

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 – III Teaching & Learning Scheme

Course Codes	Category of course	CourseTitles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2420301	PCC	Electrical Circuit and Networks	03	-	04	02	09	06
2420302	PCC	Electrical Measurements and Instrumentation	03	-	04	02	09	06
2420303	PCC	DC Machines and Transformers	03	-	04	02	09	06
2469304	PCC	Automobile Control Engineering	02	01	-	02	05	04
2418305	BCC	Python Programming (CE, CSE, AIML, EE, ME, ME (Auto), ELX, ELX (R), MIE, FTS, CRE, CHE, TE, CACDDM, GT)	03	-	04	02	09	06
2420306	PSI	Summer Internship – I (After 2 nd Sem) (Common for all programmes)	-	-	02	02	04	02
Total			14	1	18	12	45	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)

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 - III 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)	
2420301	PCC	Electrical Circuit and Networks	30	70	20	30	20	30	200
2420302	PCC	Electrical Measurements and Instrumentation	30	70	20	30	20	30	200
2420303	PCC	DC Machines and Transformers	30	70	20	30	20	30	200
2469304	PCC	Automobile Control Engineering	30	70	20	30	-	-	150
2418305	BCC	Python Programming (CE, CSE, AIML, EE, ME, ME (Auto.), ELX, ELX (R), MIE, FTS, CRE, CHE, TE, CACDDM, GT)	30	70	20	30	20	30	200
2420306	PSI	Summer Internship – I (After 2 nd Sem) (Common for all programmes)	-	-	10	15	10	15	50
Total			150	350	110	165	90	135	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.

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** : 2420301(T2420301/P2420301/S2420301)
 B) **Course Title** : Electrical Circuit and Networks
 C) **Pre- requisite Course(s)** : Basic Electrical Engineering
 D) **Rationale** :

Electrical circuits are everywhere starting from simple circuits to giant ones that carry power to our homes. This course deals with basic laws and theorems governing electrical circuits which can be applied to analyze and solve the complex electrical circuits. This course enables the students to measure various electrical quantities/parameters in single and three phase ac circuits. This course is one of the most important core engineering courses and also a prerequisite to learn the advanced electrical courses and develop skills to apply the principle of DC and AC circuits to trouble shoot electrical circuits. Therefore, after taking this course, the diploma students are expected to analyze and develop mastery over concepts of electrical circuits for effective working as an electrical diploma engineer.

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

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

- CO-1** Apply basic laws and analysis techniques to simplify the electrical circuits.
CO-2 Apply network theorems principles to solve the electrical circuit problems
CO-3 Measure electrical quantities in single phase AC circuits.
CO-4 Ascertain the resonance condition in a series and parallel RLC circuit and measure 2 port network parameters.
CO-5 Measure power and power factor in three phase AC circuits.

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

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	1	3	2	2	-	2		
CO-2	3	3	2	2	1	2	-		
CO-3	3	2	2	2	3	-	2		
CO-4	3	3	2	2	-	1	-		
CO-5	3	2	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				
2420301	Electrical Circuit and Networks	03	-	04	02	09	06

Legend:

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

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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)	
2420301	Electrical Circuit and Networks	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

