Curriculum of Diploma Programme

in

EV Technology

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

State Board of Technical Education (SBTE), Bihar

Semester – V

Teaching & Learning Scheme

Course Codes	Category of Course	Course Titles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2469501	**PCC**	**EV Batteries and Charging System**	03	-	04	02	09	06
2420502	**PCC**	**Solar & Wind Power Technology**	03	-	04	02	09	06
2469503	**PCC**	**EV Component Manufacturing Process**	03	-	-	02	05	04
2400504	**OEC**	**Open Electives*/ COE** (Basic - Any One)	03	-	04	02	09	06
2400505	**NRC**	**Entrepreneurship Development & Start ups** (Common for All Programmes)	-	-	04	02	06	03
2420506	**PSI**	**Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes)	-	-	02	04	06	03
2420507	**PSI**	**Minor Project** (Common for all programmes)	-	-	02	02	04	02
Total			**12**	**-**	**20**	**16**	**48**	**30**

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

Legend:

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

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

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

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

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

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

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

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

Semester - V
Assessment Scheme

Course Codes	Category of course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2469501	**PCC**	**EV Batteries and Charging System**	30	70	20	30	20	30	200
2420502	**PCC**	**Solar & Wind Power Technology**	30	70	20	30	20	30	200
2469503	**PCC**	**EV Component Manufacturing Process**	30	70	20	30	-	-	150
2400504	**OEC**	**Open Electives*/ COE** (Basic - Any One)	30	70	20	30	20	30	200
2400505	**NRC**	**Entrepreneurship Development & Start ups** (Common for All Programmes)	-	-	20	30	20	30	100
2420506	**PSI**	**Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes)	-	-	20	30	20	30	100
2420507	**PSI**	**Minor Project** (Common for all programmes)	-	-	10	15	10	15	50
Total			**120**	**280**	**130**	**195**	**110**	**165**	**1000**

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

Legend:

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

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

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

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

Note:

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

A) Course Code : 2469501(T2469501/P2469501/S2469501)

B) Course Title : EV Batteries and Charging System

C) Pre- requisite Course(s) : Fundamental of EV

D) Rationale :

Automobile sector helping the overall for overall development and it create the wages and self-employment opportunity. EV technologist should have better fundamental knowledge on electrochemical energy storage systems considering the operation and design of various battery technologies. This course is designed to enable the students to understand the requirement of batteries for automotive application combined with environment policy considerations.

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** Define various battery terminology and establish the relation between them.
- **CO- 2** Evaluate the performance of battery on the basis of various performance parameters and chemical reactions.
- **CO- 3** Select material for battery construction by understanding the functions and working of electrochemical cell.
- **CO- 4** Select the battery for a given purpose by understanding the recent trends and advances in battery technology.
- **CO- 5** Illustrate the requirements of battery systems for automotive applications and understand the modelling of battery 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	1	-	-	-	-
CO-2	3	3	1	2	1	-	-	-	-
CO-3	3	3	1	2	2	-	1	-	-
CO-4	3	3	-	3	1	1	1	-	-
CO-5	3	3	2	1	3	1	2	-	-

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

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

G) Teaching & Learning Scheme:

Course Code	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				
2469501	EV Batteries and Charging system	03	-	04	02	09	06

Legend:

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H) Assessment Scheme:

Course Title	Course Title	Assessment Scheme (Marks)						
		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)	
2469501	EV Batteries and Charging system	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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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), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) 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: T2469501

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a: Identify the different types of batteries (primary and secondary) and their applications. *TSO 1b:* Explain the function of reversible electrodes and their significance in achieving equilibrium in electrochemical cells. *TSO 1c:* Interpret the relationship between free energy changes (ΔG) and the cell's electromotive force (E). *TSO 1d:* Identify key limitations in existing battery technologies, including energy density, cost, and safety concerns. *TSO 1e:* Define fundamental battery-related terms, including cell, battery, nominal voltage, and capacity.	**Unit 1.0 Introduction to Electrochemical energy storage and Battery Terminology:** 1.1 Introduction to battery technologies 1.2 Electromotive force- Reversible cells- Reversible electrodes 1.3 Relation between electrical energy and energy content of a cell-Free energy changes and electromotive force in cell 1.4 Current challenges in Energy storage Technologies 1.5 Battery Terminology: Cells, Battery, Nominal Voltage and Capacity, C-Rate, Energy and Power, Cells in series and parallel.	**CO1**
TSO 2a: Discuss methods and equipment used to evaluate battery performance, including capacity tests and load tests. *TSO 2b:* Apply the understanding of service time and load curves to practical scenarios like low-power electronic devices. *TSO 2c:* Investigate the temperature variations impact on the chemical reactions within a battery. *TSO 2d:* Relate discharge characteristics to practical applications in renewable energy systems, EVs, and UPS systems. *TSO 2e:* Study the construction and components of lead-acid batteries, including electrodes, electrolyte, and separators.	**Unit 2.0 Battery Chemistries:** 2.1. Battery performance evaluation 2.2. Primary battery Service time- Voltage data- Service life – ohmic load curve 2.3. Effect of operating temperature on service life – other characteristic curves 2.4. Secondary batteries- Discharge curves - Terminal voltages Plateau voltage 2.5. Lead acid Batteries – Construction and application	**CO2**
TSO 3a: Explains the role of the negative/positive electrode in releasing/accepting electrons during discharge and accepting/releasing them during charging. *TSO 3b:* Explains the role of ions in the electrolyte moving from the cathode to the anode during charging and vice versa during discharging. *TSO 3c:* Describes the function of Battery Management Systems (BMS) in monitoring and regulating charge levels. *TSO 3d:* Identify materials for electrochemical cell for a given application and discuss their importance.	**Unit 3.0 Electrochemical Cell:** 3.1 Function of parts: Negative electrode, positive electrode, electrolyte, separator and current collectors 3.2 Charging and discharging procedure 3.3 Overcharge and undercharge 3.4 Charging modes 3.5 Materials for electrochemical cell 3.6 Examples of electrochemical cells	**CO3**

TSO 3e: Identifies common types of electrochemical cells and highlight their applications and distinguishing features.		
TSO 4a: Describe challenges such as safety, scalability, and cost associated with new electrode materials. *TSO 4b:* Explain types of solid electrolytes: ceramic-based (garnet, sulfides) and polymer-based, and their respective advantages. *TSO 4c:* Define polymer solid electrolytes (PSEs) and their mechanism of lithium-ion conduction. *TSO 4d:* Illustrate about the structural construction of thin-film batteries, including the deposition of electrodes, solid electrolytes, and current collectors. *TSO 4e:* Explore the construction and applications of super capacitors in energy storage, regenerative braking systems, and portable electronics due to their high-power density and fast charging.	**Unit 4.0 Recent Technologies** 4.1 Recent development of electrode materials in lithium ion batteries 4.2 Recent development of solid electrolytes and their application to solid state batteries 4.3 Polymer solid electrolytes for lithium ion conduction 4.4 Construction and state of art of Thin Film Batteries 4.5 Super Capacitors: Fundamental, Construction and application	**CO4**
TSO 5a: Define and distinguish the various levels of vehicle electrification, including ICE, MHEV, HEV, PHEV, BEV, and FCEV. *TSO 5b:* Identify battery capacity requirements for different vehicle categories such as city EVs, sedans, SUVs, and commercial vehicles. *TSO 5c:* Discuss the importance of USABC and DOE targets in advancing EV adoption and addressing performance Constraints. *TSO 5d:* Study advanced modelling techniques for battery life prediction under various conditions. *TSO 5e:* Describe environmental challenges, carbon footprint and energy intensity of battery manufacturing processes.	**Unit 5.0 Batteries for Automotive – Future prospect** 5.1 Degrees of vehicle electrification 5.2 Battery size vs. application 5.3 USABC and DOE targets for vehicular energy storage systems 5.4 Analysis and Simulation of batteries - Equivalent circuit and life modelling 5.5 Environmental concern in battery production 5.6 Environmental concerns in recycling of batteries	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2469501

Practical/Lab Session Outcomes (LSOs)	Sr. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Measure the EMF of electrochemical cells using a potentiometer and understand the principles behind non-invasive voltage measurement techniques. LSO 1.2 Analyze experimental data, compare it with theoretical values, and validate the reliability and precision of the potentiometer for electrochemical measurements.	1.	Measure and analyze the EMF of reversible cells using a potentiometer.	CO1

Practical/Lab Session Outcomes (LSOs)	Sr. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Set up cells in series and parallel configurations, measure their nominal voltage and capacity, and understand the effects of these arrangements on overall performance. LSO 2.2 Evaluate the impact of varying C-rates on cell performance and capacity, gaining insights into practical battery operation and energy delivery in different applications.	2	Set up cells in series and parallel, and measure nominal voltage, capacity, and C-rate with different configurations.	CO1
LSO 3.1 Measure and analyze the discharge characteristics of a primary battery under varying load conditions, understanding the relationship between load and battery performance. LSO 3.2 Assess the impact of different discharge loads on battery life and efficiency, and draw conclusions about the suitability of primary batteries for various applications based on experimental data.	3	Measure and analyze discharge characteristics of a primary battery under different loads.	CO2
LSO 4.1 Identify various components of lead-acid battery LSO 4.2 Use suitable tools for assemble lead acid battery. LSO 4.3 Assemble a basic lead-acid battery, understand its internal components, and explain the chemical reactions involved during charging and discharging processes. LSO 4.4 Demonstrate and analyze the charging and discharging behaviour of a lead-acid battery, including parameters like voltage, current, and state of charge, to assess its efficiency and performance.	4	Assemble a basic lead-acid battery and demonstrate its charging and discharging process.	CO2
LSO 5.1 Disassemble a standard battery and identify the key components such as electrodes, electrolytes, and separators, understanding their individual functions within the battery. LSO 5.2 Analyze the role of each component in the electrochemical reactions and overall performance of the battery, gaining insights into battery design and operation.	5	Disassemble a standard battery to identify and analyze the function of electrodes, electrolytes, and separators.	CO3
LSO 6.1 Record and analyze the charge-discharge cycles of a rechargeable cell, understanding the relationship between cycle performance and battery life. LSO 6.2 Calculate the efficiency and capacity fade of a rechargeable cell over multiple cycles, gaining insights into the degradation patterns and long-term performance of the cell.	6	Record the charge-discharge cycles of a rechargeable cell and calculate efficiency and capacity fade.	CO3
LSO 7.1 Compare the electrochemical properties of different electrode materials. LSO 7.2 Evaluate the impact of materials on battery performance.	7	Investigate and compare electrode materials (e.g., graphite, lithium cobalt oxide) in terms of electrochemical properties.	CO3
LSO 8.1 Fabricate a solid-state electrolyte. LSO 8.2 Test and evaluate the ionic conductivity of the electrolyte.	8	Fabricate and test the ionic conductivity of a solid-state electrolyte.	C04

Practical/Lab Session Outcomes (LSOs)	Sr. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 9.1 Prepare a polymer-based electrolyte for lithium-ion conductivity testing. LSO 9.2 Measure and analyze the lithium-ion conductivity of the prepared electrolyte.	9	Prepare a polymer-based electrolyte and measure its lithium-ion conductivity.	CO4
LSO 10.1 Construct a miniature thin-film battery, understanding the layering process and material selection for its fabrication. LSO 10.2 Assess the voltage and capacity of the thin-film battery, analyzing its efficiency and performance characteristics.	10	Construct a miniature thin-film battery and evaluate its voltage and capacity.	CO4
LSO 11.1 Measure and assess the voltage and capacity of a thin-film battery under different conditions. LSO 11.2 Analyze the efficiency and performance characteristics of the thin-film battery, including its energy output and cycle life.	11	assess the voltage and capacity of the thin-film battery, analyzing its efficiency and performance characteristics.	CO5
LSO 12.1 create an equivalent circuit model for a lithium-ion battery, incorporating key components like resistance and capacitance. LSO 12.2 validate the circuit model using experimental data, comparing theoretical predictions with real-world battery performance.	12	Create an equivalent circuit model for a lithium-ion battery and validate it using experimental data.	CO5

L) Suggested Term Work and Self Learning: S2469501 Some sample suggested assignments, micro project and otheractivities are mentioned here for reference.

a. Assignments:

1. Write a detailed report on the evolution of battery technologies, highlighting key breakthroughs and current trends in electrochemical energy storage systems.
2. Describe the concept of electromotive force (EMF), reversible cells, and reversible electrodes, and illustrate with examples from different battery types.
3. Prepare a report on compare different methods for evaluating battery performance, such as charge/discharge cycles, efficiency, and longevity. Use specific examples from lithium-ion and lead-acid batteries.
4. Explore primary applications of lead acid battery in automotive and industrial fields.
5. Provide a detailed explanation of the function of each part of an electrochemical cell: the negative electrode, positive electrode, electrolyte, separator, and current collectors.
6. Describe the different charging modes (constant current, constant voltage, trickle charge) and their suitability for various battery types.
7. Research and provide a comprehensive overview of the materials used in the construction of electrochemical cells, including cathode and anode materials, electrolytes, and separators.
8. Discuss the construction and working principles of thin-film batteries. Provide examples of current applications and explore the future potential of thin-film technology.
9. Analyze recent advancements in electrode materials for lithium-ion batteries, such as silicon anodes, high-capacity cathodes, and their implications for battery performance.

Note: Some more 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 could be added by the concerned faculty:
- Create a visual model or simulation of a reversible electrochemical cell and explain the concepts of

electromotive force and reversible electrodes.

- Create a glossary and visual aids explaining key battery terminology like nominal voltage, capacity, C-rate, and energy versus power.
- Present the current challenges in energy storage technologies, such as efficiency, cost, and scalability.
- Design an experiment or simulation to evaluate how different operating temperatures affect the service life of a battery.
- Create a report or prototype that explains the construction, application, and limitations of lead-acid batteries in energy storage systems.
- Build a model or diagram of an electrochemical cell and explain the functions of each part: negative electrode, positive electrode, electrolyte, separator, and current collectors.

1. **Visits:**
   - Visit a manufacturing facility or lab focused on lead-acid batteries, explaining their construction, materials, and various industrial applications.
   - Visit a facility researching and producing solid-state batteries, discussing advantages, challenges, and future prospects.
   - Tour a battery manufacturing plant, covering the process from individual cells to battery packs for various applications.
   - Highlight quality control, safety measures, and testing protocols during production.
   - Visit a recycling facility to understand the challenges and technologies involved in the recycling of batteries, especially lithium-ion and lead-acid batteries.
2. **Self-learning topics:**
   - Prepare journals based on practical performed in laboratory.
   - Use internet/ other sources to compare the different battery designs. Sketch the same. Prepare a report
   - Explore how artificial intelligence is being utilized in battery design.
   - Explore the latest developments in EV battery technology, its potential as a clean and efficient energy source
   - Prepare power point presentation or animation for understanding constructional details and working of EV battery system.

