershed area preferably the catchment area of a nearby nalla and visualize the type of soil, vegetation, land slope while planning land use as per the land capability classification. ONLINE visit of the suggested you tube channels for innovative idea that could be implemented.
3. Self-Learning Topics:
 - Concept of bio-industrial watershed
 - Effect of climate change on watershed development works
 - Climate resilient and climate smart technologies of crop cultivation
 - Low cost materials for watershed works

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%	15%	10%	25%	-	10%	20%
CO-3	15%	20%	15%	25%	33%	15%	20%
CO-4	30%	30%	30%	25%	33%	15%	20%
CO-5	30%	20%	30%	25%	34%	40%	20%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Concept of watershed	8	CO1	10	3	3	4
Unit-2.0 Water budgeting and yield of a watershed	8	CO2	10	3	2	5
Unit-3.0 Hydrologic and Hydraulic Design	10	CO3	15	5	3	3
Unit-4.0 Watershed management plan	12	CO4	20	5	6	9
Unit-5.0 Social and Economical Analysis	10	CO5	15	4	6	9
Total	48	-	70	20	20	30

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Exercises on delineation of watersheds using toposheets.	CO1	30	60	10
2.	Field surveying and preparation of watershed map	CO1	30	60	10
3.	Quantitative analysis of watershed characteristics and parameters.	CO1	30	60	10
4.	Analysis of hydro-meteorological data for planning watershed management	CO2	40	50	10
5.	Water budgeting of watersheds	CO2	50	40	10
6.	Exploring sediment yield index for prioritization of watersheds.	CO2	50	40	10
7.	Study of basic functional requirement of structures for watershed development - 1	CO3	50	40	10
8.	Study of basic functional requirement of structures for watershed development - 2	CO3	50	40	10
9.	Development of Watershed Management Work Plan - 1	CO4	30	60	10
10.	Development of Watershed Management Work Plan - 2	CO4	30	60	10
11.	Techno-socio-economic viability of watershed projects - 1	CO5	50	40	10
12.	Techno-socio-economic viability of watershed projects - 2	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, 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.	Personal Computer, Laptops	Operating System: Windows 11, Windows 10 (version 20H2 or higher), Windows Server 2019 or Windows Server 2022 Processor: Minimum: Any Intel or AMD x86-64 processor Recommended: Any Intel or AMD x86-64 processor with four logical cores and AVX2 instruction set support RAM: Minimum: 4 GB Recommended: 8 GB Storage: Minimum 512 GB Graphics: No specific graphics card is required, but a hardware accelerated graphics card supporting OpenGL 3.3 with 1GB GPU memory is recommended.	All
2.	Map Scanner / Plotter	Scanning Area: Around 22 inches by 30 inches Resolution: Typically in the range of 600 dpi (dots per inch) or higher for clear and detailed scanning of toposheets.	1, 2, 3
3.	Auto Level	Bright and sharp view, reduced operator's eye strain, quick collimation, horizontal angle measurement, fast and easy aiming, Leveling Accuracy: $\pm 0.7\text{mm}$ to $\pm 2.0\text{mm}$, Telescope Magnification: 24x to 32x, Minimum focus distance: 0.2m from end of telescope, 0.3m from center, dust tight and water tight protection, Precise: Reliable Automatic Compensator	2
4.	Total Station	Telescope: Magnification / Resolving Power: 30x / 2.5", Objective aperture: 45mm (48mm for EDM), Image: Erect, Field of View: 1°30' (26m / 1,000m), Minimum focus: 13 m, Reticle illumination: 5 brightness levels Angle Measurement: Display Resolution 1"/5", Collimation Compensation On/Off (selectable), Dual Axis Compensator Working range ± 6 Distance Measurement: Laser output (Reflectorless mode) Class 3R / Prism / sheet mode: class 1, Range reflectorless mode 0.3 to 500m (1,640ft.), Range prism mode 1.3 to 4,000m (4.3 to 13,120ft.) Measuring Time: Fine Measurement Mode 0.9 sec.(Initial 1.5 sec.), Rapid Measurement Mode 0.6 sec.(Initial 1.3 sec.), Tracking Measurement Mode 0.4 sec.(Initial 1.3 sec.) Interface and Data Management: Display / Keyboard Graphic LCD, 192 x 80 dots, backlight, contrast adjustment / alphanumeric keyboard / 28 keys with backlight, Data storage (Internal	2

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		memory) Approx. 50,000 points, Data storage (Plug-in memory device) USB flash memory (max. 32GB) General: Laser pointer Coaxial red laser using EDM beam, Optical Magnification: 3x Minimum focus: 0.5m from tribrach bottom Power Supply: Battery (BDC46C) Detachable battery Li-ion rechargeable battery, Operating time (20°C) BDC46C Approx. 14 hours (In use of ECO mode. Fine single measurement every 30sec)	
5.	ArcGIS	ArcGIS is a powerful geospatial platform that can be used for a variety of tasks, including watershed management License Version - ArcGIS 10.8.2 Open Source Software's – 1. QGIS 2. Google Earth Pro 3. Global Mapper 4. Google Maps API 5. SAGA GIS	1, 2, 3, 4, 5 and 6
6.	Digital Planimeter	Type: Roller Type With Computing Function, Display: Liquid Crystal, 8-digit figures, Converting Function: Unit and Scale value, Accumulated Measuring Value : Maximum 10m ² (scale 1:1) , Measuring Range: Maximum vertical width: 325mm, Horizontal roller rotating length: 30m, Accuracy: within ±0.2% (within ±2/1,000 pulses), Power Supply: Built-in Ni-Cd storage battery (rechargeable through AC adapter, AC 100V, 120V, 220V and 240V (using the supplied AC adapter) (provided with auto power-off function)	1, 2, 3, 4, 5 and 6
7.	3-D Models of different structures like Check dam, Contour trench, Embankment, Farm pond, etc.	Proportionate model	7 and 8

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Land and Water Management Engineering	VVN Murty and Madan K. Jha	Kalyani Publishers, 6, ISBN-13: 978-9327214659
2.	Rained Agriculture And Watershed Management	S. R. Reddy and G. Prabhakara Reddy	Kalyani Publishers, ISBN-13: 978-9327289510
3.	Principles of Agricultural Engineering Vol-2	A.M. Michael, T.P. Ojha	Jain Brothers, 6th Edition, ISBN : 9788183601849
4.	Hydrology and Soil Conservation Engineering: Including Watershed Management	Ghanshyam Das	Prentice-Hall of India Learning Pvt. Ltd., New Delhi. 2nd Edition, ISBN-13, 978-8120335868
5.	Field Manual on Watershed Management	Katyal, J.C., R.P. Singh, Shrinivas Sharma, S.K. Das, M.V. Padmanabhan and P.K. Mishra.	Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
6.	Watershed Management: Guidelines for Indian Conditions.	Tideman, E.M.	Omega Scientific Publishers, New Delhi.
7.	Fundamentals of Watershed Management Technology	Singh, G.D. and T.C. Poonia	Yash Publishing House, Bikaner.
8.	Participatory Integrated Watershed Management: A Field Manual.	Sharda, V.N., A.K. Sikka and G.P. Juyal	Central Soil and Water Conservation Research and Training Institute, Dehradun.