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

J) **Theory Session Outcomes (TSOs) and Units: T2420301**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO 1a. Classify the given components into active and passive.</p> <p>TSO 1b. Differentiate between the following:</p> <ul style="list-style-type: none"> • Linear and nonlinear, • Unilateral and bilateral, • Lumped and distributed parameters, • Independent and dependent source <p>TSO 1c. Describe the nature of the voltage-current characteristics of the given type of voltage source</p> <p>TSO 1d. Reduce the given passive network by using star-delta transformation</p> <p>TSO 1e. Determine the equivalent resistance by using star/delta transformation from voltage to current transformation and vice versa.</p> <p>TSO 1f. Apply Kirchoff's Current and Voltage Law to analyze the given electric circuit(s).</p> <p>TSO 1g. Apply mesh analysis and nodal analysis to determine the current and voltage in a given circuit.</p> <p>TSO 1h. Explain Transient and steady state condition in a given circuit</p> <p>TSO 1i. Determine initial state and steady state of R, L & C in DC Circuit and give its application</p>	<p>Unit-1.0 Basics of Electrical Circuits</p> <p>1.1 Definition of:</p> <ul style="list-style-type: none"> • Linear and non-linear • Active and passive components • Unilateral and bilateral • Lumped and distributed parameters • Independent and dependent source <p>1.2 Concept of open circuit, closed circuit and short circuit, node, branch, mesh and loop</p> <p>1.3 Star/Delta transformation of passive network</p> <p>1.4 Source transformation</p> <p>1.5 Kirchoff's Current Law (KCL) and Kirchoff's Voltage Law (KVL), Applications</p> <p>1.6 Mesh Analysis and Nodal analysis of networks</p> <p>1.7 Transient & steady state</p> <p>1.8 Concept of initial and final conditions in switching circuits, Meaning of $t = 0^-$, $t = 0^+$, and $t = \infty$. R, L and C at initial and final conditions</p>	<p>CO1</p>
<p>TSO 2a. Solve a given complex linear active bilateral electrical circuit/network with multiple source using superposition theorem.</p> <p>TSO 2b. Substitute a given complex electrical circuit/network across its load terminals by a equivalent circuit comprising of a voltage source in series with Thevenin's resistance.</p> <p>TSO 2c. Simplify a given linear complex electrical circuit/network to an equivalent circuit comprising of current source in parallel with resistance.</p> <p>TSO 2d. Transfer supply voltage and output current mutually in a linear passive</p>	<p>Unit-2.0 Network Theorems:</p> <p>2.1 Superposition theorem and its applications</p> <p>2.2 Thevenin's theorem and its applications</p> <p>2.3 Norton's theorem and its applications</p> <p>2.4 Reciprocity theorem and its applications</p> <p>2.5 Maximum power transfer theorem</p> <p>2.6 Application of theorems to solve DC networks</p>	<p>CO1, CO2</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>electrical circuit/network by applying reciprocity theorem and also mention its applications</p> <p>TSO 2e. Determine the conditions for maximum power transfer across Load</p>		