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

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

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant Cos Number(s)	Total Marks	ETA (Marks)		
				Remember ®	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Electrochemical energy storage and Battery Terminology	10	CO1	14	8	6	-
Unit-2.0 Battery Chemistries	10	CO2	14	4	6	4
Unit-3.0 Electrochemical Cell	10	CO3	14	5	5	4
Unit-4.0 Recent Technologies	8	CO4	14	6	4	4
Unit-5.0 Batteries for Automotive – Future prospect	10	CO5	14	4	6	4
Total	**48**	-	**70**	**27**	**27**	**16**

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 (Marks)		
			Performance		Viva-Voce(%)
			PRA(%)	PDA(%)	
1.	Measure and analyze the EMF of reversible cells using a potentiometer.	CO1	30	60	10
2.	Set up cells in series and parallel, and measure nominal voltage, capacity, and C-rate with different configurations.	CO1	40	50	10
3.	Measure and analyze discharge characteristics of a primary battery under different loads.	CO2	40	50	10
4.	Assemble a basic lead-acid battery and demonstrate its charging and discharging process.	CO2	40	50	10
5.	Disassemble a standard battery to identify and analyze the function of electrodes, electrolytes, and separators.	CO3	30	60	10
6.	Record the charge-discharge cycles of a rechargeable cell and calculate efficiency and capacity fade.	CO3	40	50	10
7.	Investigate and compare electrode materials (e.g., graphite, lithium cobalt oxide) in terms	CO3	30	60	10

	of electrochemical properties.				
8.	Fabricate and test the ionic conductivity of a solid-state electrolyte.	C04	40	50	10
9.	Prepare a polymer-based electrolyte and measure its lithium-ion conductivity.	CO4	40	50	10
10	Construct a miniature thin-film battery and evaluate its voltage and capacity.	CO4	40	50	10
11	assess the voltage and capacity of the thin-film battery, analyzing its efficiency and performance characteristics.	CO5	40	50	10
12	Create an equivalent circuit model for a lithium-ion battery and validate it using experimental data.	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.	Potentiometer	Precision device for measuring electromotive force (EMF) with high accuracy, typically used in electrochemical cells.	Measure and analyze the EMF of reversible cells using a potentiometer.
2.	Multi-channel Digital Multimeter	Multimeter with the ability to measure voltage, current, resistance, and capacity. Range: DC voltage: 200mV to 1000V DC, Current: 2mA to 20A DC, Capacity measurement.	Set up cells in series and parallel, and measure nominal voltage, capacity, and C-rate with different configurations.
3.	Primary Battery Setup with Load Testing Equipment	Primary battery (e.g., alkaline, zinc-carbon) with adjustable resistive load for testing under various conditions.	Measure and analyze discharge characteristics of a primary battery under different loads.
4.	Lead-Acid Battery Kit	Lead-acid battery with basic components: positive and negative electrodes, electrolyte, and a charging circuit.	Assemble a basic lead-acid battery and demonstrate its charging and discharging process.

5.	Battery Disassembly Kit	Tools for disassembling standard batteries, including cutters, tweezers, and magnifying equipment.	Disassemble a standard battery to identify and analyze the function of electrodes, electrolytes, and separators.
6.	Charge/Discharge Testing System	Equipment to record charge/discharge cycles of a rechargeable battery, including current/voltage control and measurement tools.	Record the charge-discharge cycles of a rechargeable cell and calculate efficiency and capacity fade.
7.	Electrochemical Testing System with Electrode Materials	System for testing electrochemical properties of various electrode materials (e.g., graphite, lithium cobalt oxide).	Investigate and compare electrode materials (e.g., graphite, lithium cobalt oxide) in terms of electrochemical properties.
8.	Solid-State Electrolyte Fabrication Kit	Materials and equipment for preparing and testing solid-state electrolytes (e.g., ceramic, glass).	Fabricate and test the ionic conductivity of a solid-state electrolyte.
9.	Polymer Electrolyte Fabrication Kit	Materials and tools for preparing polymer-based electrolytes and conductivity testing devices.	Prepare a polymer-based electrolyte and measure its lithium-ion conductivity.
10.	Thin-Film Battery Fabrication and Testing Equipment	Equipment for constructing thin-film batteries, including deposition systems for electrodes and electrolytes.	Construct a miniature thin-film battery and evaluate its voltage and capacity.
11.	Battery Testing Station (e.g., for thin-film batteries)	Testing system capable of measuring voltage, capacity, and performance characteristics of small-scale batteries.	Assess the voltage and capacity of the thin-film battery, analyzing its efficiency and performance characteristics.
12.	Equivalent Circuit Modeling Software (e.g., SPICE, MATLAB)	Simulation software for creating and analyzing the equivalent circuit model of lithium-ion batteries.	Create an equivalent circuit model for a lithium-ion battery and validate it using experimental data.

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electric Vehicle Technology	James Larminie, John Lowry	Wiley, 2nd Edition, ISBN-13: 978-0470026956
2.	Electric Vehicle Engineering	Ali Emadi	McGraw-Hill Education, 1st Edition, ISBN-13: 978-0071792120
3.	Fundamentals of Electric Vehicle Technology	Sandeep Dhameja	Woodhead Publishing, 2nd Edition, ISBN-13: 978-1855739903
4.	Electric and Hybrid Vehicles	Tom Denton	Routledge, 3rd Edition, ISBN-13: 978-1138614189
5.	Introduction to Electric Vehicle Technology	K. S. V. S. S. S. Prasad	CRC Press, 1st Edition, ISBN-13: 978-0367333044

(b) Online Educational Resources:

1. https://www.youtube.com/watch?v=ebWQC9yC2nk&list=PLQVGcyFvFGFNfOhOeEkD_JF_u581AgMaf
2. https://youtube.com/playlist?list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr&si=p87_Md4bL3I-aIXi
3. https://youtu.be/j9rXi1g40fM?si=lvvLHCELGzFoM3Op
4. https://youtu.be/PH1DR0c-jqw?si=mM5xMCjGDDMUyIOl
5. https://youtube.com/playlist?list=PLlYm0-AHZdZRLYSylFinxkspWmcgNvbtl&si=Z8AOeoPTlgqXgydG
6. https://youtube.com/playlist?list=PLdzIIxVTz4AsglVyHhZJ6Jj7tnpa3NL0n&si=g9iCGRzc-cWCIaax

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

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A) Course Code : **2420502(T2420502/P2420502/S2420502)**

B) Course Title : Solar & Wind Power Technology

C) Pre- requisite Course(s) : Basic Electronics Engineering and Basic Electrical Engineering, Power Electronics

D) Rationale :

In India, where many wind and solar grid connected electric power installations are in operation and supporting national grid by feeding electrical power to cope up the electric power demand of the country. Competent technicians to maintain these vital renewable energy power plants is a dire need of the industry. This curriculum has been designed to fulfill this need, so that the diploma engineer would be able to maintain the installations and thereby minimizing the downtime.

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. Install Solar PV systems with battery as per the requirement.
CO-2. Install different types of solar thermal system for the given application.
CO-3. Perform wind resource assessment of the identified site.
CO-4. Identify different components of wind power plants.
CO-5. Maintain small wind turbine 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/ Developmentof Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	2	3	2	2	2		
CO-2	3	3	3	3	2	2	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 the respective program coordinator at the institute level. As per the 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				
2420502	Solar & Wind Power Technology	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)	
2420502	Solar & Wind Power Technology	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: T2420502

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Define the given terms related to solar radiation and geometry. TSO.1b Describe the general arrangement of solar power plant. TSO.1c Explain the given type of solar cell Technologies. TSO.1d Interpret the V-I characteristics of a PV cell. TSO.1e Describe the series and parallel connection of solar panels. TSO.1f Explain the given term(s) related to battery used in solar PV system. TSO.1g Describe the sizing process of PV solar system for the given applications. TSO.1h Explain the working principle of converter used in solar PV system. TSO.1i Use maximum power point tracking system for tracking the maximum power generation. TSO.1j Describe the features of given type of solar PV system.	**Unit-1.0 Solar PV Systems** 1.1 Solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability. 1.2 Solar PV system, Block diagram and its components. 1.3 Solar Cell fundamentals, Technologies- Amorphous, monocrystalline, polycrystalline. 1.4 V-I characteristics of a PV cell, PV module, Panel, array. 1.5 Series and parallel connection PV Cell and panels. 1.6 Batteries: battery capacity, battery charging-rate, battery efficiency, energy and power density, 1.7 PV sizing for a given application 1.8 Power Electronic Converters for Solar Systems. 1.9 Maximum Power Point Tracking (MPPT). 1.10 Off grid and ON Grid solar system.	CO-1
TSO.2a Explain solar thermal energy systems. TSO.2b Explain Solar absorption and radiation. TSO.2c Explain the working principle of the given solar heating systems. TSO.2d Identify the components of the given solar water heating systems. TSO.2e Interpret the specifications of the given solar water heating systems. TSO.2f Describe the installation and maintenance procedure of the given solar water heating system. TSO.2g Explain the working principle of given type of solar cooking system. TSO.2h Describe the use of solar power for refrigeration and air conditioning.	**Unit-2.0 Solar Thermal Systems** 2.1. Solar thermal energy systems. 2.2. Solar absorption and radiation. 2.3. Solar heating systems: principle of conversion, operation of solar water heater, types of heating systems, components and specifications of solar water heating system, installation and maintenance. 2.4. Solar cooking system: principle of cooking, types of solar cooker (Box type, Dish type and heat transfer type). 2.5. Solar refrigeration and Air conditioning.	**CO2**
TSO.3a State the History of wind power, Indian and Global statistics. TSO.3b Calculate the relation between wind speed and power.	**Unit-3.0 Wind Resource Assessment** 3.1 History of wind power, Indian and Global statistics.	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3c Interpret the wind resources assessment. TSO.3d Explain the different types of monitoring station instrumentation. TSO.3e Interpret the data related to wind profile of a particular site. TSO.3f Maintain the monitoring station.	3.2 Energy and Power in Wind, Wind energy Dynamics. 3.3 Wind Resource assessment; • Initial Site identification • Wind speed measurement (Cup anemometer, Ultrasonic anemometer, Propeller Aerometer). 3.4 Monitoring station instrumentation: sensors, Data loggers, Data storage Devices, Tower sensors support hardware, grounding and lighting protection. 3.5 Data collection and analysis 3.6 Installation of monitoring station.	
TSO.4.a Interpret the basic block diagram of WECS. TSO.4.b Explain the given terms related to wind turbine technology. TSO.4.c Classify the given type of wind power plant based on the construction and capacity. TSO.4.d Explain the functions of the given WPP components. TSO.4.e Explain with sketches rotation principle of the wind turbine rotor.	**Unit-4.0 Wind Power Systems** 4.1 Block diagram of wind energy conversion systems (WECS). 4.2 Wind turbine terminologies: Cut-in, cut-out and survival wind speed, threshold wind speed, rated power, nominal power and wind power curve. 4.3 Types of wind power plant: small and large wind turbine, Horizontal and vertical axis, constant and variable speed, geared, direct drive and semi geared (hybrid) 4.4 Major parts and function of WPP: Rotor blades, hub, nacelle, tower, electric substation, nacelle layout of geared turbine, main shaft, electric generators, electronic control panel. 4.5 Rotation Principle: Lift and Drag principle, thrust and torque of wind turbine rotor.	**CO4**
TSO 5.1 Explain the working principle of SWT. TSO.5.2 Explain the working principle of electric generators used in SWT. TSO.5.3. Describe the SWT tower features. TSO.5.4 Describe the maintenance procedure of small wind turbine. TSO.5.5 Describe the maintenance procedure of given type of fault in SWT.	**Unit-5.0 Working of small wind turbines (SWT)** 5.1 Working of SWTs. 5.2 Electric generators in SWTs: permanent magnet synchronous generators, induction generators. 5.3 SWT towers: lattice tubular type, hydraulic towers, ladders, cables. 5.4 Maintenance of small wind turbine: • Installation of different types of small wind turbines (SWT). • Preventive maintenance of SWT components. • Common mechanical faults in SWTs. • Common electrical faults in SWTs.	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420502

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1. 1.Test the solar cell	1.	Testing of solar cell available in the laboratory	CO1
LSO 1. 2.Test the performance of PV cell, PV module and PV panel	2.	V-I characteristics of a PV cell, module and Panel.	CO1
LSO 1. 3. Connect the solar panels in series and parallel	3.	Series and parallel connection of solar cell.	CO1
LSO 1. 4.Test the battery for its performance	4.	Testing of batteries on No load and with load	CO1
LSO 1. 5.Connect solar panels for the desired load.	5.	Preparation of a solar PV array for 100 watt load using available panels.	CO1
LSO 1. 6.Connect solar inverter with solar PV system	6.	Connection of solar inverter with solar PV system.	CO1
LSO 1. 7.Install PV panel with battery for a given load	7.	Installation of PV panel with battery for a given load	CO1
LSO 1. 8.Install PV panel without battery for a given load	8.	Installing PV panel without battery for a given load	CO1
LSO 2.1. Dismantle solar cooker	9.	Dismantling solar cooker (Box type, Dish type and heat transfer type).	C02
LSO 2.2. Assemble solar cooker.	10.	Assembling solar cooker (Box type, Dish type and heat transfer type).	CO2
LSO 3.1. Draw the graph different speed and power for small wind power plant	11.	Tabulation of different speed and power for small wind power plant.	CO3
LSO 3.2. Measure of different wind speed using anemometer.	12.	Measurement of different wind speed using anemometer.	CO3
LSO 3.3. Explain the installation of monitoring station.	13.	Do the installation of monitoring station.	C03
LSO 4.1 Identify given parts of wind power plants	14.	Identification of given parts of wind power plants.	CO4
LSO 4.2 Identify specified parts inside the nacelle of small wind power plants	15.	Identification of specified parts inside the nacelle of small wind power plants.	CO4
LSO 5.1 Check the performance of PMSG.	16.	Test the performance of PMSG.	C05
LSO 5.2 Check the performance of Induction generator	17.	Test the performance of Induction generator.	C05
LSO 5.3 Simulate of mechanical faults in SWTs	18.	Simulation of mechanical faults in SWTs.	C05
LSO 5.4 Simulate of Electrical faults in SWTs.	19.	Simulation of Electrical faults in SWTs	C05
LSO 5.5 Maintain of small power wind turbine.	20.	Maintenance of small power wind turbine.	C05

L) Suggested Term Work and Self-Learning: S2420502 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

1. Carry out internet survey and prepare a report on installed capacity of solar and wind energy in India**.**
2. Carry out internet survey and prepare a report showing manufacturers of wind turbine and blades separately in India**.**
3. Carry out internet survey and prepare a report on material used to manufacturing solar panels.

b. Micro Projects:

i. Prepare a report on use of solar energy for various domestic and commercial applications.
ii. Prepare a report to address the maintenance of a solar power plant.
iii. Prepare a Case study to address the issues related to site selection of a wind power plant.

c. Other Activities:

1. Seminar Topics:
- Material used in manufacturing of solar PV Panels.
- Batteries used in Solar PV system.
- Global and Indian statistics of wind power.
- Generators used in wind turbine.

2. Survey
- Prepare a survey report on solar power plant capacity available in Bihar.
- Prepare a survey report on wind power plant capacity available in Bihar.