(b) Online Educational Resources:

1. https://youtu.be/2_QLE30Bg7Y
2. <https://youtu.be/WGkr8eCZufs?list=RDCMUcoz--4iY9aqEMeawgUhhwA>
3. https://www.riversweb.org/namton/0420/KIT/1Basics/113___WSM_Objectives_Concept_Principles.pdf
4. <https://agrimoon.com/watershed-planning-and-management-pdf-book-notes-free/>
5. https://cfpub.epa.gov/watertrain/pdf/modules/watershed_management.pdf
6. https://www.researchgate.net/publication/325044724_Watershed_Management_Concept_Principles_and_Challenges_to_Improving_Productivity_Resources_and_Livelihoods
7. https://www.unishivaji.ac.in/uploads/journal/Journal_42/3.pdf

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: Low cost, cost effective and environment friendly ideas that could be applied in watershed works

1. <https://youtu.be/INpKjdX2oIw>
2. <https://youtu.be/n5O2ERQGfTA>
3. <https://youtu.be/U-zaycBwi7U>
4. <https://youtu.be/GF9Q2EfqGnA>
5. <https://youtu.be/TzBvbZFsEbl>
6. <https://youtu.be/tFActN53yD8>

- 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)

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2400604B	Artificial Intelligence (Advanced)	30	70	20	30	20	30	200

Legend:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
algorithm TSO 4e. Use ART (Adaptive Resonance Theory) learning model TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network	Learning Methods, Backpropagation, Counter propagation, Adaptive Resonance Theory (ART), Associative memories, BAM.	
TSO 5a. Illustrate the features of Tens or flow TSO 5b. Manipulate tensors TSO 5c. Explain features of Tens or Board visualization TSO 5d Explain the concept and features of Tens or flow playground	Unit-5.0 Tensor flow features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension and two-dimension tensor, Tensor handling and manipulations, Tensor board visualization- symbols Tensors, Variables, Automatic differentiation, Graphs and tf.function, modules layers and models, training loops, features of Tens or flow playground- data ,the ration of train and test data, features, hidden layers, Epoch, learning rate, activation function, regularization, problem type	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: P2400604B

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	CO-2

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

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

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

b. **Micro Projects:**

Use python programming for the solutions of Microproject problems

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

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

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

Legend:

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

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to machine learning	08	CO1	11	5	4	2
Unit-2.0. Supervised and unsupervised learning	10	CO2	18	5	6	7
Unit-3.0. Introduction to neural networks	10	CO3	17	5	7	5
Unit-4.0. Neural networks models and Learning Methods	10	CO4	14	3	3	8
Unit-5.0. Tensor flow	10	CO5	10	2	6	2
Total Marks	48		70	20	26	24

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

O) Suggested Assessment Table for Laboratory (Practical):

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

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer Systems	Desktop Computers with i3 processor, 16 GB RAM, 512 GBHDD	S. No. 1 to 10
2.	Online Python IDE	https://www.online-python.com/	S. No. 1 to 10
3.	Jupyter Notebook	Download from https://jupyter.org/	S. No. 1 to 10
4.	Pip Python package manager	Download Pip 22.3 From https://pypi.org/project/pip/	S. No. 1 to 10
5.	Google colab	https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/quickstart/beginner.ipynb#scrollTo=DUNzJc4JTj6G	S. No. 1 to 10
6.	Various modules, Libraries and Packages	Tens or flow, NumPy, Pandas, package	S. No. 1 to 10

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

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Machine Learning using Python	Manaranjan Pradhan, U Dinesh Kumar	Wiley, ISBN-10: 8126579900 ISBN-13: 978-8126579907
2.	Introduction to Machine Learning	Jeeva Jose	Khanna Book Publishing Co. (P) ltd, 2020. ISBN-10: 9389139066 ISBN-13: 978-9389139068
3.	Machine Learning for Dummies	John Paul Mueller and Luca Massaron, For Dummies,	For Dummies; 2nd edition, ISBN-10: 1119724015 ISBN-13: 978-1119724018
4.	Machine Learning	Rajeev Chopra	Khanna Book Publishing Co., 2021 ISBN-10: 9789386173423 ISBN-13: 978-9386173423
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>

- A) **Course Code** : 2400604C(T2400604C/P2400604CS2400604C)
 B) **Course Title** : Internet of Things (Advanced)
 C) **Pre- requisite Course(s)** : IoT (Basics), Computer Networks
 D) **Rationale** :

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

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

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

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

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

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

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

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

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

G) Teaching & Learning Scheme:

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO.1. a. Write the steps to install Python.</p> <p>TSO.1. b. Explain given types of variables in python.</p> <p>TSO.1. c Explain use and importance of Tuple, Dictionary, operators in python</p> <p>TSO.1. d. Explain use of array in python.</p> <p>TSO.1. e. Explain use of 2-Dimensional Array in python</p> <p>TSO.1. f Explain uses of given type of Conditional statement in python.</p>	<p>Unit-1.0 Python Basics: -</p> <p>1.1 Installation of Python</p> <p>1.2 Variables, Print () function, Escape character sequence and run python Program</p> <p>1.3 Python Tuple, Dictionary, operators</p> <p>1.4 Python arrays, create, reverse and append data into it.</p> <p>1.5 Python 2 Dimensional arrays.</p> <p>1.6 Python Conditional statement.</p>	<p>CO-1 and CO-5</p>
<p>TSO.2. a. Explain uses of given type of do & while loops in python</p> <p>TSO.2. b. Explain working of break, continue and pass statement in python</p> <p>TSO.2. c. Write the benefits of using OOP methodology in python.</p> <p>TSO.2. d. Explain given type of string operation related to python.</p> <p>TSO.2. e. Explain given function in python</p> <p>TSO.2. f Explain use of Lambda function in python.</p>	<p>Unit 2. Python Advance: -</p> <p>2.1 Python Do & 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>CO-1 and CO5</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>Unit-3.0 Cloud Features: -</p> <p>3.1 Cloud computing and IoT cloud</p> <p>3.2 Benefits of cloud in IoT</p> <p>3.3 Types of Cloud public, private and hybrid</p> <p>3.4 Cloud services like SaaS, PaaS and IaaS</p> <p>3.5 Cloud connectivity and Data storage on Cloud.</p> <p>3.6 Arduino: Architecture, Programming, and Applications</p> <p>3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications</p>	<p>CO-1, CO-2 and CO-5</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 & LoRaWAN</p> <p>TSO.4. g Explain use of NB-IOT (Narrow Band IOT)</p> <p>TSO.4.h Create heterogenous network using RFID.</p>	<p>Unit.4 IoT Networking and Application: -</p> <p>4.1 Wired and short-range wireless network</p> <p>4.2 M2M – 2G, 3G, 4G & 5G networks</p> <p>4.3 LPWAN – Low Power Wide Area Networks</p> <p>4.4 SigFox & LoRaWAN.</p> <p>4.5 NB-IOT (Narrow Band IOT)</p> <p>4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors-Cables- Readers- encoder/ printers for smart labels- Controllers software</p> <p>4.7 RFID advantages over Bar codes.</p>	<p>CO-1 and CO-4</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>TSO.5. d. Implement and deploy the app</p>	<p>Unit. 5 IoT App Development: -</p> <p>5.1 Framework selection for IoT app development</p> <p>5.2 Identify stages of app to be developed.</p> <p>5.3 Develop, Implement, and Deploy the App</p> <p>5.4 Testing and Integration</p> <p>5.5 Maintain and improve</p>	<p>CO-4 and CO-5</p>