<p>TSO 3a. Explain the behavior of AC voltage, current and power through pure resistance, pure inductance and pure capacitance with sketches</p> <p>TSO 3b. Determine the current and voltage, impedance of the given series/parallel RL/RC/LC/ RLC circuit</p> <p>TSO 3c. Determine the active, reactive, apparent power and power factor of the given AC circuit Differentiate the given AC circuit quantities.</p> <p>TSO 3d. Represent the given AC circuit quantities in complex form.</p> <p>TSO 3e. Convert the given AC quantity in rectangular to polar and vice versa and other arithmetic operations.</p> <p>TSO 3f. Determine the current and voltage, impedance of the given series/parallel RL/RC/ RLC circuit</p> <p>TSO 3g. Determine the active, reactive, apparent power and power factor of the given AC circuit</p>	<p>Unit-3.0 Single Phase AC Circuits:</p> <p>3.1 Generation of an alternating EMF</p> <p>3.2 AC circuit quantities: Peak value, RMS and Average value of a Sinusoidal voltage waveform</p> <p>3.3 Vector representation of an alternating quantity, addition, subtraction, multiplication and division, Conversion from rectangular to polar and vice versa and exponential form</p> <p>3.4 Waveforms, phasor diagram and expression of voltage, current and power in pure: Resistance, Inductance, Capacitance</p> <p>3.5 AC Series and parallel circuits, Phasor diagrams and impedance triangle</p> <p>3.6 Active, reactive, apparent power with examples, Power factor, lagging, leading and unity power factor, effects of poor power factor, power triangle</p>	<p>CO3</p>
<p>TSO 4a. Explain the phenomena of resonance in the given RLC series and parallel circuit with sketches</p> <p>TSO 4b. Determine the resonant frequency of the given series RLC circuit</p> <p>TSO 4c. Explain the significance of quality factor of the given series RLC circuit.</p> <p>TSO 4d. Determine the equivalent impedance and current magnitude of the given parallel RLC circuit under resonance condition</p> <p>TSO 4e. Explain 2-port network and classify it.</p> <p>TSO 4f. Determine the Z, Y & T parameter using electrical circuits</p> <p>TSO 4g. Determine the conditions of symmetry and reciprocity of two port networks</p>	<p>Unit-4.0 Resonance and Two Port Network:</p> <p>4.1 Resonance and its importance in electrical circuit</p> <p>4.2 Series & Parallel resonance: Resonant frequency, Quality factor, bandwidth and selectivity in series & Parallel RLC circuit.</p> <p>4.3 Magnification in series and parallel resonant circuit</p> <p>4.4 Comparison of series and parallel resonance and its applications</p> <p>4.5 Significance of two port network and its types</p> <p>4.6 Open Circuit (Z) parameter, Short Circuit (Y) parameter & Transmission parameter</p> <p>4.7 T and Pie representation of circuits Symmetry and reciprocity of two port network</p>	<p>CO3, CO4</p>
<p>TSO 5a. Explain phase and time displacement of three phases.</p> <p>TSO.5.b Determine the current drawn by the given three phase balanced load connected in star/delta.</p>	<p>Unit-5.0 Three phase AC circuits</p> <p>5.1 Generation of three phase voltage</p> <p>5.2 Three phase three wire source and three phase four wire source, Phase sequence and phasor diagram</p> <p>5.3 Line and phase relationship: Star/Delta</p>	<p>CO4, CO5</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5.c Explain the line and phase relation of current /voltage of three phase circuit.	5.4 Three phase load -balanced and unbalanced Load 5.5 Measurement of power in three phase circuits	
TSO.5.d Determine the current drawn by the given three phase loads connected in parallel.		
TSO.5.e Determine the power and power factor of the given three phase load using two wattmeters		
TSO.5.f Determine the power factor of the given type of three phase load connected in parallel using power triangle.		