3. Visit
- Visit to a Solar power plants and submit report on the following aspects: a) Capacity, b) type of panels, c) type connections
- Visit to a wind power plant and submit report on the following aspects: a) Capacity, b) type of wind turbine c) types of generator.
- Use Video films/animation films on working of various types of wind power plants
- Use Video films/animation films on working of various types of solar power plants

d. Self-Learning Topics:

- Power electronics converter.
- Integration with smart grid.
- Hybrid power generation systems.
- Automatic control (SCADA and Vibration based).
- Hybrid solar and wind energy systems.
- http://www.windpowerwiki.dk/
- http://learn.kidwind.org/teach

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	Term Work & Self Learning Assessment	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	20%	20%	20%	33%	20%	20%
CO-2	20%	20%	20%	20%	33%	25%	20%
CO-3	20%	20%	20%	20%	34%	20%	20%
CO-4	25%	25%	20%	20%	--	20%	20%
CO-5	15%	15%	20%	20%	--	15%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-.1.0 The Solar PV Systems	8	CO1	14	4	5	5
Unit-.2.0 Solar Thermal Systems	12	CO2	15	4	5	6
Unit-.3.0 Wind Resource Assessment	10	CO3	15	4	5	6
Unit 4.0 Wind Power Systems	10	CO4	16	5	5	6
Unit 5.0 Working of Small Wind Turbines (SWT)	8	CO5	10	3	3	4
Total Marks	**48**	**-**	**70**	**20**	**23**	**27**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1.	Testing of solar cell available in the laboratory	CO1	50	40	10
2.	V-I characteristics of a PV cell, module and Panel.	CO1	50	40	10
3.	Series and parallel connection of solar cell.	CO1	50	40	10
4.	Testing of batteries on No load and with load	CO1	50	40	10
5.	Measurement of open circuit and short circuit voltage and current of solar PV cell.	CO1	50	40	10
6.	Preparation of a solar PV array for 100 watt load using available panels.	CO1	50	40	10
7.	Connection of solar inverter with solar PV system.	CO1	50	40	10
8.	Installation of PV panel with battery for a given load	CO2	50	40	10
9.	Installing PV panel without battery for a given load	CO2	50	40	10
10.	Dismantling solar cooker (Box type, Dish type and heat transfer type).	CO2	50	40	10
11.	Assembling solar cooker (Box type, Dish type and heat transfer type).	CO2	50	40	10
12.	Tabulation of different speed and power for small wind power plant.	CO3	50	40	10
13.	Measurement of different wind speed using anemometer.	CO3	50	40	10
14.	Do the installation of monitoring station.	C03	50	40	10
15.	Identification of given parts of wind power plants.	CO4	50	40	10
16.	Identification of specified parts inside the nacelle of small wind power plants.	CO4	50	40	10
17.	Test the performance of PMSG.	C05	50	40	10
18.	Test the performance of Induction generator.	C05	50	40	10
19.	Simulation of mechanical faults in SWTs.	C05	50	40	10
20.	Simulation of Electrical faults in SWTs	C05	50	40	10
21.	Maintenance of small power wind turbine.	C05	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.

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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.	Planetary Gearbox: Matching with 30/50/100/ 250 kW wind turbine second hand or new: 5 Nos	30/50/100/ 250 kW	**1-18**
2.	GFRP Wind Turbine blades: suitable for 10kW Wind turbines: 12 Nos	10kW	**1-18**
3.	3-bladed Geared Wind Turbine: 5/10/20/30 kW, Upwind with 20/30 m hydraulically operated tilt-up/tilt-down tubular tower or whichever lowest rating that is available in the market - 1 No.	5/10/20/30 kW	**1-18**
4.	Concentrated Solar Power (CSP) system - 5/10/20/30 kW or whichever lowest rating that is available in the market	5/10/20/30 kW	**1-18**
5.	Polycrystalline solar PV module: 10/20/30/30 or 50 W module or whichever lowest rating that is available in the market - 5 Nos. or whichever lowest rating that is available in the market - 5 Nos.	10/20/30/30	
6.	Wind (1kW) - Solar PV (1kW) Hybrid System complete in all aspects - 1 set	1kW	1, 6
7.	Non-motorised solar PV tracking systems -	200/300 or 500 W	14

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2014 ISBN-13. 978-9388028493
2.	Solar Photovoltaic: A Lab Training Module	Solanki, Chetan Singh, Arora, Brij M., Vasi Juzer, Patil, Mahesh B.	Cambridge University Press, New Delhi, 2009, ISBN- 9789382993254
3.	Solar Photovoltaic: Fundamentals, Technologies and Application	Solanki, Chetan Singh	PHI Learning, New Delhi, 2009 ISBN-10: 9788120351110 ISBN-13: 978-8120351110
4.	Wind Power Plants and Project Development	Earnest, Joshua and Wizelius, Tore	PHI Learning, New Delhi, 2011 ISBN-10: 8120351274 ISBN-13: 978-8120351271
5.	Introduction to Photovoltaics	John R. Balfour, Michael L. Shaw, Sharlave Jarosek	Jones & Bartlett Publishers, 2012, ISBN: 1449624731, 9781449624736

(b) Open Educational Resources:

- https://onlinecourses.nptel.ac.in/noc20_ee64/preview
- https://archive.nptel.ac.in/courses/108/108/108108076/
- https://nptel.ac.in/courses/122106025

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

(c) Others:

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

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A) Course Code : **2469503(T2469503/S2469503)**
B) Course Title : EV Component Manufacturing Process
C) Pre- requisite Course(s) :
D) Rationale :

The core automotive industry includes vehicle and components manufacturing industries which supports a wide range of business segments, both upstream and downstream, along with adjacent industries and leads to a multiplier effect for growth and economic development of nation. As a diploma engineer, students are supposed to manage operations of manufacturing in the industries. Therefore, they should have operational knowledge and skills to operate various machine tools to perform different types of manufacturing processes. This course enables students to know about various manufacturing processes used to manufacture various components of vehicles, to select proper tools and practices for working at workshop and also develops safety consciousness through performing job on machine tool.

E) Course Outcomes (COs): The underpinning knowledge and the relevant skills associated with this competency are to be developed in the student to display the following COs:

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

CO- 1 Select appropriate manufacturing process and associated tools based on its benefit to satisfy functional requirements of automobile components
CO- 2 Develop pattern and mould for the given casting process to produce casted various engine components
CO- 3 Use relevant Metal hot and cold Working Processes and methods for the given application.
CO- 4 Perform various metal joining processes (i.e. welding, soldering and brazing) for different materials in manufacturing auto components
CO- 5 Execute relevant surface treatment processes for required job.
CO- 6 Apply concept of modern manufacturing technology for green and sustainable growth of automobile industries.

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	-	-	-		
CO-2	3	-	-	3	-		-		
CO-3	3	-	-	3	-	2	-		
CO-4	3	3	-	2	-	-	-		
CO-5	3	2	2	3	-	2	3		
CO-6	3	2	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)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2469503	EV Component Manufacturing Process	03	-	-	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)

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	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2469503	EV Component Manufacturing Process	30	70	20	30	-	-	150

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

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 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), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) 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: T2469503

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a. Describe various manufacturing processes and its applications in automobile. TSO 1b. Describe working principles of common machine Tools. TSO 1c. Describe factors affecting the selection of suitable Machine tool.	**Unit-1.0 Basics of Manufacturing Processes** 1.1 Nature, role and scope of manufacturing process. 1.2 Classification, Selection and Applications of each manufacturing processes 1.3 Fundamentals of Basic Machine Tools 1.4 Working principle and operation of: lathe, milling, drilling, shaper, planer and grinding machine. 1.5 Factors affecting the selection of suitable Machine tool.	**CO1, CO5**
TSO 2a. Classify different types of patterns, pattern allowances, TSO 2b. Explain various types of molding sands and its properties TSO 2c. Describe the need of gating system. TSO 2d. Explain with sketches the working of melting furnaces TSO 2e. Observe various Casting defects and its remedial measures	**Unit-2.0 Metal Casting Processes** 2.1. Basics and classification of metal casting methods. 2.2. Working principles of sand casting 2.3. Types of patterns, allowances and pattern materials 2.4. Types of moulding sands and its properties. 2.5. Introduction about Gating system 2.6. Working of melting furnaces. 2.7. Casting defects & remedial measures.	**CO1, CO3**
TSO 3a. Classify metal working methods. *TSO 3b.* Describe principles and applications of different metal working processes in automobile. *TSO 3c.* Explain with sketches the usage of different forging tools and salient features of different forging methods. *TSO 3d.* Observe defects and its remedies in metal working process *TSO 3e.* Identify suitable Press machine for the given press operation with justification	**Unit-3.0 Metal Working Processes** 3.1 Fundamentals and classification of metal working methods. 3.2 Hot and cold working processes. 3.3 Working principles of: Rolling, Blanking, Piercing, Wire and Tube Drawing, Spinning, Forging, Bending, Embossing and Extrusion and applications of each processes in automobile. 3.4 Defects observed in cold and hot working processes & its Remedial measures. 3.5 Classification, construction and working principle of press machine. 3.6 Material used in press work for automobile industry.	**CO1, CO2, CO5**
TSO 4a. Describe different metal joining processes. *TSO 4b.* Identify appropriate metal joining process for the given jobs	**Unit-4.0 Metal Joining Processes** 4.1 Basics and classification of metal joining methods 4.2 Types of Welding joints	**CO1, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 4c. Explain working principle of welding process. *TSO 4d.* Describe principles, application and limitation of gas welding and arc welding. *TSO 4e.* Describe special welding processes. *TSO 4f.* Compare welding, soldering, brazing and braze welding. *TSO 4g.* Identify defects and remedial measures in the process of welding job	4.3 Working principles, application, and limitations of Gas Welding, Arc Welding, 4.4 Special welding processes such as TIG, MIG, friction welding, Resistance Welding, Laser beam welding and Electron beam welding. 4.5 Working principle of Soldering, Brazing and Braze Welding. 4.6 Defects and Remedial Measures in Welding.	
TSO 5a. Select the relevant surface cleaning process for the given materials. TSO 5b. Explain with sketches the relevant surface coating process for the given component. TSO 5c. Explain with sketches the relevant surface finishing process for the given component. TSO 5d. List the applications of the given surface treatment processes with justification.	**UNIT 5.0 Surface Treatment Processes** 5.1 Surface Cleaning Processes: acid alkaline, electrolytic cleaning, blasting and tumbling. 5.2 Metallic Surface Coating: Electroplating, Galvanizing, Metal Spraying and Powder Coating. 5.3 Surface finishing methods: honing, buffing, lapping and polishing.	**CO1, CO5**
TSO 6a. Compare conventional and non- TSO 6b. conventional manufacturing processes. TSO 6c. Explain need and role of automation in automobile industry. TSO 6d. Describe working principles of advance machine tools. TSO 6e. Illustrate working principle, application and limitations of various non-conventional manufacturing processes. TSO 6f. List applications of automatic material handling tools. TSO 6g. Describe Additive manufacturing.	**Unit-6.0 Modern Manufacturing Processes** 6.1 Classification, comparison between conventional and non- conventional machining processes 6.2 Need and Role of Automation in manufacturing of automobile industry. 6.3 Basic concepts of NC, CNC, DNC, CIM, GT, FMS. 6.4 Application of Automated Material handling tools like AGVs, AS/RS and Robots. 6.5 Working principles, applications, and limitations of Electrical Discharge Machining (EDM), Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Laser Beam Machining (LBM), Electron Beam Machining (EBM) 6.6 Classification, basic principles and need of Additive Manufacturing.	**CO1, CO6**

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

K) Suggested Term Work and Self Learning: S2469503 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 a casting process by using different types of patterns and estimate the cost.
2. Manufacture auto parts using appropriate metal forming process.
3. Weld two pieces of the same components using gas welding and arc welding and compare their strength, surface roughness, weight, and cost.
4. Use appropriate cutting fluids and lubricants in given situations for better machining.

c. Other Activities:

a) Seminar Topics:
- Usage of different forging tools and different forging methods.
- Metal casting processes and their industrial application
- Analysis of casting defects for quality improvement of sand casting.
- Recent development in welding process.
- Forging hammers, press and dies.
- Selection of cutting tool for machining of given material for better surface finish.
- Modern manufacturing processes (CNC and VMC)
- Additive manufacturing
- Automation in Auto component manufacturing technology

b) Visits: Visit nearby automobile Industry /Tool-room/plant which having casting, forming, welding, and machining facilities. Prepare report of visit of components produce by casting, forming, welding, machining, technique used, material used, single component/batch production/mass production and cost of component.

c) Self-Learning Topics:
- Prepare Display Board such as gas cutting kit, welding kit etc.
- Metal forming defects causes and its remedies.
- Explore advanced welding techniques and their applicable in automobile Industries.
- Industrial application of surface finishing operation such as honing, buffing & lapping
- Application of latest machining process such as Electrical Discharge Machining (EDM), Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Laser Beam Machining (LBM), Electron Beam Machining (EBM)

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	10%	-	-	-	-
CO-2	20%	20%	20%	25%	-	-	-
CO-3	20%	20%	20%	25%	30%	-	-
CO-4	20%	20%	20%	20%	30%	-	-
CO-5	15%	15%	15%	15%	15%	-	-
CO-6	15%	15%	15%	15%	25%	-	-
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 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.

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant Cos Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Basics of Manufacturing Processes	6	CO1, CO5	7	2	3	2
Unit-2.0 Metal Casting Processes	10	CO1, CO3	14	4	6	4
Unit-3.0 Metal Working Processes	10	CO1, CO2, CO5	14	4	6	4
Unit-4.0 Metal Joining Processes	10	CO1, CO4	14	4	6	4
Unit 5.0 Surface Treatment Processes	6	CO1, CO5	10	2	5	3
Unit-6.0 Modern Manufacturing Processes	6	CO1, CO6	11	4	4	3
Total	**48**	**-**	**70**	**20**	**30**	**20**

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

N) 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, 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.

O) Suggested Learning Resources:

Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Manufacturing technology volume 1	P. N. Rao	McGraw Hill Education ,2017 ISBN: 978-1259062575
2.	Manufacturing technology volume 2	P. N. Rao	McGraw Hill Education ,2018 ISBN: 978-353160524,9789353160524
3.	A Textbook of manufacturing Technology-1 and 2	Dr. pc. SHARMA	S. Chand,2011 ISBN:9788211928212
4.	A Textbook of manufacturing Technology-2	Dr. pc. SHARMA	S. Chand,2013 ISBN:9788211928465
5	Production technology	R.K Jain	Khana publishers,2021 ISBN:978-8195207565
6	Manufacturing science	Amitabha Ghosh, Ashok Kumar Mallik	East-west Press Pvt-Ltd,2010 ISBN:8176710636

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/112/107/112107219/
2. https://swayam.gov.in
3. https://auto.howstuffworks.com
4. https://tinyurl.com/mpvhf2as for video link
5. https://tinyurl.com/ms4pe636 for web link
6. https://www.youtube.com/watch?v=Kmb5tivQ_bY
7. https://www.youtube.com/watch?v=h-c4_Ukqgx4
8. http://www.youtube.com/watch?v=Kmb5tivQ_bY
9. https://www.youtube.com/watch?v=jk0Kap7afMc
10. https://www.youtube.com/watch?v=OOyAaWT6WQU
11. https://www.youtube.com/watch?v=BBqzca2gmNI
12. http://www.youtube.com/watch?v=U99asuDT97I
13. http://www.youtube.com/watch?v=RIbdYmmhPDI
14. https://www.youtube.com/watch?v=CoNw_faThgQ

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:

- Automation, Production Systems, and Computer- integrated Manufacturing; Prentice Hall
- Production Technology; Khanna Publication
- Lab Manuals

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

B) Course Title : Artificial Intelligence (Basic)

C) Pre- requisite Course(s) :

D) Rationale :

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

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

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

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

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

CO-1 Elaborate the use of Artificial Intelligence for the problem solving as Technological driver.

CO-2 Write Python Programmes for solving problems.