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		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 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool. 4.2 Connect the computers in Local Area Network 4.3 Connect 2 or more devices using Bluetooth 4.4 Connect 2 or more devices using infrared 4.5 Connect 2 more machine using m2m 4.6 Connect 2 or more different devices using access point 4.7 Connect 2 devices using LPWAN (Smart Meter) 4.8 Connect 2 or more devices using RFID	CO-4
LSO 5.1 Develop a IoT app LSO 5.2 Develop IoT applications using smartphones.	5.	5.1 Identify a problem and develop an app 5.2 Building a temperature monitoring system using sensors and Smartphone	CO-5

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

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

b. **Micro Projects:**

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

c. **Other Activities:**

1. Seminar Topics: - "Future of wireless network."
2. "Smart electricity billing ", "Cloud computing and IoT"
3. Visit to industry for IoT implementation in industrial process.
4. Reading RFID cards using 8051- RFID in the supply chain- Vehicles parking using RFID- library management system- electronic toll payment- smart shipping containers fleet monitoring and management.

5. Building IoT Applications like pressure, air quality, temperature and motion detector using Arduino and raspberry-pi Universal boards.
6. Surveys of market for availability of various types of network devices and its pricing.
7. Product Development: Development of projects for real life problem solution app.
8. Software Development: Using Python

d. Self-Learning Topics:

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

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

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Install given version of Python the computer system.	CO-1	70	20	10
2.	Prepare a python program using print() function and run it.	CO-1	60	30	10
3.	Access given value from the tuple	CO-1	60	30	10
4.	Print the given value of key from the dict.	CO-1	60	30	10
5.	Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes	CO-1	60	30	10
6.	Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array.	CO-1	60	30	10
7.	Write a python program to check whether person is eligible for voting or not. (accept age from the user)	CO-1	60	30	10
8.	Write a python program to check whether the entered number is even or odd.	CO-1	60	30	10
9.	Write a python program to check whether entered number is divisible by another entered number.	CO-1	60	30	10
10.	Write a python program to display "Yes" is entered number is divisible by 5 otherwise display "No"	CO-1	60	30	10
11.	Prepare a python program which can print first 10 even and odd numbers using while statement	CO-2	60	30	10
12.	Write a python program which can print first 10 integers and its square using while/for loop.	CO-2	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
13.	Write a python program which can print sum of first 10 natural numbers using while/for loop.	CO-2	60	30	10
14.	Write a python program which can identify the prime number between the range given using while/for loop.	CO-2	60	30	10
15.	Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
16.	Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
17.	Create a Class with instance attributes	CO-2	60	30	10
18.	Create a Vehicle class without any variables and methods	CO-2	60	30	10
19.	Write a Python function to find the Max of three numbers.	CO-2	60	30	10
20.	Write a Python program to reverse a string.	CO-2	60	30	10
21.	Create a free cloud account	CO-3	70	20	10
22.	Store data on cloud and retrieve it.	CO-3	60	30	10
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
2. en.wikipedia.org/wiki/Shear_and_moment_diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
6. https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/
7. https://wiki.python.org/moin/TimeComplexity
8. www.engineerstudent.co.uk/stress_and_strain.html
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work.
<https://github.com/OpenRCE/sulley>

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

(c) Others:

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

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

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

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

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

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

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

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

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

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

G) Teaching & Learning Scheme:

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.	Unit-1.0 Engineering mechanics for Drone Technology 1.1 Drone Mechanics <ul style="list-style-type: none"> Free body diagram of drone Method of finding resultant of force system Equilibrium of coplanar force system 1.2 Center of Gravity <ul style="list-style-type: none"> Centroid of plane figure Center of gravity of solid bodies 1.3 Force analysis in drone <ul style="list-style-type: none"> Force analysis in drone Forces of flight Principle axes and rotation of aerial systems 1.4 Dynamics of machine <ul style="list-style-type: none"> Static and dynamic force analysis Gyroscopic motions 	CO-1
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	Unit-2.0 Drone Frame and Components 2.1 Drone frame design <ul style="list-style-type: none"> Calculation principle for drone frame sizes Quadcopter frame design Smart materials for UAV frame Green material uses in drone 2.2 Advance Drones component <ul style="list-style-type: none"> GPS, Interfacing of GPS hardware Thermal and chemical sensor Tilt and LiDAR sensor 2.3 RF transmitter and receiver <ul style="list-style-type: none"> RF blocks RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	CO-2
TSO 3a. Identify features and specifications of FCB use in different application TSO 3b. Explain ports of any given advance flight controller board.	Unit-3.0 Advance flight controller Board (FCB) 3.1 Specification and ports of FCB 3.2 Software for FCB <ul style="list-style-type: none"> Software installation 	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
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.	3.3 Radio Communication with FCB <ul style="list-style-type: none"> • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC 3.7 GPS interface with FCB 3.8 Safety features of advance FCB	
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	Unit-4.0 Maintenance and assembling of Drone 4.1 Need and scope of drone maintenance 4.2 Types of maintenance 4.3 Routine drone maintenance and its checklist <ul style="list-style-type: none"> • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones <ul style="list-style-type: none"> • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling 	CO-4
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	Unit-5.0 Advance Drone Application 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in <ul style="list-style-type: none"> • Military • Precision Agriculture 	CO-5