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420301

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify the commonly used components in an electrical circuit.	1.	Identification of components used in the given electrical Circuit	CO1
LSO 1.2. Measure voltage and current using suitable meters/instruments in the given linear electric circuit.	2.	Measurement of voltage and current in a given linear electrical circuit.	CO1
LSO 1.3. Measure current and voltage in a given electric circuit by applying Kirchoff 's Current law.	3.	Measurement of current and voltage in a branch of the given electrical circuit using Kirchoff's Current Law.	CO1
LSO 1.4. Measure voltage drop in a closed loop in a given electric circuit by applying Kirchoff's Voltage Law.	4.	Measurement voltage drop in closed loop of the given electrical circuit using Kirchoff's Voltage Law.	CO1
LSO 1.5. Connect star connected resistances to its equivalent delta connection and determine the equivalent resistance.	5.	Connection of star connected resistances to its equivalent delta connection to measure the equivalent resistance.	CO1
LSO 1.6. Connect delta connected resistances to its equivalent Star connection and determine the equivalent resistance.	6.	Connection of delta connected resistances to its equivalent Star connection to measure the equivalent resistance.	CO1
LSO 1.7. Measure current and voltage of the given electric circuit using mesh analysis technique.	7.	Application of mesh analysis to measure current and voltage of the given electric circuit.	CO1
LSO 1.8. Measure voltage across a circuit element of a given electric circuit Applying nodal analysis technique.	8.	Application of nodal analysis to measure voltage across a circuit element of a given electric circuit	CO1
LSO 2.1. Measure current in a branch of the given bilateral multiple source circuit using superposition theorem.	9.	Measurement of current in a branch of the given electrical circuit having two or more input sources using Super position theorem.	CO1, CO2
LSO 2.2. Determine the circuit parameters of the given network using Thevenin's theorem.	10.	Measurement of load current in the load resistance using Thevenin's theorem in a given circuit.	CO1, CO2
LSO 2.3. Determine the circuit parameters of the given network using Norton's theorem.	11.	Measurement of load current in the load resistance using Norton's theorem in a given circuit.	CO1, CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.4. Measure the value of load resistance for which maximum power is produced in the given electric circuit.	12.	Measurement of the value of load resistance for which maximum power is produced in a given electric circuit.	CO1, CO2
LSO 3.1. Measure the peak value, RMS value, Period and frequency of a sinusoidal voltage using CRO.	13.	Measurement of peak value, RMS value, Period and frequency of a sinusoidal voltage using CRO.	CO2, CO3
LSO 3.2. Plot the waveform of voltage and current in a resistive load using CRO.	14.	Waveform of voltage and current in a resistive load.	CO2, CO3
LSO 3.3. Plot the waveform of voltage and current in a R-L load.	15.	Plot the waveform of voltage and current in a R-L load.	CO2, CO3
LSO 3.4. Plot the waveform of voltage and current in a R-L-C load.	16.	Plot the waveform of voltage and current in a R-L-C load	CO2, CO3
LSO 3.5. Measure the voltage, current in a series RLC circuit and calculate power and power factor and draw phasor diagram.	17.	Measurement of voltage, current, power and power factor in a series RLC circuit	CO2, CO3
LSO 3.6. Measure voltage, current, power and power factor in an RLC parallel circuit and draw phasor diagram	18.	Measurement of voltage, current, power and power factor in a RLC parallel circuit	CO2, CO3
LSO 3.7. Determine the power and power factor in AC circuit using three ammeter method.	19.	Determination of the power and power factor in AC circuit using three ammeter method	CO2, CO3
LSO 4.1. Determine the current at resonance in a series RLC circuit	20.	Determination of the current in an electric circuit at series resonance.	CO3, CO4
LSO 4.2. Determine the resonance frequency and impedance of the given parallel RLC circuit at resonance	21.	Determination of the resonance frequency and impedance of the given parallel RLC circuit at resonance	CO3, CO4
LSO 4.3. Measure Open Circuit (Z) parameter, Short Circuit (Y) of a two-port network	22.	Measurement of Open Circuit (Z) parameter, Short Circuit (Y) of a two-port network	CO3, CO4
LSO 5.1. Measure the line/phase current, line voltage/phase voltage for the given three phase loads connected to a three-phase source.	23.	Measurement of the line/phase current, line voltage/phase voltage for the given three phase loads connected to a three-phase source.	CO5
LSO 5.2. Measure three phase power for the given star connected load.	24.	Measurement of neutral displacement voltage of the given three phase unbalanced load connected to a three-phase source	CO4, CO5
LSOs 5.3 Measure three phase power for the given star/delta connected load	25.	Measurement of three phase power for the given star/delta connected load	CO4, CO5

L) **Suggested Term Work and Self Learning: S2420301** 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.

a) Solve simple numerical by applying Kirchoff's laws, mesh analysis and nodal analysis techniques.

- b) Justify that a diode is a unilateral element and the transmission line is a bilateral element.
- c) Solve simple numerical by applying various Network theorems.
- d) Collect information about the ratings of single-phase electrical equipment in kVA and kW in your electrical machine lab.
- e) Explain the significance and applications of series and parallel resonance.
- f) Solve simple numerical on Open Circuit (Z) parameter, Short Circuit (Y) parameter & Transmission parameters
- g) Enumerate the different ways of measuring 3 phase active and reactive power.
- h) Enumerate the uses of different measurement connections that are possible in three phase systems and their differences.

b. Micro Projects:

- i. Connect two identical battery sources in parallel /series. Find the current flowing through and voltage across given resistor connected as load and verify it theoretically. Also submit the detail report on it.
- ii. Prepare a chart illustrating the principle of transformation of sources.
- iii. Prepare a chart depicting various network theorems studied.
- iv. Build and test an electrical circuit to verify maximum power transfer theorem.
- v. Measure the energy consumed by a single-phase AC circuit by using watt meter and energy meter and compare the results measured.
- vi. Prepare an RC and RL series circuit with a toggle switch and DC source and also plot the voltage/current time response and calculate the time constant

c. Other Activities:

1. Seminar Topics:

- Network theorems and its applications.
- Compare series resonance with parallel resonance
- Active, reactive and apparent power with examples
- Phase sequence Indicator and its working

2. Visits: Visit nearby industry/supplier to Collect information about the working of phase sequence indicator available in market.

3. Self-Learning Topics:

- Compile the rating of the different types of components and materials used in a typical electric circuit. Prepare a chart of the same
- Explore the practical application of Maximum Power Transfer theorem
- Compare power factor of a resistive, inductive and capacitive circuit
- Determine Power factor by different methods
- Analyse the causes and effects of resonance in a electrical network.
- Phase sequence indicator and its working.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	20%	25%	20%	32%	20%
CO-2	20%	20%	20%	25%	20%	16%	20%
CO-3	20%	20%	20%	25%	20%	28%	20%
CO-4	20%	20%	20%	-	20%	12%	20%
CO-5	20%	25%	20%	25%	20%	12%	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 Basics of Electrical Circuits	8	CO1	12	3	5	4
Unit-2.0 Network Theorems	8	CO1, CO2	14	4	5	5
Unit-3.0 Single Phase AC Circuits	10	CO3, CO4	14	4	5	5
Unit-4.0 Resonance and Two Port Network	10	CO3, CO4	14	4	5	5
Unit-5.0 Three Phase AC circuits	12	CO4, CO5	16	5	5	6
Total	48	-	70	20	25	25