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504B	Artificial Intelligence (Basics)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400504B

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

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

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

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

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

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

Practical/ Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 4.1 Use built-in functions to solve given problem LSO 4.2 Create user defined functions to solve given problem	4	**Python Functions** 4a. Write a function to reverse a string. 4b. Write a function to calculate the factorial of a number.	CO-2
LSO 5.1 use basic data structure using NumPy LSO 5.2 Convert the list and tuple as NumPy array	5.	**Basic data structures in NumPy** 5a. Create a List, set, tuple and dictionary whichstores the details of a student (roll no, name, dept, branch, percentage of mark) inPython and print the values. 5b. Convert the list and tuple as NumPy array.	CO-3
LSO 6.1 Create Arrays in Numpy using different intrinsic methods LSO 6.2 Perform arithmetic operations and mathematical operations using arrange and ones intrinsic method.	6	**Arrays in NumPy** 6a. Create arrays using different intrinsic methods (ones, zeros, arange, linspace,indice) and print their values. 6b. Check the results of arithmetic operations like add(), subtract(), multiply() and divide()with arrays created using arrange and ones intrinsic method. 6c. Check the results of mathematical operations like exp(), sqrt(), sin(), cos(), log(), dot() on an array created using arrange intrinsic method.	CO-3
LSO 7.1 Apply aggregate functions on data by using Built-in function s in Numpy	7	**Built-in functions in NumPy.** 7a. Load your class Mark list data from a csv (comma separated value) file into an array. Perform the following operations to inspect yourarray. Len(), ndim, size, dtype, shape, info() 7b. Apply the aggregate functions on this data and print the results. (Functions like min(), max(), cumsum(), mean(), median(), corrcoef(), std())	CO-3
LSO 8.1 Handle multiple arrays by applying various operations on arrays	8	**Handling Multiple Arrays** 8a. Create two python NumPy arrays (boys, girls) each with the age of nstudents in the class. 8b. Get the common items between twopython NumPy arrays. 8c. Get the positions where elements of twoarrays match. 8d. Remove from one array those items thatexist in another. 8e. Extract all numbers between a given rangefrom a NumPy array.	CO-3
LSO 9.1 Apply indexing on the given set of data	9	**Indexing in NumPy** 9a. Load your class Mark list data from a csv fileinto an array. 9b. Access the mark of a student in a particularsubject using indexing techniques. 9c. Select a subset of 2D array using fancyindexing (indexing using integer arrays	CO-3
LSO 10.1 Create series using list and dictionary in pandas LSO 10.2 Print different values from series.	10	**Working with a Series using Pandas** 10a. Create a series using list and dictionary. 10b. Create a series using NumPy functions in Pandas. 10c. Print the index and values of series. 10d. Print the first and last few rows from the series.	CO-4
LSO 11.1 Perform various operation in a Data Frame rows	11	**Working with Data Frame Rows** 11a. Slicing Data Frame using loc and iloc.	CO-4

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

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

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

b. Micro Projects:

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

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

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

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

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

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

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

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

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

5. **Array Slicing in NumPy:**
   a. Load your class Mark list data into an array called “marks” to store students roll num, subject marks and result.
   b. Split all rows and all columns except the last column into an array called “features”.
   c. Split the marks array into 3 equal-sized sub-arrays each for 3 different subject marks.
   d. Split the last column into an array “label”.
   e. Delete the roll num column from the marks array and insert a new column student name in its place.

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

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

   a. Visualize the Histogram for each feature (Sepal Length, Sepal Width, petal Length & petal Width) separately with suitable bin size and color.

b. Plot the histograms for all features using subplots to visualize all histograms in one single plot.Save the plot as JPEG file.
c. Plot the box plots for all features next to each other in one single plot. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.

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

c. Other Activities:

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

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

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

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

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

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

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Artificial Intelligence	9	CO-1	14	6	5	3
Unit-2.0. Python Programming	12	CO-2	14	4	4	6
Unit-3.0. Data Analytics and Computing with NumPy	10	CO-3	17	4	5	8
Unit-4.0. Data Analysis with Pandas	10	CO-4	18	4	5	9
Unit-5.0. Data Visualization with Matplotlib	7	CO-5	7	2	2	3
Total Marks	**48**		**70**	**20**	**21**	**29**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Conditional and Iterative statements	CO-2	-	90	10
2.	String handling	CO-2	-	90	10
3.	List, Tuples and Dictionary	CO-2	20	70	10
4.	Python Functions	CO-2	-	90	10
5.	Basic data structures in NumPy	CO-3	-	90	10
6.	Arrays in NumPy	CO-3	-	90	10
7.	Built-in functions in NumPy.	CO-3	20	70	10
8.	Handling Multiple Arrays	CO-3	20	70	10

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
9.	Indexing in NumPy	CO-3	-	90	10
10.	Working with a Series using Pandas	CO-4	-	90	10
11.	Working with Data Frame Rows	CO-4	20	70	10
12.	Merge and combine data	CO-4	40	50	10
13.	Consider the Salary dataset, which contains 30 observations consisting of years of working experience and the annual wage.	CO-5	80	10	10
14.	Consider the Iris dataset, where observations belong to either one of three iris flower classes.	CO-5	80	10	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer Systems	Desktop Computers with i3 processor, 16 GB RAM, 512 GBHDD	S. No. 1 to 14
2.	Online Python IDE	https://www.online-python.com/	S. No. 1 to 14
3.	Jupyter Notebook	Download from https://jupyter.org/	S. No. 1 to 14
4.	Pip Python package manager	Download Pip 22.3 From https://pypi.org/project/pip/	S. No. 1 to 14
5.	Various modules, Libraries and Packages	NumPy, Pandas, Matplotlib, PyPlot package	S. No. 1 to 14

R) Suggested Learning Resources:

(a) Books:

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

(b) Online Educational Resources:

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

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

(c) Others:

Data Source:

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

*****

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

B) Course Title : Internet of Things (Basic)

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

D) Rationale :

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

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

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

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

CO-1 Describe the functions of each block of the basic IoT system

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

CourseCode	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504C	IoT (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant Cos Number (s)
LSO 1.1 List various IoT platforms. LSO 1.2 List Down broad features of given platforms. LSO 1.3 List IoT based features in python language.	1.	Prepare a list of platforms used for IoT. Prepare a list of features of above IoT platforms. Prepare a list of features provided by python language for IoT applications.	CO-1
LSO 2.1 Arduino connection with Arduino IDE. LSO 2.2 Connect Bluetooth with Arduino. LSO 2.3 Verification of data communication with Bluetooth.	2.	Establish connectivity between various components of IoT. Establish connection between Arduino and Bluetooth module. Establish connection using WiFi	CO-2
LSO 3.1 Measure the temperature of the givensensor. LSO 3.2 Measure the humidity of the given sensor. LSO 3.3 Measure the pressure of the given sensor.	3.	Publish data on the IoT platform. Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system. Measure the humidity of a remotely located humidity sensor Using IOT based humidity data-monitoring system. Measure the pressure of a remotely located pressure sensor Using IOT based pressure data-monitoring system.	CO-3
LSO 4.1 Working with APIs. LSO 4.2 Implementation of APIs using POSTMAN Application.	4	Download and Configure POSTMAN Application Verify REST APIs through POSTMAN. Verify JSON APIs through POSTMAN. Verify SOAP APIs through POSTMAN.	CO-4
LSO 5.1 Identification of components for variousapplications. LSO 5.2 Estimate the cost for components.	5.	Identify components for given project Estimate the cost to make Project working.	CO-5

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

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

b. Micro Projects:

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

c. Other Activities:

1. Seminar Topics: - "Future of IoT"
   "Technologies for IoT ", "Smart City and IoT"
2. Visit to industry for latest IoT setup in industrial process.
3. Surveys of market for availability of various types of sensors and its pricing.

4. Product Development: Development of projects for real life problem solution using IoT.
5. Software Development: various open source platform operations.

d. Self-Learning Topics:

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

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

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

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to IoT	5	CO-1	7	3	4	-
Unit-2.0. IoT Communication protocols	5	CO-2	7	3	2	2
Unit-3.0. Sensors and Hardware for IoT	14	CO-3	21	6	7	8
Unit-4.0 IoT APIs and its Integration	14	CO-4	21	6	5	10

Unit-5.0. IoT Applications	10	CO-5	14	2	4	8
Total Marks	**48**		**70**	**20**	**22**	**28**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Prepare a list of platforms used for IoT.	CO-1	60	30	10
2.	Prepare a list of features of above IoT platforms.	CO-1	60	30	10
3.	Prepare a list of features provided by python language for IoT applications.	CO-1	60	30	10
4.	Establish connectivity between various components of IoT.	CO-2	60	30	10
5.	Establish connection between Arduino and Bluetooth module.	CO-2	60	30	10
6.	Establish connection using WiFi	CO-2	70	20	10
7.	Publish data on the IoT platform.	CO-3	70	20	10
8.	Measure the temperature of a remotely located temperature sensorUsing IOT based temperature data-monitoring system.	CO-3	60	30	10
9.	Measure the humidity of a remotely located temperature sensor Using IOT based temperature data-monitoring system.	CO-3	60	30	10
10.	Measure the pressure of a remotely located temperature sensor UsingIOT based temperature data-monitoring system.	CO-3	60	30	10
11.	Publish the data using Mqtt	CO-4	60	30	10
12.	Download and Configure POSTMAN Applications	CO-4	60	30	10
13.	Verify REST APIs through POSTMAN.	CO-4	60	30	10
14.	Verify JSON APIs through POSTMAN.	CO-4	60	30	10
15.	Verify SOAP APIs through POSTMAN.	CO-4	60	30	10
16.	Identify components for given project	CO-5	50	40	10
17.	Estimate the cost to make Project working.	CO-5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1	Bluetooth Modem-BlueSMiRF Silver	Sparkfun Bluetooth modem	As mentioned above list
2	Postman Software	Open-source downloadable	
3	Node MCU board	Generic	
4	IoT free cloud	Arduino cloud/Thing Speak/Blynk	
5	ATAL Lab Package-1 Package-2 Package-4	As per the list as address below ATAL Equipment list' (http://aim.gov.in/guidelines-for-school.php).	

R) Suggested Learning Resources:

(a) Books:

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

(b) Online Educational Resources:

1. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
2. en.wikipedia.org/wiki/Shear and moment diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf

6. https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/
7. https://wiki.python.org/moin/TimeComplexity
8. www.engineerstudent.co.uk/stress_and_strain.html
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
10. Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work.
11. https://github.com/OpenRCE/sulley

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

(c) Others:

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

******

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

B) Course Title : Drone Technology (Basic)

C) Pre- requisite Course(s) :

D) Rationale :

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

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

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

CO-1 Operate a drone safely by applying appropriate drone rules and regulations.

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

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

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

CO-5 Use python programming while drone designing.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504D	Drone Technology (Basics)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400504D

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

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

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 8.1 Configure Flight control board (FCB) LSO 8.2 Demonstrate use of Flight control board (FCB	8.	Test and troubleshoot Flight control board (FCB).	CO-3
LSO 9.1 Measure various parameters of sensor LSO 9.2 Interface sensor with flight controller board.	9.	Test and perform communication of Flight control board (FCB) with sensor	CO-3, CO-2
LSO 10 Use motor with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with motor.	CO-3, CO-2
LSO 11 Interface ESC with flight controller board.	11.	Test and perform communication of Flight control board with ESC.	CO-3
LSO 12 Configure radio communication device to control drones	12.	Test and perform communication of Flight control board with RF transceiver.	CO-3
LSO 13.1 Identify different types of ports and connectors of drone. LSO 13.2 Assemble drone component.	13.	Test Hardware assembly for drone.	CO-4 CO-3
LSO 14.1 Identify different motions in drone simulator. LSO 14.2 Operate drone in simulator for specific task	14.	Perform different motion in drone simulator.	CO-4
LSO 15.1 Write code of loop and decision statement in python. LSO 15.2 Interpret loop and decision statement LSO 15.3 Debug code of loop and decision statement	15.	Build and run loops and decision statements for specific application in Python.	CO-5
LSO 16.1 Make function in python. LSO 16.2 Interpret given function statement LSO 16.3 Debug code of function in python	16.	Build and Run functions for specific application and pass arguments in Python.	CO-5
LSO 17.1 Identify python programming steps to interface drone components. LSO 17.2 Identify error in python program LSO 17.3 Debug the given python program	17.	Write basic programming in python to interface different component of Drones	CO-5, CO-3

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

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

b. Micro Projects:

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

c. Other Activities:

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

d. Self-Learning Topics:

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

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

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

Legend:

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

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

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant Cos Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to Drone Technology	6	CO-1	08	03	02	03
Unit-2.0. Drone and its component	12	CO-2	20	05	07	08
Unit-3.0. Drone controller and motion	12	CO-3	20	05	07	08
Unit-4.0. Connections and Interfaces of Devices in Drone and Drone Simulator	8	CO-4	08	03	02	03
Unit-5.0. Introduction to Python for Drone	10	CO-5	14	04	04	06
Total Marks	**48**		**70**	**20**	**22**	**28**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine the strength of materials used in drones frame.	CO-2	60	30	10
2.	Determine the strength of materials used in drones Propellers.	CO-2	60	30	10
3.	Test different parameters of batteries used in drones	CO-2	50	40	10
4.	Test motors suitable for specific Drone application.	CO-2	50	40	10
5.	Test and measure Gyro sensor and Accelerometer and their characteristics.	CO-2	50	40	10
6.	Test different sensors and their characteristics with Microcontroller based Flight controller board.	CO-2, CO-3	50	40	10
7.	Determine thrust/torque of motor by changing different dronemotion	CO-2, CO-3	60	30	10
8.	Test and troubleshoot Flight control board (FCB).	CO-3	60	30	10
9.	Test and perform communication of Flight control board (FCB) with sensor	CO-3, CO-2	60	30	10
10.	Test and perform communication of Flight control board (FCB) with motor.	CO-3, CO-2	60	30	10
11.	Test and perform communication of Flight control board with ESC.	CO-3	60	30	10
12.	Test and perform communication of Flight control board with RF transceiver.	CO-3	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
13.	Test Hardware assembly for drone.	CO-4 CO-3	50	40	10
14.	Perform different motion in drone simulator.	CO-4	50	40	10
15.	Build and run loops and decision statements for specific applicationin Python.	CO-5	50	40	10
16.	Build and Run functions for specific application and pass arguments in Python.	CO-5	50	40	10
17.	Write basic programming in python to interface different componentof Drones.	CO-5, CO-3	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Drone Frame	Tricopter/Quadcopter/Hexacopter	1-13
2.	Propellers	10X4.5 CW/Others	1-13
3.	Speed Sensor	3.3 or 5.0Vdc	1-13
4.	Distance Sensor	5Volt operating voltage	1-13
5.	Gyro sensor and Accelerometer	5Volt operating voltage	1-13
6.	Barometer	Altitude tracking, temp range from 25°C to 40°C	1-13
7.	TOF Sensor	Accurate ranging up to 4 m, Fast ranging frequency up to 50	1-13
8.	Battery	Lithium Polymer Battery,2200mAH/others	1-13
9.	Motor	BLDC,1000kv or 1000RPM/volt	1-13
10.	Electronic speed Controller (ESC)	30 Amp,2-4s or cell	1-13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
11.	Flight Controller Unit	KK 2.1.5/ ArdupilotAPM 2.8/ Pixhawk/others	1-13
12.	Transmitter and Receiver for radio signal	4 channels/6 Channels, 2.4 GHz & 5.8 GHz	1-13
13.	Drone Simulator Software	RC flight simulator	14
14.	Python Software	Hardware required-More than 4 GB RAM, 64-bitCPU preferable	15,16,17

R) Suggested Learning Resources:

(a) Books:

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

(b) Online Educational Resources:

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

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

(c) Others:

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

******

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

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

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

D) Rationale :

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

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

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

CO-1 Develop CAD models for 3D Printing.
CO-2 Import and Export CAD data in .STL file format to generate GCODE file.
CO-3 Select suitable FDM based 3D Printing material for given applications.
CO-4 Select suitable FDM based 3D Printing process parameters for given situations.
CO-5 Produce products using FDM based 3D Printing processes.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504E	3D Printing and Design (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400504E	3D Printing and Design (Basics)	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400504E

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4b. Estimate the cost and time of FDM based 3D printing of the given component.		
TSO 5a. Select suitable 3D Printer (FDM) and software for the given application with justification. *TSO 5b.* Analyze the effect of given FDM based 3D printing process parameters using 3D printer software simulation. *TSO 5c.* List steps to perform 3D scanning of the given object. *TSO 5d.* Repair 3D scanned digital model. *TSO 5e.* Set different FDM 3D printing process parameters to get a sound plastic component.	**Unit-5.0 3D Printers and Software and Scanners** 5.1 Construction details and working of established FDM based 3D printers for plastics parts. 5.2 Accuracy, Precision and Tolerance in 3D printing. 5.3 3D Printer software- Fusion 360, Solidworks, Onshape, Tinkercad, Ultimaker Cura, MeshLab, Simplyfy 3D, Repetier host, Slic3r, etc. – use and operation of anyone. 5.4 3D Scanners and working. 5.5 Producing a part using FDM based 3D Printer.	**CO4, CO5**

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

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 7.1. Select appropriate layer thickness, tolerance, fit. *LSO 7.2.* Produce an assembly of plastic components using available 3D printer.	7.	Print one assembly on available FDM based 3D printer with PLA/ABS material	CO3, CO4, CO5
LSO 8.1. Choose suitable material for printing flexible structure (assembly of same small pieces to give flexible fabric effect). *LSO 8.2.* Choose suitable design/shape to create a flexible type structure. *LSO 8.3.* Produce flexible plastic structure using available 3D printer.	8.	Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect)	CO3, CO4, CO5
LSO 9.1. Selection of 3D printing process parameters.	9.	Change printing process parameters and repeat experiment number 6.	CO4, CO5
LSO 10.1. Use of available 3D scanner. *LSO 10.2.* Develop 3D digital model using scanning approach. *LSO 10.3.* Modeling of complex 3D objects using 3D scanning.	10.	Scan the given complex component using available 3D Sanner.	CO5
LSO 11.1. Produce a complex plastic structure using available 3D printer and scanner. *LSO 11.2.* Apply Reverse Engineering approach to exactly 3D print an existing real object.	11.	Print the 3D scanned digital model of Pr. No. 10 on available FDM based 3D printer with PLA/ABS material	CO5

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

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

b. Micro Projects:

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

c. Other Activities:

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

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

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

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

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

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks) Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Additive Manufacturing Introduction and CAD	8	CO1	10	3	3	4
Unit-2.0 Data Preparation for 3D Printing	8	CO1, CO2	10	3	2	5
Unit-3.0 Additive Manufacturing Techniques	8	CO3, CO4	10	5	2	3
Unit-4.0 Application of 3D Printing	12	CO3, CO4	20	5	6	9
Unit-5.0 3D Printers and Software and Scanners	12	CO4, CO5	20	4	6	10
Total	**48**	**-**	**70**	**20**	**19**	**31**

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

O) Suggested Assessment Table for Laboratory (Practical):

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

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

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	High end computers	Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10	All
2.	Parametric Computer Aided Design software	CATIA/Solid works/NX/Creo **OR** Available with CoE	1,2
3.	3D printer	Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 **OR** Available with CoE	6, 7, 8, 10
4.	3D Printing Material	ABS/PLA **OR** Available with CoE	6, 7, 8, 10
5.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE	3,4
6.	Post processing equipments and tools	Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper etc.	6, 7, 8, 10
7.	3D Scanner and Processing software	Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software **OR** Available with CoE	10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074
2.	3D Printing and Design	Sabrie Soloman	Khanna Publishing House, Delhi ISBN: 9789386173768
3.	3D Printing and Rapid Prototyping- Principles and Applications	C.K. Chua, Kah Fai Leong	World Scientific, 2017 ISBN: 9789813146754
4.	Getting Started with 3D Printing: A Hands-on Guide to the Hardware, Software, and Services Behind the New Manufacturing Revolution	Liza Wallach Kloski, Nick Kloski	Make Community, LLC; 2nd edition, 2021 ISBN: 9781680450200

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://archive.nptel.ac.in/courses/112/104/112104265/
3. https://www.youtube.com/watch?v=b2Od4YHcLAQ
4. https://www.youtube.com/watch?v=EF8CNR-gcXo
5. https://www.academia.edu/41439870/Education_Resources_for_3D_Printing
6. https://www.think3d.in/landing-pages/beginners-guide-to-3d-printing.pdf
7. https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/

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

(c) Others:

1. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. 3D Printer Users' Guide
4. 3D Printer Material Handbook
5. Lab Manuals

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

B) Course Title : Industrial Automation (Basic)

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

D) Rationale :

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

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

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

CO-1 Apply principles and strategies for automation for a given situation.

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

CO-3 Test the given PLC for its functionality.

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504F	Industrial Automation (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
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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 (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon thecompletion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a Describe Industry 4.0 and its component TSO.1. b Explain different types of automation systems TSO.1.c Identify the type of automation used in a given industry TSO.1.d Analyze the working of industrial processes and products for automation. TSO.1.e Select principles and strategies for automation for a given situationusing 4R's and 1U TSO.1. f Select criteria for factory automation and processes automation for a given industry. TSO.1. g Describe briefly different systems used for industrial automation. TSO.1.h Describe IOT, IIOT and role of robots with respect to automation.	**Unit-1.0 Overview of Industrial Automation** Introduction to Industry 4.0 and its components, Issues and challenges in automation Need of automation in industries, Principles and strategies of automation, factory automation, process automation Basic elements of an automated system, Structure of Industrial Automation Advanced automation functions, Levels of automations Industrial control Systems- Process andDiscrete system Types of automation system: Fixed, Programmable, Flexible IntegratedAutomation and its application Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives. Introduction to Internet of Things (IoT) and Industrial Internet of Things (IIOT) and its application in Automation. Role of robots in automation and its components.	**CO1**
TSO.2. a Explain PLC and list its advantages over relay systems. TSO.2.b Distinguish between PLC and a PC, PLC and dedicated controllers. TSO.2.c List the types of PLCs and brands available in the market. TSO.2.d Describe the function of each block of a PLC with the help of a block diagram. TSO.2.e Describe the basic sequence of operation of a PLC with a simple example. TSO.2.f Explain different PLC programming languages withsimple examples. TSO.2.g Describe a simple PLC programming using ladder logic specifying I/O addressing TSO.2.h List the applications of PLC	**Unit-2.0 Fundamentals of PLC** Introduction to PLC, evolution of PLC • Comparison of PLC and Personal Computer(PC) • Comparison of PLC and dedicated controllers like PAC and CNC • Types of PLC – Fixed, Modular and their types • Different brands of PLCs available in the market Building blocks of PLC -CPU, Memory organization, Input-Output modules (Discreteand Analog) Specialty I/O Modules, Power supply PLC programming languages with simpleexamples: • Functional Block Diagram (FBD), • Instruction List. • Structured text, • Sequential Function Chart (SFC), • Ladder Programming PLC I/O addressing in ladder logic Simple programming example using ladderlogic Applications of PLC: Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature control, Conveyor system control	**CO2**
TSO.3.a Identify the commonly used input field devices in PLC installations along with their symbols. TSO.3.b Draw symbol of various switches used in PLC installations describing the function of each switch. TSO.3.c Identify the various digital input devices used in a PLC installation. TSO.3.d Identify the commonly usedsensors as input field devices found in PLC	**Unit 3.0 – Sensors and Input field devices** Analog input devices-Electromagnetic relays, Contactors, Motor starters, Manually operated Switches Toggle switch, pushbutton switch, knife switch and selector switches Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
installations. TSO.3.e Describe the working of different types of discrete sensors giving their applications. TSO.3.f Describe the working of different types of advanced sensors giving their applications. TSO.3.g Select Sensors as per the given requirement for ecofriendly automation	Discrete/Digital Input device, Constructionand working of Sensors • Proximity sensors- Inductive, Capacitive, Optical and ultrasonic Advanced sensors- Construction and workingof • Temperature sensors- Thermistor, Thermocouple and Resistance temperature Detector (RTD) • Liquid level sensor -Capacitive and Ultrasonic • Force -Strain/Weight sensors • Flow sensors – turbine flow sensor • Pressure sensors- Linear Variable Differential Transformer (LVDT) • Inclination sensor -Inclinometer • Acceleration sensor- Accelerometer Angular and linear position sensor	
TSO.4.a Classify the actuators. TSO.4.b Describe the construction and working of a given actuator. TSO.4.c Explain the basic principle of operation of a given actuator. TSO.4.d Differentiate between hydraulic and pneumatic actuators TSO.4.e Explain the basic principle of operation of a given control valve. TSO.4.f Select actuators and valves as per the given requirement for ecofriendly automation. TSO.4.g Develop different hydraulic and pneumatic circuits for simple application. TSO.4.h Identify the commonly used output field devices in PLC installations TSO.4.i Draw the symbol of various output devices used in PLC installations describing the function of each. TSO.4.j Select output devices for a PLC installation as per the requirement.	**Unit 4.0- Actuators and output devices** Introduction to actuators, Classification ofactuators Mechanical actuators -Translational and rotation motion, kinematic chains,cams, gears, belt and chain drives, bearings Hydraulic and Pneumatic actuators- linear and rotary actuators, single and doubleacting cylinder, directional, process and pressure control valves Electrical actuators • Electromechanical actuators Construction, working and application of Stepper motors, AC/DC Servo motors,BLDC Motor (Very brief) • Electrohydraulic actuators-Construction, working and application of Electro- hydrostatic actuator (EHA), ON/OFF Electro-hydraulic Rotary Actuator (E2H90, Control Valve Rotary Actuator (E2HR), Solenoid valve Thermal actuators -Construction, workingand application of Hot-And-Cold-Arm Actuators, Chevron-Type Actuators Magnetic actuators- Construction, working principle and application of Moving coil actuators, moving magnet actuator, Moving iron actuator Selection criteria of actuators Other Output devices- Indicators, Alarms Pilot Lights, Buzzers, Valves, Motor starters, Horns and alarms, Stack lights Control relays,Pumps and Fans.	**CO4**
TSO.5.a Describe the basic process control system with the help of a block diagram TSO.5.b Explain the types of control available in a process control TSO.5.c Describe the different types of controllers in a closed loop systemwith the help of a block diagram TSO.5.d Describe the construction, working and application of a given control system components.	**Unit 5.0– Control System** Block diagram of a basic control system Open and closed loop system, their transfer function First order and second order system and their output response and parameters Different types of inputs-step and ramp Types of control – On-off, Feed forward, Open loop and closed loop control and Transfer function Controllers in closed loop control	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	• Proportional Controller (P Controller) • Integral Controller (I Controller) • Derivative controller (D- Controller) • P-I Controller • P-D Controller PID Controller	

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify various building blocks and major automation components in a given robotic system LSO 1.2 Identify various building blocks and major automation components in a given electrical drives	1.	Identify major automation components in a given system	CO1
LSO 1.3 Analyze and plan the steps to automate the given system.	2.	Analyze given traditional machine in the laboratory for and identify thesteps and components required to automate it.	
LSO 1.4. Identify the building blocks of a given typical SCADA system LSO 1.5. Identify the symbol library of SCADA software	3.	Use Scada software for simple application	
LSO 2.1 Identify the various parts and front panel status indicators of the given PLC.	4.	Observe various parts and frontpanel indicators of a PLC	CO2
LSO 2.2 Identify different input and output devices that can be connected to a given PLC.	5.	Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC	
LSO 2.3 Test the analog input and output lines of the given PLC.	6.	Identify Analog input and output lines of a PLC	
LSO 2.4 Test the digital input and outlines of the given PLC.	7.	Identify digital input and output lines of a PLC	
LSO 2.5 Use PLC to control the devices like Lamp, Alarm, motor using push button switches	8.	Practice using PLC to control various digital and analog output devices	
LSO 3.1. Test the response of digital inductive proximity sense or used to detect different types of materials	9.	Identify different types of digital inductive proximity sensor and itsuse	CO3
LSO 3.2. Test the response of digital capacitive proximity sensors used to detect o different materials	10.	Identify different types of digital capacitive proximity sensor and itsuse	
LSO 3.3. Test the response of digital optical proximity sensor used to detect different materials	11.	Identify different types of digital optical proximity sensor and its use	
LSO 3.4. Test the response of digital ultrasonic proximity sensors used to detect different materials	12.	Identify different types of digital ultrasonic proximity sensor and itsuse	
LSO 3.5. Use thermistor to measure temperature of a given material	13.	Identify different types ofthermistor and its use	
LSO 3.6. Use Thermocouple to measure the temperature of a given liquid and plot the output voltage versus temperature	14.	Observe the conversion of temperature to electric parameter conversion of a Thermocouple	
LSO 3.7. Use RTD to control the temperature of an oven	15.	Observe different types of RTDs usedin industries for temperature	

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		measurement	
LSO 3.8. Use flow sensors to measure the flow of a given liquid or gas	16.	Observe different types of flow sensors used in industries for flow measurement	
LSO 3.9. Use pressure sensors to measure the pressure of a liquid or gas	17.	Observe different types of pressure sensors used in industries for pressure measurement	
LSO 3.10. Use load cell for measurement of mechanical force/weight.	18.	Observe the different types of loadcell used in industries for force/weight measurement	
LSO 4.1 Design and actuate pneumatic circuit for lift control LSO 4.2 Design a pneumatic system that rivets the pockets on jeans LSO 4.3 Design pneumatic circuit to open and close the security gate and control the speed. LSO 4.4 Design a circuit for speed control of hydraulic motor meter out circuit by using 4/3 DC valve. LSO 4.5 Design a circuit for speed control of double acting cylinder meter in by using 4/2 dc solenoid valve. LSO 4.6 Designing a circuit for speed control of double acting cylinder meter out by using 4/3 solenoid valve	19.	Design and actuate pneumatic/ hydraulic circuit for the given situation	CO4
LSO 4.7 Direct acting of hydraulic motor	20.	Operate hydraulic motor	
LSO 4.8 Operate stepper motor and control the motor by changing number of steps, the direction of rotation and speed.	21.	Operate stepper motor	
LSO 4.9 Identify the components of thermal and magnetic actuators available in the laboratory. LSO 4.10 Use thermal and magnetic actuators	22.	Thermal and magnetic actuators	
LSO 5.1 Test the output response of a open loop closed loop and feed forward path	23.	Analyze the given system to studyopen loop, closed loop and feed forward path.	CO5
LSO 5.2 Build and test the output response of a first order system for a step input using a CRO	24.	Analyze the given first order system and its transfer function and output response	
LSO 5.3 Build and test the response of a second order system for a step input using CRO. Also mark various parameters	25.	Analyze the given second order system and its transfer function andoutput response	
LSO 5.4 Test the Output response of an on-off and Proportional control-based level control system.	26.	Analyze the given water level control system with on-off, Proportional control.	
LSO 5.5 Test the Output response pf a P+I+D based level control system.	27.	Analyze the given water level control system with P+I+D control.	