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Use the force of gravity to compute the centre of gravity for a given drone structure.	1.	Determine Centre of gravity of different drone structure.	CO-1
LSO 2.1 Develop skills of observation and interpreting phenomenal changes on Drone model for stability and hovering.	2.	Demonstrate gyroscopic effect on a drone model	CO-1
LSO 3.1 Draw various frame to be required in designing drone structure. LSO 3.2 Use Measuring instrument in designing drone frame. LSO 3.3 Choose suitable materials for making drone frame	3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	CO-2, CO-4
LSO 4.1 Identify and measure the condition of sensors. LSO 4.2 Interface Tilt and LiDAR sensors in drone.	4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2
LSO 5.1 Identify different component of GPS module LSO 5.2 Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	CO-2
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identify different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	CO-3
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator. LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.	12.	Measure various electric parameters in drone hardware	CO-4

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

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

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

b. **Micro Projects:**

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

c. **Other Activities:**

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

d. **Self-Learning Topics:**

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

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

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

O) Suggested Assessment Table for Laboratory (Practical):

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

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

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

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

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

(b) Online Educational Resources:

1. <https://archive.nptel.ac.in/courses/101/104/101104083/>
2. https://onlinecourses.nptel.ac.in/noc21_ae14/preview
3. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
4. <https://fusion.engineering/>
5. <https://robocraze.com/blogs/post/best-flight-controller-for-drone>
6. <https://www.youtube.com/watch?v=LrkFG7GilPQ>
7. <https://www.youtube.com/watch?v=KjG6FKCNCbM>
8. <https://ardupilot.org/>
9. <https://px4.io/>

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational 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
7. http://tricopter.hu/docs/cc3d_manual.pdf

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

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

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

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

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

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

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

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

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

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

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

Legend:

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

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

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

Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain various forms of 3D printing raw material.</p> <p><i>TSO 1b.</i> Select material for the given popular 3D printing processes with justification.</p> <p><i>TSO 1c.</i> Select various Polymer based 3D printing raw materials with justification.</p> <p><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>Unit-1.0 3D Printing Materials</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>Unit-2.0 Solid based 3D Printing Processes</p> <p>2.1 Basic principle and working of fused deposition modeling (FDM) process.</p> <p>2.2 Liquefaction, solidification and bonding.</p> <p>2.3 Laminated Object Manufacturing process.</p> <p>2.4 Cost estimation of FDM 3D printed component.</p>	CO1, CO2
<p><i>TSO 3a.</i> Explain the phenomenon of Photo Polymerization.</p> <p><i>TSO 3b.</i> Explain the working of a typical Stereo Lithography based 3D Printer.</p> <p><i>TSO 3c.</i> Explain procedure of 3D Scanning of the given component.</p> <p><i>TSO 3d.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 3e.</i> Estimate the cost and time of the given SLA based 3D printed component.</p> <p><i>TSO 3f.</i> Apply Curing process to SLA based 3D printed component.</p>	<p>Unit-3.0 Liquid based 3D Printing Processes</p> <p>3.1 Photo polymerization.</p> <p>3.2 Principle and working of stereo lithography apparatus.</p> <p>3.3 SLA based 3D printing processes.</p> <p>3.4 SLA based 3D printing process materials.</p> <p>3.5 Scanning techniques.</p> <p>3.6 Curing processes.</p> <p>3.7 Cost estimation of SLA 3D printed component.</p>	CO1, CO3
<p><i>TSO 4a.</i> Explain powder fusion mechanism.</p> <p><i>TSO 4b.</i> Explain working of a typical SLA based 3D Printer.</p> <p><i>TSO 4c.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 4d.</i> Explain Net shape process.</p> <p><i>TSO 4e.</i> Explain Binder Jet 3D printing process.</p> <p><i>TSO 4f.</i> Justify use of Binder Jet 3D printing process and material for the given component.</p> <p><i>TSO 4g.</i> Estimate the cost and time of the given SLS based 3D printed component.</p>	<p>Unit-4.0 Powder based 3D Printing Processes</p> <p>4.1 Powder fusion mechanism.</p> <p>4.2 Principle and working of Selective Laser Sintering (SLS) process.</p> <p>4.3 SLS based 3D printers.</p> <p>4.4 Laser Engineering Net Shaping process.</p> <p>4.5 Electron Beam Melting.</p> <p>4.6 Binder Jet 3D Printing.</p> <p>4.7 Materials and Process parameters for SLS based 3D printing processes.</p> <p>4.8 Cost estimation of SLS based 3D printed component.</p>	CO1, CO4

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>Unit-5.0 Post Processing and Quality</p> <p>5.1 Need of post processing: Functional and Aesthetic reasons.</p> <p>5.2 Steps of Post Processing: Cleaning/Support removal, Fixing, Curing or hardening, Surface finishing, Colouring.</p> <p>5.3 Cleaning: Support Removal (FDM and Material Jetting); Powder Removal (SLS and Powder Bed 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: P2400604E

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

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%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

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

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

O) Suggested Assessment Table for Laboratory (Practical):

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

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

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

10.	Inspection and Testing devices	<ul style="list-style-type: none"> • Visual inspection, Devices related to: • Scanning electron microscopy (SEM), CT system, X-ray, • Penetration testing, • Infrared thermography, • Leak or pressure testing for complex structures, • Eddy current, • Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength • Metallography (Microstructure testing) 	8
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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
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=TQY2IF-sFal>
7. <https://www.youtube.com/watch?v=Oz0PoS5LPxg>
8. <https://www.youtube.com/watch?v=6ejjh0GdyDc>

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

(c) Others:

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

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

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>system to reduce environmental impact</p> <p>TSO.3e Identify faults in the given PLC system</p> <p>TSO.3f Explain the procedure for Troubleshooting PLC system</p> <p>TSO.3g Prepare preventive maintenance plan for the PLC system</p> <p>TSO.3h Use safety equipment's.</p> <p>TSO.3i Follow safe practices</p>	<p>3.4 Common problems</p> <ul style="list-style-type: none"> • Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory • External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI), Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated Circuitry, Field Input and Output Devices, Communication Issues. • Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer <p>3.5 Troubleshooting of Specific Components of the PLC System</p> <ul style="list-style-type: none"> • Power Supply Troubleshooting • I/O Modules Troubleshooting • Troubleshooting PLC Program Errors • Troubleshooting the Working Environment of a PLC • Replacement of CPU <p>3.6 PLC trouble shooting flowchart</p> <p>3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system.</p> <p>3.8 Safety procedure and safety equipment's.</p>	
<p>TSO.4.a Describe the function of given element of a SCADA system.</p> <p>TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC).</p> <p>TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application.</p> <p>TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.</p>	<p>Unit-4.0 SCADA and DCS</p> <p>4.1 Introduction, need, benefits and typical applications of SCADA and DCS</p> <p>4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA</p> <p>4.3 Comparison of SCADA with DCS</p> <p>4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture</p> <p>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.</p> <p>4.6 Procedure to maintain the SCADA based PLC system.</p>	<p>CO-3</p>
<p>TSO.5a Identify different components used for automation in the given system</p> <p>TSO.5b Select automation components for a given situation</p> <p>TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible.</p> <p>TSO.5d Prepare plan for sustainable automation as per the requirement.</p>	<p>Unit-5.0 Applications of Industrial Automation</p> <p>5.1 Manufacturing- Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation.</p> <p>5.2 Health Care- microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci</p>	<p>CO-5</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	5.3 Defense- guided rockets and missiles , counter measures, UAV drones, launcher, radar antenna, engagement control system 5.4 Automobile –Break monitoring system , Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps, Intelligent Parking Assist System, Driverless/Autonomous Cars 5.5 Agriculture- harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor 5.6 Mining- Mine planning system, mine picture compilation, mine control system, seismic imagining, laser imaging, Rig control system, automated drilling, automated exploration, automated truck	

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 3.1</i> Use hygrometer to measure the humidity inside the panel</p> <p><i>LSO 3.2</i> Use thermometer to measure ambient temperature inside the panel</p> <p><i>LSO 3.3</i> Use tester to determine the voltage fluctuation at the power supply terminals is within specifications</p> <p><i>LSO 3.4</i> Test the ground connections of the given PLC.</p> <p><i>LSO 3.5</i> A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output</p> <p><i>LSO 3.6</i> Investigate the cause of Noise in the given PLC</p> <p><i>LSO 3.7</i> PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.</p> <p><i>LSO 3.8</i> Troubleshoot the corrupted PLC memory.</p> <p><i>LSO 3.9</i> Replace CPU and power supply fuses in a given PLC system.</p>	13.	Troubleshooting of PLC system	CO3
<p><i>LSO 4.1</i> Download any open source SCADA software and install the same.</p> <p><i>LSO 4.2</i> Interpret the available components in symbol factory of SCADA software</p> <p><i>LSO 4.3</i> Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list)</p> <ol style="list-style-type: none"> i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property. <p><i>LSO 4.4</i> Create historical and real time trends for the given automation</p>	14.	Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties	CO4
<p><i>LSO 5.1</i> Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.</p> <p><i>LSO 5.2</i> Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application</p> <p><i>LSO 5.3</i> Develop a PLC program to control the robot in such a way that the robot can automatically pick and</p>	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p>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%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

**.: Mentioned under point- (N)

#: Mentioned under point- (O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-.1.0 Industrial automation Communication and Interfacing	9	CO1	14	5	4	5
Unit-.2.0 PLC Programming	12	CO2	17	5	6	6
Unit-.3.0 Installation and maintenance of PLC systems	10	CO3	14	4	5	5
Unit-.4.0 SCADA and DCS	9	CO4	14	4	5	5
Unit-.5.0 Applications of Industrial Automation	8	CO5	11	2	4	5
Total Marks	48		70	20	24	26

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

O) Suggested Assessment Table for Laboratory (Practical):

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

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 (Any Three) . i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.	CO4	50	40	10
24.	Create historical and real time trends for the given automation	CO4	50	40	10
24	Select any three of the following: - i. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. ii. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application iii. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. iv. Develop a Automation system to Open and close the door in the shop v. Develop a line following robot with RFID sensor for supplying materials and automating workflow. vi. Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on	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
2. Software: - www.logixpro.com
3. Software: - www.plctutor.com
4. Software; - www.ellipse.com
5. PLC lecture: - <https://www.youtube.com/watch?v=pPiXefBO2qo>

6. PLC tutorial: http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API_I_C3_3_ST.pdf
7. <https://www.youtube.com/watch?v=277wwYWolpw>-PLC system troubleshooting and repair. Industrial control panel. PLC system repair.
8. <https://www.youtube.com/watch?v=5Jmtvrch5Jg>
9. <https://www.youtube.com/watch?v=peyV9bwEaLY>
10. <https://www.youtube.com/watch?v=QdJhRmtKpxk&list=RDCMUCke36Liq-w5fboMHkq1APZw&index=3>
11. <https://www.youtube.com/watch?v=ygrrRwajz3M>

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

(c) Others:

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

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

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

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

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

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

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

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)						Legend:
		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	

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>Unit-1.0 Vehicle Dynamics</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"> • Hybrid and Electric Vehicles • DC Motor Dynamics and Control • AC Motor Dynamics and Control 	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>Unit-2.0 Elements of Automobile</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>TSO 3j. Describe the Mechanism of Gear and Differential Assembly.</p>	<p>Unit-3.0 EV Power Transmission System</p> <p>3.1 Transmission System: Single and Multi-transmission system</p> <p>3.2 EV Power Train</p> <p>3.3 EV Power Train Components: Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger.</p> <p>3.4 Battery Parameters: 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>3.5 Battery Assembly and Dismantling.</p> <p>3.6 Gear and Differential Assembly</p> <p>3.7 Safe disposal of used battery</p>	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.	Unit- 4.0 Vehicle Control Unit (VCU) 4.1 Electronic Control Unit: Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	CO4
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.	Unit- 5.0 EV Charging Technologies 5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	CO5

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	<ul style="list-style-type: none"> Testing of Control Disc Braking system and Control Regenerative Braking system. 	CO2
LSO 2.3 Test the performance of different types of propulsion motors.	2.	<ul style="list-style-type: none"> Testing of Motors 	
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	<ul style="list-style-type: none"> Testing of the automotive wiring system. 	
LSO 3.1 Test the performance of a new set of batteries and aged batteries. LSO 3.2 Compare the performance of the battery and find the Fuel Gauge after discharging the battery. a. 0% - 100% b. 30% - 100% c. 50% - 100% LSO 3.3 Evaluate the following parameters of the given EV battery. a. Specific power b. Specific energy c. Life span and	4.	<ul style="list-style-type: none"> Testing of Batteries used in EVs 	CO2, CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.4 d. Cost parameters 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"> Speed control of Electrical Motors 	
LSO 4.1 Connect the components of the EC Units with EV subsystems. LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.	6.	<ul style="list-style-type: none"> Connection of Electronic Control Unit components Troubleshooting of electronic control unit 	CO4
LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	<ul style="list-style-type: none"> Impacts of G2V and V2G 	CO5
LSO 5.2 Prepare a layout of a charging station	8.	<ul style="list-style-type: none"> Demonstration of Charging stations 	

- L) **Suggested Term Work and Self-Learning: S2400604G** Some sample suggested assignments, micro projects and other activities are mentioned here for reference.
- a. **Assignments:** Questions/ Problems/ Numerical/ Exercises to be provided by the course teacher in line with the targeted COs.
- b. **Micro Projects:**
- Design and build a physical model of an EV motor and powertrain components from scratch.
 - Build and simulate communication systems of EVs using some software tools.
 - Prepare a report on “the way carbon credit works and companies utilize it to reduce their emission values”.
 - Develop an EV prototype power train using locally procured hardware components.
- c. **Other Activities:**
- Seminar Topics:**
 - Safe disposal process of Used Batteries.
 - Charging Technologies used for charging the EV.
 - EV power transmission systems.
 - Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.