L) Suggested Term Work and Self Learning: S2400504F Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

i. State three advantages of using programmed PLC timer over mechanical timing relay.
ii. Prepare a list of open source PLC software
iii. Prepare a list of open source SCADA software.
iv. List the practical applications of PLC systems
v. List the practical applications of SCADA systems.
vi. Compare the PLC and PC with regard to:
   - Physical hardware differences
   - Operating environment
   - Method of programming
   - Execution of program
vii. Prepare classification chart of different types of actuators.
viii. Differentiate between Nano and micro actuators.

b. Micro Projects:

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

c. Other Activities:

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

d. Self-Learning Topics:

1. Use of PLC for different industrial applications
2. Use of sensors in commercial field
3. Use of sensors in home automation
4. Compare Specifications of PLCs of different manufacturers of any one type PLC

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

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

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Overview of Industrial Automation	8	**CO1**	11	3	4	4
Unit-2.0 Fundamentals of PLC	12	**CO2**	17	5	5	7
Unit-3.0 Sensors and Input field devices	9	**CO3**	14	4	6	4
Unit-4.0 Actuators and output devices	10	**CO4**	14	4	6	4
Unit- 5.0 Control system	9	**CO5**	14	4	5	5
Total Marks	**48**		**70**	**20**	**26**	**24**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify major automation components in a given system	CO1	50	40	10
2.	Analyze given traditional machine in the laboratory for and identify the steps and components required to automate it.	CO1	50	40	10
3.	Use Scada software for simple application	CO1	50	40	10
4.	Observe various parts and front panel indicators of a PLC	CO2	50	40	10
5.	Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC	CO2	50	40	10
6.	Identify Analog input and output lines of a PLC	CO2	50	40	10
7.	Identify digital input and output lines of a PLC	CO2	50	40	10
8.	Practice using PLC to control various digital and analog output devices	CO2	50	40	10
9.	Identify different types of digital inductive proximity sensor and its use	CO3	50	40	10
10.	Identify different types of digital capacitive proximity sensor and its use	CO3	50	40	10
11.	Identify different types of digital optical proximity sensor and its use	CO3	50	40	10
12.	Identify different types of digital ultrasonic proximity sensor and its use	CO3	50	40	10
13.	Identify different types of thermistor and its use	CO3	50	40	10
14.	Observe the conversion of temperature to electric parameter conversion of a Thermocouple.	CO3	50	40	10
15.	Observe different types of RTDs used in industries for temperature measurement	CO3	50	40	10
16.	Observe different types of flow sensors used in industries for flow measurement	CO3	50	40	10
17.	Observe different types of pressure sensors used in industries for pressure measurement	CO3	50	40	10
18.	Observe the different types of load cell used in industries for force/weight measurement	CO3	50	40	10
19.	Design and actuate pneumatic/ hydraulic circuit for the given situation	CO4	50	40	10
20.	Operate hydraulic motor	CO4	50	40	10
21.	Operate stepper motor	CO4	50	40	10
22.	Thermal and magnetic actuators	CO4	50	40	10
23.	Analyze the given system to study open loop, closed loop and feed forward path.	CO5	50	40	10

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
24.	Analyze the given first order system and its transfer function and output response	CO5	50	40	10
25.	Analyze the given second order system and its transfer function and output response	CO5	50	40	10
26.	Analyze the given water level control system with on-off, Proportional control.	CO5	50	40	10
27.	Analyze the given water level control system with P+I+D control.	CO5	50	40	10

Legend:

PRA*: Process Assessment
PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	SCADA software (reputed make like Allen Bradley, Siemensetc.,)	Ready-to-use symbol library, React and respond in real-time,Real time monitoring, Friendly, manageable, secure, extensible, Easy-to-use, easy to implement, Easy configuration, simplified maintenance, Communication with PLC, easy and flexible alarm definition, data collection and analysis for new and existing systems, easy-to-use for report generation, open access to historical data, different packages available with input/output structure. Open source software SCADA software: like Ellipse/FTVSE/Wonderware/ open SCADA can also be used	3
2.	Universal PLC Training System with HMI (Of reputed make such as Allen bradely, Siemens, etc.,) Compatible with SCADA software	Human Machine Interface (HMI) display, PLC with 16 digital inputs, 16 digital outputs with RS232 communication facility. Open platform to explore wide PLC and HMI applications. Industrial look & feel. Toggle switches, push to ON switch, proximity sensor, visual indicator, audio indicator, and DC motor. Experiments configurable through patch board. Powerful instruction sets. Several sample ladder and HMI programs. PC based ladder and HMI programming. Extremely easy and student friendly software to develop different programs. Easy downloading of programs. Practice troubleshooting skills. Compact tabletop ergonomic design. Robust construction. PLC gateway for cloud connectivity. Open source software like Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools can also be used	4,5,6,7,8

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
3.	Proximity sensors kit	The kit should comprise of the following proximity sensor - Inductive Proximity Sensor, Capacitive Proximity Sensor, Magnetic Sensor, Optical Sensor, Audio and LED indicator for the object detection. Along with learning material	9,10,11,12
4.	Temperature transducer kit	Temperature Transducers Test Bench includes different types of temperature sensors including bimetallic strip, RTD, thermocouple, thermistor, RTD/thermocouple temperature display and thermistor, temperature display, heater, fan, switches and its indicator. Separate heater and fan chamber withstand. On panel digital voltmeter, digital ammeter, RTD/thermocouple temperature display, NTC temperature display, toggle switch for heater and fan with indicator, experiments configurable throughpatch board, heavy duty Test bench, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration.	12,13,14
5.	Pressure transducer kit	Pressure transducer kit should include different types of pressure sensors including capacitive pressure transducer, load cell, bourdon tube pressure gauge, and pressure vessel. Pressure vessel with pressure gauge, safety valve, non-returning valve bourdon gauge and capacitive transducer and air compressor, on panel digital voltmeter, digital ammeter, 4-20ma display, 0- 10V DC display, toggle switch for compressor, load cell with suitable weight, experiments configurable through patch board, self - contained, bench-mounting arrangement, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration. Detailed experiment manual should be supplied with the kit.	16
6.	Flow sensor kit	Turbine flow sensor kit	15
7.	Strain Gauge kit	The kit should provide study of Strain Gauge and their application for measurement of Strain. It should help to study bridge configuration of Strain Gauge and the signal conditioning circuits required to measure strain. It should use cantilever beam arrangement to produce strain on Strain Gauge. The Strain Gauges are firmly cemented to the cantilever at the point wherethe strain is to be measured. Weights are placed on free end of cantilever. Strain developed changes the resistance of Strain Gauge which is detected by full bridge configuration. It should comprise of Seven-segment LED display showing strain in micro strain units. Different weights should be provided to perform linearity and sensitivity experiments. Detailed experiment manual should be supplied with the kit. Test-points to observe input output of each block, onboard gain and offset null adjustment, built in DC Power Supplies, 3½ digits LED display, onboard Cantilever arrangement, high repeatability and reliability The kit should be capable of performing following experiments: • Measuring strain using strain gauges and cantileverassembly.	17

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		• Determination of linear range of operation of strainmeasurement. Determination sensitivity of the kit	
8.	Cut sections of pumps, actuators, valves and accessories used in hydraulic systems	Suitably cut and mounted on a sturdy base to show the internal details.	18
9.	Working models of pumps, actuators, valves and accessories used in hydraulic systems	Working models mounted on sturdy base to demonstrate theoperation.	18
10.	Working models of pumps, actuators, valves and accessories used in pneumatic systems	Working models mounted on sturdy base to demonstrate theoperation.	18
11. 8	Oil Hydraulic trainer	Mounted on sturdy base fitted with all standard units andaccessories to create various hydraulic circuits. Hydraulic trainer with simulation software Pneumatic trainer with simulation software • Filter Regulator Combination with Lubricator (FRL Unit) withpressure gauge, Junction Box with slide valve, Push Button Valve, 3/2 NC Roller lever valve ,3/2 NC Roller lever valve ,5/2 Double external pilot operated valve, 5/2 External pilot operated valve with spring return, 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent – for maintained pilot operation of a SAC, 5/2 Valve with Lever head, 5/2 Value with Mushroom head, Flow control valve – Metering IN & OUT, Shuttle Valve (OR valve), Quick ExhaustValve with Quick coupler plug • Double Acting Cylinder (DAC) with Quick coupler socket (with accessories: Screw driver – for cushioning adjustment),Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug, Multi distributor fittings (for cascading circuit designing) • Single Solenoid Valve with Spring Return (with LED), Double Solenoid Valve (with LED), Magnetic Reed Switch, Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit, Timer	18
12.	Pneumatic Trainer	Mounted on sturdy base fitted with all standard units and accessories to create various Pneumatic circuits. Pneumatic trainer with simulation software • Filter Regulator Combination with Lubricator (FRL Unit) with pressure gauge, Junction Box with slide valve • Push Button Valve, 3/2 NC Roller lever valve, 3/2 NC Roller lever valve, 5/2 Double external pilot operated valve (Memoryvalve) • 5/2 External pilot operated valve with spring return, 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent, 5/2 Valve with Lever head ,5/2 Value with Mushroom head, Flow control valve, Shuttle Valve (OR valve), AND valve • Quick Exhaust Valve with Quick coupler plug, Double Acting Cylinder (DAC) with Quick coupler socket, Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug	18

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		• Aluminum Profile Table Top, Profile Table Top, Miniature Double Acting Cylinder (DAC), Single Solenoid Valve with Spring Return, Double Solenoid Valve (with LED) • Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit (Black Selector – 1 no, Green Push Button – 1 no), Timer, Simulation software	
13.	Advanced Electro - Hydraulic and Electro - Pneumatic Hardware systems with work stationsand simulation software	• Electro - Hydraulic and Electro - Pneumatic Hardware systemswith PLC and simulation software Profile plate, Frame with Castor Wheels, Filter, Lubricator, Regulator with pressure gauge, Hand Slide Valve, Connectioncomponent set, Plastic Tubing, Power Supply & cables, Pressure Gauge, 3/2 Way double solenoid valve	18
14.	Output devices	Servomotor, DC motor, AC motor, stepper motor, Conveyer Belt control by PLC, water level control etc.	18,19,20
15.	Thermal actuators	Hot-And-Cold-Arm Actuators, Chevron-Type Actuators	21
16.	Magnetic actuators	Moving Coil Controllable Actuators, Moving Iron ControllableActuator	21
17.	Open and closed loop control system kit	Open and closed loop system kit should be able to measure theoutput response using CRO	22
18.	First and second order control system	First and second order system with input and output terminalsprovision	23,24
19.	Process control system with feed forward path kit	Process control system with feed forward path kit with input and output terminals provision	22
20.	PID Controller Test Bench	PID Controller Test Bench is a complete setup to control process through two-point (on/off) and three-point (PID) controllers. Industrial PID controller with RS485 communication facility, Thermocouple temperature sensor, Float switch for detection of water level, Temperature measurement and control, User friendly software, USB Interface, Heavy duty Test bench, Electrical control panel, Leak proof sturdy piping and tanks, SS Sump tank for inlet and outlet of water, Enhanced electricalsafety considerations, Caster wheel (with locking mechanism) at the legs of Testbench for easy movement.	25,26

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Introduction to Programmable Logic Controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005,ISBN13: 9781401884260
2.	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill India, New Delhi, 2010, ISBN:9780071067386
3.	Programmable Logic Controllers	Hackworth, John; Hackworth,Federic	PHI Learning, New Delhi, 2003, ISBN:9780130607188
4.	Industrial automation and Process control	Stenerson Jon	PHI Learning, New Delhi, 2003, ISBN: 9780130618900

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
5.	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN: 9788174092281
6.	Programmable Logic Controllers and IndustrialAutomation - An introduction,	Mitra, Madhuchandra; Sengupta, Samarjit,	Penram International Publication, 2015,ISBN: 9788187972174
7.	Control System	Nagrath & Gopal	New Age International Pvt Ltd, ISBN:9789386070111, 9789386070111
8.	Linear Control Systems with MATLAB Applications,Publisher:	Manke, B. S.	Khanna Publishers, ISBN: 9788174093103,9788174093103
9.	Supervisory Control and Data Acquisition	Boyar, S. A.	ISA Publication, USA, ISBN: 978-1936007097
10.	Practical SCADA for industry,	Bailey David; Wright Edwin	Newnes (an imprint of Elsevier), UK 2003,ISBN:0750658053

(b) Online Educational Resources:

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

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

(c) Others:

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

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

B) Course Title : Electric Vehicle (Basic)

C) Prerequisite Course(s) :

D) Rationale :

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

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

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

CO-1 Classify the EVs based on configurations.

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

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

integrated appropriately.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Identify the types of the vehicle based on the physical features, specification data and information. TSO 1b. State the advantages of EVs over Conventional IC Engine Vehicles. TSO 1c. Identify different components of Electric Vehicle systems TSO 1d. Explain the functions of different components of the EV	**Unit-1.0 Introduction to Electric Vehicle** Review of Conventional Vehicle Engine System Electric Vehicle (EV) • The necessity of Electric Vehicle • Types of Electric Vehicles - Plug-in hybrid - Battery electric vehicle - Hybrid electric vehicle - Fuel Cell Electric Vehicle • Advantages of Electric Vehicles Electric Vehicle Components: Motor, Motor Controller, Battery, Battery Management System, and ChargingSystem.	**CO1**
TSO 2a. Explain the general characteristics of motorsused in EV TSO 2b. List different types of motors used in EV TSO 2c. Explain the working principles of motors used in EV applications TSO 2d. Interpret the nameplate ratings of the motorsfor EV applications. TSO 2e. Explain the motor selection criteria forparticular EV applications. TSO 2f. Describe the Mechanical and ElectricalConnections of Motors.	**Unit-2.0 Electric Motors used in EVs** Electric Motors for EV applications • General Characteristics of motors • Types of Motors: DC, Brushless DC, Induction, Permanent Magnet Synchronous Motors, SwitchedReluctance Motors Rating of Motors Selection Criteria Physical Location Connection of Motors: Mechanical Connections and Electrical Connections	**CO2**
TSO 3a. List the batteries used in EVs for energy storage TSO 3b. State various parameters related to batteries used in EV applications. TSO 3c. Explain the charging and discharging process ofthe given batteries. TSO 3d. Explain the salient features of Lithium Ionbatteries TSO 3e. Explain the Fuel Cell Storage System. TSO 3f. Identify various sensors installed for monitoringBattery condition. TSO 3g. Explain Battery Management System in EV usingBlock Diagram. TSO 3h. **Describe the procedure of battery Disposal andRecycling**	**Unit- 3.0 EV Batteries and Energy Storages** Types of Batteries: Lead Acid, Nickel Based, Lithium Based Battery Parameters Charging (AC) and Discharging (DC) Process Lithium Ion Batteries Fuel Cells, Fuel Cell Storage System Battery Condition Monitoring Battery Management System (BMS) • Need of BMS • Block Diagram of BMS **Battery Disposal and Recycling**	**CO3**
TSO 4a. Identify different types of diodes andtransistors. TSO 4b. Describe the testing procedure for the givenDiode and Transistor. TSO 4c. Explain the working principles of the givenpower electronic converter circuit. TSO 4d. Describe the types of Charging Systems TSO 4e. Describe different Components of the ChargingSystem	**Unit- 4.0 EV Charging Systems** Power electronics in EV • Power electronics components • Rectifiers • DC to DC Converter • DC to AC Converter Charging System • Types of charging Systems	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 4f. Explain the working of the Charging Systemusing a single-line diagram.	• Components of Charging Systems • Single line Diagram of Charging System	
TSO 5a. Understand the Rules and Regulations set by theGovernment for selecting and manufacturing various components of an electric vehicle. TSO 5b. Understand the Policies for E-Vehicles. TSO 5c. Appreciate the importance of the reduction ofgreenhouse gases in the environment.	**Unit- 5.0 Regulatory Requirements and Policies for EV Industry** Rules and Regulations set by the Indian government for the designer/manufacturer of EVs. Policies in India Global Policies for E- Vehicles. Carbon Footprint Issues	**CO5**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1 Use the relevant digital meter for the given application. LSO 1.2 Use a measuring instrument for the given application. LSO 1.3 Use safety kits while working in the laboratory.	1.	• Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc. Practice using Screw Driver Kit, Vernier Caliper, Micrometer, Ampere Meter,Voltage Meter, and Techno-meter. Practice using safety kits.	CO1
LSO 2.1 Identify the motors used in EV applications LSO 2.2 Identify the given motor terminals	2.	• Identification of motors used in EVs	CO2
LSO 3.1 Identify the batteries available in the laboratory. LSO 3.2 Measure an open circuit voltage of the given battery. LSO 3.3 Determine the Ampere -Hour Capacity of the given battery with a given load. LSO 3.4 Test the performance of the given battery with different charging rates and at different ambient temperatures LSO 3.5 Demonstrate the effect on the state of health of the battery after several charge/ discharge cycles. LSO 3.6 Evaluate the temperature cut-off point for the given BMS.	3.	• Testing of Batteries used in EVs • Battery Management System	CO3
LSO 4.1 Identify the Electrical & Electronics components available in the laboratory using Digital Multimeters. LSO 4.2 Test the given power electronic components using digital meters LSO 4.3 Identify the given Power Electronic Circuits used in EVs LSO 4.4 Identify the components of the Charging System LSO 4.5 Recognize the types of Charging Systems available in the Laboratory	4.	• Power electronic circuits • Identification of Charging systems	CO4

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

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

b. Micro Projects:

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

c. Other Activities:

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

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

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

d. Self-Learning Topics:

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

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

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

Legend:

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

** : Mentioned under point- (N)

: Mentioned under point- (O)

Note:

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

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

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

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

O) Suggested Assessment Table for Laboratory (Practical):

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

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

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	AC, DC Clamp Meters	Application: Non-contact AC/DC Voltage and Current measurement **AC Application:** Current: 0-200Amp, Voltage: 0-600Volt **DC Application:** Current: 4-20mA, Voltage: 0-30Volt.	1
2.	Digital Multimeters	Display: 4 ½ digit Indications: overload protection, polarity indication, over range indication. Auto range change and auto polarity change facility, auto display of polarity and decimal point. **DC**: Volt: 200mV-600V, Current: 200mA-2A **AC**: Volt: 200mV-1000V, Current: 200mA-2A Resistance: 200W-20mW, Power supply: 230V, 50Hz Battery operation: 9 Volt battery Electronic components testing facility should be provided in the Multimeter. A provision for an A.C. adaptor(eliminator) must be available along with the multimeter.	1, 3
3.	Lux Meters	Functions: MAX / MIN, Backlight, Auto Power Off Range: 0 ~ 200,000 lux 0 ~ 20,000 fc Accuracy: ± 5% rdg + 10 dgt (< 10.000 lux / fc) ± 10% rdg + 10 dgt (>10.000 lux / fc) Resolution: 0.1 lux or 0.1 fc Accessories: Carrying Case, Installation Manual, 9V Battery (installed).	1
4.	Screw Driver toolbox	All types of screw drive sets.	1
5.	Vernier Caliper	**Range:** Lower scale: 0-200mm, Upper Scale: 0-12inch **Vernier Resolution:** Lower Scale: 0.02mm, Upper Scale: 0.001inch	1
6.	Micrometer	0-25mm (inside/outside)	1
7.	Ampere Meter	Moving iron and Moving Coil	1
8.	Voltmeter	AC(0-250V)/DC(0-24V)	1
9.	Tachometer	For speed measurement (0-3000rpm)	1

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
10.	Resistors	Low-value Resistors of different types	1,4
11.	Capacitors	Low-value electrolyte Capacitors.	1,4
12.	Inductors	Low-value inductors.	1,4
13.	Safety Kit	First Aid Kit, Helmet, Face Mask, Gloves etc.	1
14.	Motors for Electric Vehicleapplication	Brushless DC, Induction, Permanent Magnet Synchronous Motors, Switched Reluctance Motors	2
15.	EV Machine Cut-out section	for demonstration & training	2
16.	EV mock layout	for demonstration & training	2
17.	Lithium Ion Battery	12V, 7Ah	3
18.	Lead-acid battery	12V, 7Ah	3
19.	Nickel-based batteries (metal hydride and cadmium battery).	12V, 7Ah	3
20.	Battery internal resistance meter	For O.C. voltage & internal battery resistance of each cell	3
21.	Cell Capacity tester	Up to 15V batteries and 3A load current, 10mV voltage and 1mA current resolution, Automatic detection of termination voltage, LED display with a 3-button interface.	3
22.	BMS setup	For Demonstration & training	3
23.	DC power supply	0-32V	3
24.	Power diodes	Power diodes of different current values.	1, 4
25.	Transistors	Power Transistors (NPN, PNP) for Low-frequency high-power applications.	1,4
26.	Voltage Sensors	0-12 Volts.	1,3,4
27.	Current Sensors	Volts: + 15v, 0-5v, Current: 4-20mA.	1,3,4
28.	Converter Models	DC to DC and DA to AC converter model	4
29.	Charging Station Simulator	For Demonstration & training purposes.	4
30.	EV Technology layout 3D posterwith frame	Fuel cell, EV- Charging Systems, HEV, FCEV, Motors & Controllers etc.	3,4

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Handbook on Electric Vehicles Manufacturing (E-Car, Electric Bicycle, E- Scooter, E-Motorcycle, Electric Rickshaw, E- Bus, Electric Truck with Assembly Process, Machinery Equipment's &Layout)	P.K. Tripathi	Niir Project Consultancy Services; 1st edition (1 January 2022) ISBN-13: 978-8195676927
2.	Electric Vehicles: And the End of the ICE age	Anupam Singh	Kindle Edition ASIN: B07R3WFR28
3.	Wireless Power Transfer Technologies for Electric Vehicles (Key Technologies on New Energy Vehicles)	Xi Zhang, Chong Zhu, Haitao Song	Springer Verlag, Singapore; 1st ed. 2022 edition (23 January 2022) ISBN-13: 978-9811683473
4.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles	EHSANI	CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465
5.	Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles	John G. Hayes, G. Abas Goodarzi	Wiley; 1st edition (26 January 2018) ISBN-13: 978-1119063643
6.	New Perspectives on Electric Vehicles	Marian Găiceanu (Editor)	IntechOpen (30 March 2022) ISBN-13: 978-1839696145

(b) Online Educational Resources:

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

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

(c) Others:

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

****

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

B) Course Title : Robotics (Basic)

C) Pre- requisite Course(s) :

D) Rationale :

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

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

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

CO-1 Select robots for given applications employing basic concepts of design and functions of robots.

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

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

CO-4 Select appropriate robot control techniques,

CO-5 Use programs to operate robots.

F) Suggested Course Articulation Matrix (CAM):

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

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

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		L	T				
2400504H	Robotics (Basics)	03	-	04	02	09	06

Legend:

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

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

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 3g. Justify the selection of actuators, drives, control system, AC servo motor and path control for making of a robot.	3.3 AC servo motor; DC servo motors and Stepper motors; 3.4 Robot path control: Point to point, Continuous path control and Sensor based path control	
TSO 4a. Explain various robot programming languages. TSO 4b. Programme robot for a given simple job. TSO 4c. Describe the procedure to simulate the given robot movements using the relevant software.	**Unit– 4.0 Introduction to Robot Programming** 4.1 Need and functions of programming 4.2 Methods of robot programming: Manual Teaching, Teach Pendant, Lead through, Programming languages. Programming with graphics. 4.3 Programming languages: Types, features and applications 4.4 Controller programming 4.5 Simulation for robot movement	**CO5**
TSO 5a. Select a robot for the given application. TSO 5b. Describe various applications of Robotics. TSO 5c. Explain safety norms in robot handling. TSO 5d. Describe maintenance procedure for the given robot. TSO 5e. Describe common problems in robot operations and suggest remedial action.	**Unit– 5.0 Robotics Applications and Maintenance aspects** 5.1 Application robots including special types 5.2 Robot maintenance: Need and types 5.3 Common troubles and remedies in robot operation. 5.4 General safety norms, aspects and precautions in robot handling	**CO1, CO2, CO3, CO4**

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

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

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1 Identify parts of Robot on the basis of function. LSO 1.2 Identify joint type & link parameters (link length, link twist, and Link offset), rotational vs. linear motion, used in robot.	1.	Identify components and different configurations of robots.	CO1
LSO 2.1Identify different types of robot end effecters. LSO 2.2 Use Mechanical grippers to hold objects. LSO 2.3 Use Vacuum grippers to hold objects.	2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2
LSOs 3.1 Assemble the complete robot using the components as per the procedure LSO 3.2 Apply the functionalities available in rotor trainer kit. LSO 3.3 Test for various configurations. LSO 3.4 Test for various degrees of freedom.	3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2
LSO 4.1 Identify various types of sensors used in robotic application. LSO 4.2 Measure angular motion using Synchros. LSO 4.3 Detect objects using optical sensors.	4.	Use different types of robotic sensors for a specific situation.	CO3
LSO 5.1 Interface stepper motor. LSO 5.2 Control robot with stepper motor interfacing.	5.	Perform robot control with stepper motor interfacing	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 6.1 Draw the labelled sketch of individual parts and robot arm. LSO 6.2 Assemble the arm using the parts as per the procedure. LSO 6.3 Interface the motor drive and operate.	6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3
LSO 7.1 Use open source or available relevant software to develop pick and place programme. LSO 7.2 Perform simulation.	7.	Perform pick and place operation using Simulation Control Software.	CO5
LSO 8.1 Develop programme for using a robot arm with three degrees of freedom. LSO 8.2 Execute the programme.	8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5
LSO 9.1 Apply stepper motor control with direction control and step control logic simulation. LSO 9.2 Perform basic PLC programming LSO 9.3 Develop ladder logic programs LSO 9.4 Use programming timers	9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5
LSO 10.1Develop a program for a simple application. LSO 10.2 Execute the robot programme.	10.	Program to execute a simple robot application (like painting, straight welding) using a given configuration.	CO4, CO5

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

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

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

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

c. Other Activities:

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

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	29%	20%	10%	25%	10%	20%
CO-2	20 %	23%	20%	10%	25%	**20%**	20%
CO-3	20%	17%	20%	25%	25%	**20%**	20%
CO-4	20%	14%	20%	15%	25%	**20%**	20%
CO-5	15%	17%	20%	40%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

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

: Mentioned under point-(O)

Note:

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

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

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

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify components and different configurations of robots.	CO1	30	60	10
2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2	60	30	10
3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2	70	20	10
4.	Use different types of robotic sensors for a specific situation.	CO3	60	30	10
5.	Perform robot control with stepper motor interfacing	CO3	70	20	10
6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3	60	30	10
7.	Perform pick and place operation using Simulation Control Software.	CO5	70	20	10
8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5	60	30	10
9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5	60	30	10
10.	Program to execute a simple robot application (like painting, straight welding) using a given configuration.	CO4, CO5	60	30	10

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

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
1.	Programmable Robot trainer kit	Trainer kit with - Minimum 3 linkages, Minimum 4 degree of freedom, Mechanical end effecter with servo control, interfacing card (RC servo output, sensors input)	1,2,3
2.	Robotic Arm Control Trainer Kit	Robotic Arm with five axis control application through PLC.; PLC; Digital Inputs: 8 Nos with 4mm banana sockets for getting the external inputs; Digital Outputs: 6 Nos with 4mm banana sockets for applying the inputs; Digital Input Controls: On board Toggle switches, Push Buttons & input potentiometers; Digital Outputs Controls: 6 nos.	8,9

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		on board LED indicators; PC interfacing facility through RS-232.	
3.	Proximity trainer kit	Indicator Type:LED; PCB Type Glass Epoxy SMOBC PCB; Interconnections**:** 2mm banana Patch cords; On board DC motor to see the application of Proximity sensor. Test points to analyse the signal On board variable supply to vary the speed of DC motor. ON/OFF switch and LED for power indication. All interconnections to be made using 2mm banana Patch cords. User manual and patch cords. Built-in power supply. Robust enclosure wooden/plastic box.	4
4.	Robot - Line Tracking Mouse Kit	Product Dimensions (20.3 x 11.4 x 8.9 cm); programmed IC, 2 unassembled gear motors, printed circuit boards, mouse-shaped plastic body, necessary components and wires, step-down power converter	3, 4,5
5.	Intelligent Robot Actuator Module	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminium, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from −40°C to 125°C (Analog Devices ADT7302)	3, 4, 5
6.	6-axis Robotics Trainer	Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM processors**;** Record and Play capability**;** Optional interfacing with PL**C;** Touch operated ON/OFF switch**;** Auto set to home position**;** Applications can be developed**;** Data acquisition using USB	3, 4, 5
7.	Robotic Drive System	AC servo motor; DC servo motors, Stepper motors; DC tachometers, etc.	1,3,5,6,7,10
8.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	8, 10
9.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc	4
10.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4,10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Introduction to Robotics Mechanics and Control	John Craig	Pearson Education; 978-9356062191
2.	Industrial Robotics -Technology, Programming and Applications	Nicholas Odrey Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta	McGraw Hill Education; 2nd Edition; 978 -1259006210
3.	Robotic engineering: an integrated approach	Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin	Prentice Hall of India, N.Delhi , 978-8120308428
4.	Industrial Robotics Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey	McGraw-Hill Education, Second Edition, 978-1259006210
5.	Robotics	Appuu Kuttan K. K.	Dreamtech Press, First Edition, 2020, 978-9389583281
6.	Introduction to Robotics: Analysis, Control, Applications	Saeed B. Niku	Wiley; Second Edition, 978-8126533121
7.	Essentials of Robotics Process Automation	S. Muhkerjee	Khanna Publication, First edition, 978-9386173751
8.	Robotics	R R Ghorpade, M M Bhoomkar	Nirali Prakashan 978-9388897020

(b) Online Educational Resources:

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

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

(c) Others:

1. Learning Packages

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

2. Users' Guide

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

- https://www.scientechworld.com/robotics

3. Lab Manuals

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

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

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

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

D) Rationale :

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

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

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

CO-1 Explain the fundamental working principles of a transformer.

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

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

CO-4 Illustrate the different types of transformer protection.