3. Self-Learning Topics:

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point- (O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Vehicle Dynamics	8	CO1	12	4	5	3
Unit-2.0 Elements of Automobile.	10	CO2	15	5	6	4
Unit-3.0 EV Power Transmission System.	14	CO3	20	4	10	6
Unit-4.0 Vehicle Control Unit (VCU)	10	CO4	15	4	6	5
Unit-5.0 Charging Technologies	6	CO5	8	3	3	2
Total Marks	48		70	20	30	20

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Testing of Control Disc Braking system and Control Regenerative Braking system.	CO2	60	30	10
2	Testing of Motors.				
3.	Testing of automotive wiring system.				
4.	Testing of Batteries used in EVs	CO2, CO3	60	30	10
5.	Speed control of Electrical Motors				
6.	Connection of Electronic Control Unit components	CO4	60	30	10
7.	Troubleshooting of electronic control unit				
8.	Impacts of G2V and V2G	CO 5	30	60	10
9.	Demonstration of Charging stations				
			70	20	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

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

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

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

(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

- A) **Course Code** : 2400604H(T2400604H/P2400604H/S2400604H)
- B) **Course Title** : Robotics (Advanced)
- C) **Pre- requisite Course(s)** : Robotics (Basic)
- D) **Rationale** :
Efficiency and quality are the demands of industry 4.0. Robotics is a constituent of Industry 4.0 which not only provides the former two but also is beneficial for hazardous and similar challenging situations. The use of robotic technology is developing at a very fast rate in all types of industries whether manufacturing, service or tertiary. Engineers should be competent to use the robotic technology for industry and society advantage. This course aims for the diploma engineers to have advanced skills in robotic applications and use in digital manufacturing.
- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

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

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

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

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

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

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

G) Teaching & Learning Scheme:

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the need and scope of industrial robots. TSO 1b. Describe the concept of robot dynamics with regards to methods for orientation and location of objects. TSO 1c. Analyse robot direct kinematics for the given 2 DOF planar manipulator. TSO 1d. List types of robots TSO 1e. List safety steps while handling the given robot. TSO 1f. Interface robots with the given welding machine. TSO 1g. Interface robots with the given painting machine. TSO 1h. Interface robots with the given assembly machine.	Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications 1.1 Definition need and scope of Industrial robots 1.2 Robot dynamics – Methods for orientation and location of objects 1.3 Planar Robot Kinematics – Direct and inverse kinematics for 2 Degrees of Freedom. 1.4 Safety while operating and handling robot 1.5 Robot Industrial applications: <ul style="list-style-type: none"> • Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing • Spray painting Robots, assembly operation, cleaning. 	CO2, CO3
TSO 2a. Explain the techniques to control robot motion. TSO 2b. Describe the given robot drive system. TSO 2c. Describe the types of grippers. TSO 2d. Design grippers for specific application. TSO 2e. Test the designed gripper for the application. TSO 2f. Use Bar code technology for robotic applications. TSO 2g. Integrate radio frequency identification technology in robotic applications. TSO 2h. Assemble an automated guided vehicle for the given situation using standard components. TSO 2i. Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components.	Unit- 2.0 Robot Drives, Control and Material Handling 2.1 Controlling the Robot motion. 2.2 Position and velocity sensing devices. 2.3 Drive systems – Hydraulic and Pneumatic drives 2.4 Linear and rotary actuators and control valves 2.5 Electro hydraulic servo valves, electric drives, motors 2.6 End effectors – Vacuum, magnetic and air operated grippers 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS) 2.8 Bar code technology 2.9 Radio frequency identification technology.	CO2, CO3
TSO 3a. Differentiate between various work cell layouts. TSO 3b. Select work cell for specific robot with justification. TSO 3c. Analyse robot cycle time. TSO 3d. Explain industrial applications of robotic cell. TSO 3e. Follow safety procedures in robotic cell.	Unit- 3.0 Robot Cell Design and Application 3.1 Robot work cell design, control and safety 3.2 Robot cell layouts 3.3 Multiple Robots and machine interference 3.4 Robot cycle time analysis 3.5 Industrial application of robotic cells	CO3
TSO 4a. List different programming languages for the robots	Unit- 4.0 Robot Programming and Economics of Robotization	CO1, CO4, CO5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4b. Describe artificial intelligence TSO 4c. Write a programme in the required language to operate a robot for the given task. TSO 4d. Optimise robot programming parameters. TSO 4e. Select a robot on the basis of cycle time analysis. TSO 4f. Conduct an economic analysis for use of robots. TSO 4g. Follow testing methods and acceptance rules for industrial robots.	4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on investment method. 4.9 Testing methods and acceptance rules for industrial robots	
TSO 5a. Describe applications of robots in healthcare and medicine. TSO 5b. Describe applications of robots in Construction industry. TSO 5c. Describe applications of robots in Underground coal mining. TSO 5d. Describe applications of robots in utilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	Unit-5.0 Applications in Non-manufacturing Environments 5.1 Applications of Robots in <ul style="list-style-type: none"> • Healthcare and medicine • Construction industry • Underground coal mines • Utilities, military & firefighting operations • Undersea • Space • Logistics, • Retail and Hospitality • Smart Cities • Farming and Agriculture 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	CO5

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 15.1 Use robot simulation software for Direct Kinematic analysis upto 4-axis robots LSO 15.2 Correlate the simulated results with respective mathematical calculations.	15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2