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

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme SpecificOutcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ 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	-	-	-	-	3		
CO-2	3	1	-	-	2	-	3		
CO-3	3	2	2	-	-	-	3		
CO-4	3	3	2	2	1	-	3		
CO-5	3	3	-	2	1	-	3		

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+ SL)	Total Credits (C)
		L	T				
2400504I	Transformer Manufacturing and Repairing (Basic)	03	-	04	02	09	06

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

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

Legend:

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

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

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

Note:

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

I) Course Curriculum Detailing:

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

J) Theory Session Outcomes (TSOs) and Units: T2400504I

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

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

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

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

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

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

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

- Discuss the role of insulation in transformer reliability and longevity.
- Outline the steps involved in the construction of power transformers.
- Discuss the testing procedures to ensure quality and performance standards.
- Explore how environmental factors (temperature, humidity, pollution) affect transformer operation.
- Investigate modern monitoring techniques, including online monitoring systems and diagnostic tools.
- Compare different cooling methods (oil-immersed, air-cooled, water-cooled) and their effectiveness.
- Review recent advancements in transformer protection technologies.
- Discuss the importance of testing for ensuring reliability, efficiency, and safety.

b. Micro Projects:

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

c. Other Activities:

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

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

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

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 **Transformer Fundamentals**	12	CO1	10	3	3	4
Unit-2.0 **Transformer Construction**	8	CO1, CO2	10	3	2	5
Unit-3.0 **Transformer Operation**	8	CO3, CO4	10	5	2	3
Unit-4.0 **Transformer Protection**	8	CO3, CO4	20	5	6	9
Unit-5.0 **Transformer Testing**	12	CO4, CO5	20	4	6	10
Total	**48**	**-**	**70**	**20**	**19**	**31**

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

O) Suggested Assessment Table for Laboratory (Practical):

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Conduct open circuit and short circuit tests on a transformer	CO1	30	60	10
2.	Perform load tests on a transformer.	CO1	40	50	10
3.	Perform the Sumpner's test on two identical transformers.	CO1	30	60	10
4.	Perform various connections on three phase transformers and understand vector groups.	CO2	30	60	10
5.	Three phase to Two phase connection	CO3, CO4, CO5	30	60	10
6.	Three phase to single phase connection.	CO3, CO4, CO5	30	60	10
7.	Perform open delta connection from banks of single phase transformers.	CO3, CO4, CO5	30	60	10
8.	Understand the differential protection with different CT connections and the working of Buchholz relay.	CO3, CO4, CO5	40	50	10
9.	Perform a polarity test on a transformer.	CO4, CO5	40	50	10
10.	Perform the impulse test on a transformer.	CO5	40	50	10

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

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

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, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter.	Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-1 QTY Auto-Transformer (0-270 V,5 kVA), Multi-Meter, Voltmeter (0-300 V,0-150 V 0-50 V: -3 Qty), Ammeter (0-5 A,0-10 A,0-1 A:3Qty), Wattmeter (0-300 V,5/10A-3 Qty), Wattmeter (0-150 V,1/2 A-3 QTY), Connecting Wire.	Conduct open circuit and short circuit tests on a transformer
2.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-1 QTY Auto-Transformer (0-270 V,5 kVA), Multi-Meter, Voltmeter (0-300 V,0-150 V: -2 Qty), Ammeter (0-5 A,0-10 A,: 2 Qty), Wattmeter (0-300 V,5/10A-2 Qty), Connecting Wire.	Perform load tests on a transformer.

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
3.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter.	Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-2 QTY Auto-Transformer (0-270 V,5 kVA:-2 QTY), Multi-Meter, Voltmeter (0-300 V,0-150 V 0-50 V: -3 Qty), Ammeter (0-5 A,0-10 A,0-1 A:3Qty),Wattmeter(0-300 V,5/10A-3 Qty),Wattmeter(0-150 V,1/2 A-3 QTY), Connecting Wire.	Perform the Sumpner's test on two identical transformers.
4.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	Transformer (1 Phase, 1 kVA) - 3 Qty, multi-meter, Series Bulb, Connecting Wire, 3 Phase Auto transformer-1 Qty, Connecting Wire.	Perform various connections on three phase transformers and understand vector groups.
5.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	3 Phase Auto transformer, Transformer (1 kVA, 1 Phase)-3 Qty, Ammeter (0-20 A)-5 Qty, Voltmeter (0-500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), 1 Phase Electric Load-2 Qty, Connecting Wire.	Three phase to Two phase connection
6.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	3 Phase Auto transformer-1 Qty, Transformer (1 kVA, 1 Phase)-3 Qty, Ammeter(0-10A)-2 Qty, Voltmeter (0-300/500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), 1 Phase Load, Connecting Wire.	Three phase to single phase connection.
7.	Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box	Transformer (1 kVA, 1 Phase)-3 Qty, 3 Phase Load-1 Qty, 3 Phase Auto Transformer -1 Qty. Ammeter(0-10A)-2 Qty, Voltmeter (0-300/500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty),	Perform open delta connection from banks of single phase transformers.
8	Power Transformer, Differential relay, CT, Buchholz Relay	3 Phase Differential relay, Current transformer-3 Qty, Power Transformer with Buchholz relay -1 Qty, Connecting Wire.	Understand the differential protection with different CT connections and the working of Buchholz relay.
9	Transformer, Auto Transformer, Ammeter, Voltmeter, Multi-meter.	1 Ph Transformer (same rating)-2 Qty,1 Ph Autotransformer -1 Qty, Ammeter (0-2 A)-1 Qty, Voltmeter(0-300V), Voltmeter(0-150V)-1 Qty, Connecting Wire.	Perform a polarity test on a transformer.
10	Transformer, Impulse test Kit	3 Phase transformer -1 Qty, High voltage generating kit (rating in kV), Connecting Wire.	Perform the impulse test on a transformer.

R) Suggested Learning Resources:

(a) Books:

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

(b) Online Educational Resources:

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

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

(c) Others:

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

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

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

D) Rationale :

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

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

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

CO-1 Describe EM wave propagation through an optical fiber.
CO-2 Measure different types of losses of a given optical fiber cable.
CO-3 Perform optical fiber power launching and slicing.
CO-4 Test the performance of the Optical fiber source and detector.
CO-5 Compare mobile communication generations (2G, 3G, 4G and 5G).

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400504 J	Optical Fiber and 5G Communication(Basics)	03	-	04	02	09	06

Legend:

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

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

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

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment(TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment(LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400504 J	Optical Fiberand 5G Communication (Basics)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

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

Note:

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

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

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

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

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

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

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

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

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

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

b. Micro Projects:

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

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

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

c. Other Activities:

1. Seminar Topics: here are 5 seminar topics

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

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

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

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

Legend:

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

**: Mentioned under point-

(N)#: Mentioned under point-

(O) **Note:**

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

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

Unit Title and Number	Total Classroom Instruction(Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 **Introduction of Optical Fibers**	8	CO1	10	2	4	4
Unit-2.0 **Transmission Characteristics of Optical Fiber**	8	CO2	10	4	2	4
Unit-3.0 **Optical Sources and Detectors**	8	CO3	14	4	4	6
Unit-4.0 **Optical Receiver, Coupling and Measurements**	12	CO4	16	4	6	6
Unit-5.0 **Fundamentals of 5G Communication**	12	CO5	20	4	6	10
Total	**48**	**-**	**70**	**18**	**22**	**30**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identification of various components of Optical fiber communication system	**CO1**	30	60	10
2.	Measurement of Numerical aperture	**CO1**	40	50	10
3.	Attenuation and Signal Loss Measurement	**CO2**	30	60	10
4.	Fiber Optic Cable Testing and Troubleshooting	**CO2, CO3**	30	60	10
5.	Performance of optical source (LED, LASER)	**CO3**	30	60	10
6.	Performance of optical doctor (Photo diode, PIN diode)	**CO3**	30	60	10
7.	Optical Fiber Splicing and Monitorization	**CO4**	30	60	10
8.	Analyze the optical communication system.	**CO4**	30	60	10
9.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	**CO5**	30	60	10
10.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	**CO5**	30	60	10

Legend:

PRA*: Process Assessment PDA**: Product Assessment

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

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies 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.	Optical Time-Domain Reflectometer (OTDR) Used for measuring the length, loss, and faults in optical fiber cables.	1-3
2.	Fusion Splicer (For splicing optical fibers with minimal loss).	1-3
3.	Optical Power Meter and Light Source (For measuring the power levels in fiber optic links and testing signal loss).	1-3
4.	Visual Fault Locator (VFL): Helps to identify faults, breaks, and bending in optical fibers.	1-3
5.	Optical Spectrum Analyzer (OSA): Used for analyzing the wavelength and spectral characteristics of light in fiber optics.	1-3
6.	Software-Defined Radio (SDR): Allows for the implementation and testing of 5G communication protocols.	4-7
7.	5G NR Testbed: Complete test setups for developing and testing 5G NR systems.	4-7
8.	Vector Signal Analyzer (VSA) and Vector Signal Generator (VSG): For generating and analyzing complex modulated signals used in 5G communication.	4-7
10.	MIMO (Multiple Input Multiple Output) Test System: For testing MIMO technology, which is essential for 5G networks.	7
11.	Optical Fiber Cables and Connectors: Various types of single-mode and multi-mode fibers, along with connectors and adapters.	1-3
12.	Network Simulators: Software tools like Opti System for simulating optical networks and NS-3 for 5G network simulations.	1-3
13	MATLAB/Mathematica	1-7

R) Suggested Learning Resources:

(a) Books

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

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

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

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

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

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

a. Operating / Manufacturers' Manuals
b. Lab Manuals

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A) Course Code : 2400505(P2400505/S2400505)

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

C) Pre-requisite Course(s) :

D) Rationale :

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

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

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

CO-1 Demonstrate traits of a successful intrapreneur/ entrepreneur/ start-up co-founder.

CO-2 Innovate products and services using creativity and innovation techniques.

CO-3 Manage critical resources from support institutions.

CO-4 Prepare sustainable small business plans.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400505	Entrepreneurship Development & Startups	-	-	04	02	06	03

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400505	Entrepreneurship Development & Startups	-	-	20	30	20	30	100

Legend:

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

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

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

Note:

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

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

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

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

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

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

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

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

i. Prepare a list of successful Entrepreneurs in the city.
ii. Prepare a list of startups in the city.
iii. Prepare a list of the nearest incubators.
iv. Prepare a list of Angel Investors and Venture Capitalists.
v. Choose any product and study its supply chain.
vi. Arrange brainstorming sessions for improvement of any product.
vii. Choose any advertisement and analyse its good and bad points.
viii. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
ix. Study schemes for entrepreneurship promotion of any bank.

b. Micro Projects:

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

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

c. Other Activities:

1. Seminar Topics:

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

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

3. Self-Learning Topics:

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

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

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

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

Note:

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

N) Suggested Specification Table for End Semester Theory Assessment: (NOT APPLICABLE)

O) Suggested Assessment Table for Laboratory (Practical):

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

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
19.	Marketing communication for business.	CO4	50	40	10
20.	A techno-feasibility report of a chosen product/service.	CO4	50	40	10
21.	Business plan for the enterprise.	CO4	50	40	10
22.	Online Marketing for Business.	CO4	50	40	10
23.	Goal setting for an enterprise.	CO3	50	40	10
24.	Marketing management for an enterprise.	CO3	50	40	10
25.	Supply Chain Management	CO3	50	40	10
26.	Market Intelligence for Entrepreneurship	CO3	50	40	10
27.	Risks in business	CO4	50	40	10
28.	Breakeven point for a business	CO4	50	40	10

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

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

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

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

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Entrepreneurial Development	Khanka S.S. (2006)	S. Chand Publishing, 20068121918014,
2.	Un-Boxing Entrepreneurship Your self-help guide to setup a successful business	Dr. Nishith Dubey Aditya Vyas, AnnuSoman, AnupamSingh, CharulChaturvedi, Praveen Shukla	Indra Publishing House, 2023, ISBN- 978-93-93577-70-2

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
3.	Skill Development and Entrepreneurship in India	Rameshwari Pandya	Ingram 2016, 8177084186
4.	Production and Operations Management	SV Deshmukh, A K Chitale and Nishith Rajaram Dubey,	Archers & Elevators Publishing House, Bangalore ISBN 9789386501197
5.	Entrepreneurship Development	Sapna Jarial	New India Publishing Agency- Nipa 2022, 9395319240
6.	The Entrepreneurial Instinct: How Everyone Has the Innate Ability to Start a Successful Small Business	Monica Mehta	Tata McGraw Hill Education, New Delhi, 2012, ISBN 978-0-07-179742-9
7.	The Learn Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses	Eric Ries	Penguin UK ISBN-978-0670921607
8.	Entrepreneurship and Start-ups	Ekta Sharma	FPH
9.	The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business	Clayton M. Christensen	Harvard business ISBN: 978-142219602

(b) Online Educational Resources:

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

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

(c) Others: -

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A) Course Code **:2420506(P2420506/S2420506)**

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

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

D) Rationale **:**

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

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

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

CO-1 Develop the comprehensive view of industry 4.0 elements and 21st century skills requirements in the relevant diploma engineering programme through Summer Internship-II.

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by the respective program coordinator at the institute level. As per the 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				
2420506	Summer Internship - II	-	-	02	04	06	03

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						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)	
2420506	Summer Internship - II	-	-	20	30	20	30	100

Legend:

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

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

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

Note:

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

I) Guidelines to Teachers for Implementation & Assessment of Industrial Visit:

1. Rationale:

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

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

2. Planning for industrial internship/training:

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

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

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

3. Major outcomes expected to be attained and assessed:

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

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

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

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

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

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

5. Post Training Assessment:

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

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

1. Initiatives by Govt. of India, GOI

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Employment Exchanges Mission Mode Project (EE - MMP)

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

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

National Career Service (NCS)

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

The main stakeholders for the NCS would include:

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

e. Initiatives by Telecom Sector Skill Council (TSSC)

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

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

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

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

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

The main objectives of TSSC are as follows

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

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

2. Initiatives by other agencies

a. Initiatives by Engineering Council of India (ECI)

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

b. Others

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

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

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

M) References:

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

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A) Course Code : 2420507(P2420507/S2420507)

B) Course Title : Minor Project

C) Pre-requisite Course(s) :

D) Rationale :

Project work plays a very important role in engineering education in developing core technical skills, soft skills and a higher level of cognitive, psychomotor and affective domain skills. It encourages the critical thinking process in the students. Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in a new situation or task to solve the problems of the industries/real world. Project work also develops many soft skills like confidence, communication skills, creative ability, inquisitiveness, learning to learn skills, lifelong learning skills, problem-solving skills, management skills, positive attitude, ethics etc.

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

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

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

CO-1 Identify a real-world problem in the form of a project to be developed.

CO-2 Perform literature survey related to the identified area/problem.

CO-3 Identify preliminary resource requirements (Equipment, Tools, Software, Manpower, Services)

CO-4 Prepare project synopsis for the identified problem/project title within stipulated time period.

F) Suggested Course Articulation Matrix (CAM):

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

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

* PSOs will be developed by the respective program coordinator at the institute level. As per the 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				
2420507	Minor Project	-	-	02	02	04	02

Legend:

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

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

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

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

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

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

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

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2420507	Minor Project	-	-	10	15	10	15	50

Legend:

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

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

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

Note:

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

I) Suggested Implementation Plan of Minor Project:

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

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

(**Major Project**)

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

1.0 Guidelines to Students for Implementation of Minor Project.

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

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

1.1 Identification of Project Titles and Allocation Methodology:

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

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

Criteria for Identification of Project Titles.

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

- Environmental Considerations
- Simulated/Automated Industry's/ Improvised Process
- Application or Utility in the World of Work.
- Relevance to the Curriculum
- Mapping of Outcomes of Project with Pos and PSOs (if applicable)
- Feasibility of Implementation of the Project

1.2 Literature Survey:

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

1.3 Outcomes of the Project:

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

1.4 Identification of the recourses required:

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

1.5 Preparation of Synopsis:

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

1.6 Presentation of Synopsis:

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

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

2.0 Guidelines to Teachers for Implementation of the Minor Project:

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

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

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

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

J) Assessment of the Minor Project:

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

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

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

Assessment Scheme for Minor Project

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

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