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

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

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

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

c. **Other Activities:**

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

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

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3	40	50	10
2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2	40	50	10
3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3	40	50	10
4.	Design a computer-controlled pick and place robot (wireless)	CO1, CO4	40	50	10
5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO3, CO4	40	50	10
7.	Design an unmanned arial photography system.	CO3, CO5	40	50	10
8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5	40	50	10
9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5	40	50	10
10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5	40	50	10
11.	Develop Obstacle avoidance robot Programming	CO1, CO5	40	50	10
12.	Program and simulate welding operation using robot simulation software.	CO1, CO5	40	50	10
13.	TPP / Offline program for drilling operation.	CO1, CO5	40	50	10
14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5	40	50	10
15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2, CO3	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
1.	6 Axis Articulated Robot (Material Handling)- 1 No	<ul style="list-style-type: none"> • Articulated Type • Controlled axis: 6-axes (J1, J2, J3, J4, J5, J6) • Reach: 717 mm • Installation Floor, Upside-down (Angle mount) • Motion range (Maximum Speed) <ul style="list-style-type: none"> • J1 Axis Rotation 7.85 rad/s • J2 Axis Rotation 6.63 rad/s • J3 Axis Rotation 9.08 rad/s 	1, 2, 3, 12

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		<ul style="list-style-type: none"> • J4 Axis Rotation 9.60 rad/s • J5 Axis Rotation 9.51 rad/s • J6 Axis Rotation 17.45ras/s • Max. load capacity Wrist: 4Kg • Allowable Load moment 16.6 N-m at wrist J4 Axis, J5 Axis, J6 Axis • Allowable Load inertia).47 kg-m² at wrist J4 Axis J5 Axis, J6 Axis • Repeatability: +/- 0.05mm • Mass: 21 Kg Minimum • Installation environment: Ambient temperature: 0 – 45°C • Ambient humidity: Normally 75%RH or less. No dew, nor frost allowed. • Vibration Acceleration: 4.9 m/s² (0.5G or less) 	
2.	6 Axis Articulated Robot (General Purpose-Welding, Assembly, Drilling) - 1 No	Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic Weight of robot: 50 Kg. Accuracy: ±0.3 Repeatability: ±0.2Tip Velocity range: 500 mm / minPay load capacity: 2 kg (including griper) J1 - Waist: ± 140°J2 - Shoulder: - 100 - 60°J3 - Elbow: - 70 + 10°J4 - Wrist rotate: ± 70°J5 - Wrist pitch: ± 35°J6 - Wrist roll: ± 180°External I/O8 Programmable digital inputs8 Programmable digital outputs	8, 9, 14
3.	A mounted vision system with software (Free open source Robot simulation software)	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from -40°C to 125°C (Analog Devices ADT7302)	3, 4, 5, 11
4.	6-axis Robotics Trainer	Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM 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"> • Fire Bird V 2560 Robot • Spark V Robot • Fire Bird V P89V51RD2 adapter card • Fire Bird V LPC2148 adapter card 	1, 3, 5, 6, 7, 10

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		<ul style="list-style-type: none"> • LSM303 3 axis digital accelerometer and 3 axes magnetometers • L3G4200 3 axis digital gyroscope • Gyroscope, accelerometer and GPS interfacing module for the robot • GPS receiver • Zigbee Modules 100m range • Zigbee Modules Adapter • Metal-gear Servo Motors • Servo Motor Based Gripper kit for the Fire Bird V robot • Sharp infrared range sensor (10cm to 500cm) • Arduino Uno/Nano • Hexapod • 16 Programming Software (AVR studio, Keil, AVR Boot loader, Flash Magic) 	
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

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
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
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
8. <https://www.youtube.com/watch?v=fH4VwTgfyRQ>
9. https://www.youtube.com/watch?v=aW_BM_S0z4k
10. <https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud>
11. <https://robots.ieee.org/robots/?t=all>
12. https://www.youtube.com/watch?v=fc_Cynqr6jM

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

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

- <https://www.edx.org/learn/robotics>
- <https://www.coursera.org/courses?query=robotics>
- <https://www.udemy.com/topic/robotics/>
- <https://library.e.abb.com/public/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
- <https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf>

- 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

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

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

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

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

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

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.

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.

2. Visits:

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

3. Self-learning topics:

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 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
Total	48	-	70	20	19	31

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

O) Suggested Assessment Table for Laboratory (Practical):

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.

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400604J	Optical Fiber and 5G Communication (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

- 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

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

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

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

e. **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.

f. Other Activities:

g. 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"

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

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

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

Legend:

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

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions 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
Total	48	-	70	22	22	26

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

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

- A) **Course Code** : 2411605(P2411605/S2411605)
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 6th semester depending on the requirement of the programme. Through major project, students try to bring the industrial/real world problems in institutional setting, may be in collaboration/ networking with industries/field agencies/enterprises as per the requirement of different diploma programmes.

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & 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				
2411605	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)	
2411605	Major Project	-	-	20	30	50	100	200

Legend:

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

Note:

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

I) Suggested Implementation of Major Project:

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

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

The following steps are undertaken under the major project-

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

1.0 Design, Development and Execution of Major Project:

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

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

1.1 Unique Features of Major Project:

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

- Innovativeness
- Creativity
- Originality
- Pro-activeness
- Initiativeness
- Cost Effectiveness
- Resourcefulness
- Development of Soft Skills/Generic Skills
- Ethical Issues
- Environmental Considerations
- Simulated/Automated Industry's/Improvised Process

- Application or Utility in the World of Work.
- Relevance to the Curriculum
- Mapping of Outcomes of Project with Pos and PSOs (if applicable)
- Feasibility of Implementation of the Project

2.0 Quality of Project Report Writing and its Presentation:

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

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

2.1 Project Report Writing:

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

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

2.2 Presentation & Discussion:

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

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

2.3 Project's Potential:

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

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

J) Assessment of the Major Project:

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

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

Assessment Scheme for Major Project

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

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

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

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

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

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

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

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

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

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

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

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

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

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

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

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

a. Assignments:

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

b. Micro Projects:

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

c. Other Activities:

1. Seminar Topics:

- Emotional Intelligence.
- 21st Century Skills.
- Multitasking

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

3. Self-Learning Topics:

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point-(O)

Note:

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

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

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

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

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

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

R) Suggested Learning Resources:

(a) Books:

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

(b) Online Educational Resources:**1. 4-Year Plan for Career Success:**

https://eng.umd.edu/sites/clark.umd.edu/files/4%20Year%20Plan%20For%20Career%20Success_Categorized_1.pdf

2. CAREER DEVELOPMENT GUIDE https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/career_development_guide_may_2014.pdf

3. Tips for successful career planning [tips://www.aryacollege.in/tips-for-successful-career-planning-in-2021/](https://www.aryacollege.in/tips-for-successful-career-planning-in-2021/)

4. Career Planning – Complete Guide<https://www.mygreatlearning.com/blog/what-is-career-planning/>

5. Build Resume: <https://www.themuse.com/advice/how-to-make-a-resume-examples>

6. Build Resume <https://resumegenius.com/blog/resume-help/how-to-write-a-resume>

7. Body Language: <https://ubiquity.acm.org/article.cfm?id=3447263>

8. Group Discussions: <https://brightspeaking.com/en/how-to-effectively-participate-in-a-group-discussion/>

9. Carrier planning & goal setting: <https://www.hays.com.au/career-advice/career-development/setting-career-goals>

10. Carrier planning & goal setting: <https://www.thebalancemoney.com/step-by-step-guide-to-setting-career-goals-2059883>

11. Collaboration & teamwork: <https://www.indeed.com/career-advice/career-development/teamwork-and-collaboration>

12. Interview skills: <https://www.youtube.com/watch?v=IKCTS9dY4h4>

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

(c) Others: -

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

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

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

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

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

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

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

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

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

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

G) Teaching & Learning Scheme:

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Explain the difference between OER and other free educational materials.</p> <p><i>TSO 1b.</i> Describe the challenges and benefits of using OER in a class.</p> <p><i>TSO 1c.</i> Apply various aspects of evaluating OER before use</p> <p><i>TSO 1d.</i> Explain necessity to assess an OER's adaptability.</p> <p><i>TSO 1e.</i> Use preliminary search for open educational resource.</p> <p><i>TSO 1f.</i> Find OER using various resources.</p>	<p>Unit-1.0 Open Educational Resources</p> <p>1.1 OER - definition</p> <p>1.2 What is NOT OER.</p> <p>1.3 Benefits of using OER – Benefits to Students - Access to Quality Education</p> <p>1.4 OER - Benefits to Faculty - Use, Improve and Share, Network and collaborate with peers, Lower Cost, Improve access to information</p> <p>1.5 Challenges of Using OER – Subject Availability, Format and Material type availability, Time and Support availability</p> <p>1.6 Evaluating OER – a) Clarity, Comprehensibility, and Readability, b) Content and Technical Accuracy, c) Adaptability and Modularity, d) Appropriateness and Fit, e) Accessibility</p> <p>1.7 Finding Open Content - OER Search Scenario Filter by Usage Rights in Google, Repositories and Search Tools, Subject-specific Repositories</p>	CO1
<p><i>TSO 2a.</i> Explain benefits of copyright protection for creator</p> <p><i>TSO 2b.</i> Explain exceptions and limitations to copyright law</p> <p><i>TSO 2c.</i> List rights granted to copyright holders.</p> <p><i>TSO 2d.</i> Explain Exceptions and limitations to copyright law</p> <p><i>TSO 2e.</i> Explain Fair use/fair dealing apply to copyright</p> <p><i>TSO 2f.</i> Elaborate Public domain and how does it relate to copyright</p> <p><i>TSO 2g.</i> Elaborate penalties for copyright infringement.</p> <p><i>TSO 2h.</i> Explain copyright for digital content and the internet.</p> <p><i>TSO 2i.</i> Explain use of copyrighted works in education</p> <p><i>TSO 2j.</i> Explain the use of free licenses</p>	<p>Unit-2.0 Copyright and Open Licensing</p> <p>2.1 Copyright and what it does protect, benefits of copyright protection for creators, duration of copyright protection last, rights granted to copyright holders.</p> <p>2.2 Exceptions and limitations to copyright law, fair use/fair dealing apply to copyright</p> <p>2.3 Public domain and its relation to copyright.</p> <p>2.4 Penalties for copyright infringement</p> <p>2.5 Apply copyright to digital content and the internet</p> <p>2.6 Use of copyrighted works in education.</p> <p>2.7 Open Licenses – GNU – Free Documentation license, Free Art License</p> <p>2.8 Why Free Licenses – Retain, Reuse, Revise, Remix, Redistribute</p>	CO2

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 3a.</i> Describe the four different Creative Commons License components.</p> <p><i>TSO 3b.</i> Explain the reason some CC-licensed content might not be considered OER.</p> <p><i>TSO 3c.</i> Explain the Strength and weakness of four Open CC Licenses</p> <p><i>TSO 3d.</i> Choose the right Creative Commons license for work.</p> <p><i>TSO 3e.</i> Apply a Creative Commons license to existing work.</p> <p><i>TSO 3f.</i> Use of Creative Commons licenses for commercial purposes.</p> <p><i>TSO 3g.</i> Modify a work licensed under Creative Commons.</p> <p><i>TSO 3h.</i> Revoke a Creative Commons license, combine works with different Creative Commons licenses</p> <p><i>TSO 3i.</i> Differentiate between Attribution and Citation</p>	<p>Unit-3.0 Creative Common Licenses</p> <p>3.1 Alternatives to copyright as Creative Commons licenses.</p> <p>3.2 Four components of creative common Licenses – Attribution, Share- Alike, Non – commercial, No Derivatives</p> <p>3.3 Choosing a Creative common licenses – Wiley’s 5 Rs and Creative Common Licenses</p> <p>3.4 Four Open CC Licenses and Their Strengths and Weaknesses – (a) CC BY (b) CC BY SA (c) CC BY NC (d) CC BY NC SA</p> <p>3.5 Attribution Vs Citation - Creative Commons licensed work without giving attribution</p> <p>3.6 Apply a CC License - choose the right Creative Commons license for work, apply a Creative Commons license to existing work, Creative Commons licenses be used for commercial purposes, modify a work licensed under Creative Commons, revoke a Creative Commons license, combine works with different Creative Commons licenses</p>	<p>CO3</p>

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

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

a. Assignments:

Related to Open Educational Resources – CO1

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

Related to Copyright – CO2

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

Related to Creative Common Licenses – CO3

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

b. Micro Projects:

1. Collect information on the impact of OER on cost savings and student engagement.
2. Search at least four OER related to topic of your Engineering Discipline over Internet. Evaluate the material based on the relevance, accuracy and usability.
3. Explore the different types of resources under creative Commons licenses (e.g., CC BY, CC BY-SA, CC BY-NC, etc.) and their specific permissions and restrictions.
4. Create a comparative analysis chart or infographic that visually represents the key characteristics of each license.
5. Select minimum 5 real-world examples from different domains (such as music, art, literature, or education) where creators have used Creative Commons licenses.

c. Other Activities:

1. Seminar Topics:
 - OER Quality Assurance
 - OER Repositories and Platforms
 - Creative Commons and Digital Media
 - Creative Commons in the Visual Arts
 - Examine the legal implications of using Creative Commons licenses, including the obligations and responsibilities of both creators and users and present it.
2. Self-Learning Topics:
 - Open Licensing and Copyright: Understanding the Legal Framework for OER
 - Creative Commons and the future of Copyright
 - Copyright and Open Access Publishing
 - Copyright and Software

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications
2.	Internet	Internet Connectivity

N) Suggested Learning Resources:

(a) Books:

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

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

(b) Online Educational Resources:

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

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