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identification of components used in the given electrical Circuit	CO1	50	40	10
2.	Measurement of voltage and current in a given linear electrical circuit.	CO1	60	30	10
3.	Measurement of current and voltage in a branch of the given electrical circuit using Kirchhoff's Current Law.	CO1	60	30	10
4.	Measurement voltage drop in closed loop of the given electrical circuit using Kirchhoff's Voltage Law.	CO1	60	30	10
5.	Connection of star connected resistances to its equivalent delta connection to measure the equivalent resistance.	CO1	50	40	10
6.	Connection of delta connected resistances to its equivalent Star connection to measure the equivalent resistance.	CO1	50	40	10
7.	Application of mesh analysis to measure current and voltage of the given electric circuit.	CO1	50	40	10
8.	Application of nodal analysis to measure voltage across a circuit element of a given electric circuit	CO1, CO2	50	40	10
9.	Measurement of current in a branch of the given electrical circuit having two or more input sources using Super position theorem.	CO1, CO2	50	40	10
10.	Measurement of load current in the load resistance using Thevenin's theorem in a given circuit.	CO1, CO2	40	50	10
11.	Measurement of load current in the load resistance using Norton's theorem in a given circuit.	CO1, CO2	40	50	10
12.	Measurement of the value of load resistance for which maximum power is produced in a given electric circuit.	CO1, CO2	60	30	10
13.	Measurement of peak value, RMS value, Period and frequency of a sinusoidal voltage using CRO.	CO1, CO3	50	40	10
14.	Plot the waveform of voltage and current in a resistive load using CRO.	CO1, CO3	50	40	10
15.	Plot the waveform of voltage and current in a R-L load.	CO1, CO3	50	40	10
16.	Plot the waveform of voltage and current in a R-L-C load	CO1, CO3	50	40	10
17.	Measurement of voltage, current, power and power factor in a series RLC circuit	CO1, CO3	50	40	10
18.	Measurement of voltage, current, power and power factor in a RLC parallel circuit	CO1, CO3	45	45	10
19.	Determination of the power and power factor in AC circuit using three ammeter method	CO1, CO3	50	40	10
20.	Determination of the current in a electric circuit at series resonance.	CO3, CO4	50	40	10
21.	Determination of the resonance frequency and impedance of the given parallel RLC circuit at resonance	CO3, CO4	50	40	10
22.	Measurement of Open Circuit (Z) parameter, Short Circuit (Y) of a two-port network	CO4	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
23.	Measurement of the line/phase current, line voltage/phase voltage for the given three phase loads connected to a three-phase source.	CO1, CO3, CO5	60	30	10
24.	Measurement of neutral displacement voltage of the given three phase unbalanced load connected to a three-phase source	CO5	50	40	10
25.	Measurement of three phase power for the given star/delta connected load	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Passive components; R, L and C	R, L and C of different values	1,2,9,10,11,12
2.	Bread Board with hookup wires	-	1,2
3.	DC Ammeter	0-5/10 A, portable analog PMMC type as per relevant BIS standard	3,7, 9,10,11,12
4.	DC Voltmeter	0-150/300 V, portable analog PMMC type as per relevant BIS standard	4,8, 9,10,11,12
5.	DC Voltmeter	0-15/30/75 V, portable analog PMMC type as per relevant BIS standard	3,4,8, 9,10,11,12
6.	AC Voltmeter	0-75/150/300 V, portable analog MI type as per relevant BIS standard	6, 7, 8, 10
7.	AC Voltmeter	0-150/300/600V portable analog MI type as per relevant BIS standard	
8.	AC Ammeter	0-2.5-5-10 A, portable analog MI type as per relevant BIS standard	10
9.	Single phase Electrodynamometer wattmeter	0/100/300 V, 0,2.5/5 A portable	18
10.	Digital portable LCR meter	Inductance: 0.1 mH to 9999 H, Resolution: 0.1 mH, Capacitance: 0.1 pF to 9999 mF, Resolution: 0.1pF Resistance: 0.001 ohm to 1 M ohm, Resolution :0.001W	1,2

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
11.	Rheostat	Nichrome wire wound rheostat on epoxy test or Class F insulating tube with two fixed and one sliding contact 0-500 Ohm, 1.2A 0-100 Ohm, 5 A 0-50 Ohm, 10 A 0-350 Ohm, 10 A 0-350 Ohm, 1.5 A	1,2
12.	Digital Multimeter	5 1/2 digits resolutions with all basic measurement facility like DC Voltage: 200 mV ~ 1000 V, DC Current: 200 μ A ~ 10 A, AC Voltage: TrueRMS, 200 mV ~ 750 V, AC Current: True-RMS, 20 mA ~ 10 A, 2-Wire, 4-Wire Resistance: 200 Ω ~ 100 M Ω , Capacitance Measurement: 2 nF ~ 10000 μ F, Frequency Measurement: 20 Hz ~ 1 MHz etc., 0.015% DC Voltage Accuracy.	5,6
13.	Cathode Ray Oscilloscope	30 MHz Bandwidth, 2 channel, 20 ns sampling time	13,14,15,16
14.	Function Generator	10 HZ to 10 MHZ, 10 Vpp , rise & fall time =20ns, manual / external triggering	13,14,15,16
15.	Choke coil	0- 80 mH,	15
16.	Variable choke coil	-	-
17.	Single phase Variac	0-230V/ 260V, 4A 0-230V/ 260V, 8A	17,18,19,20,21
18.	Three phase Variac	0-415V/0-460V, 15 Amps	23,24,25

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	A Text book of Electrical Technology, Volume-I	Theraja, B.L.	S. Chand and Co. New Delhi ISBN-10: 8121924405 ISBN-13: 978-8121924405
2.	Network and System	Hussain Ashfaq	Khanna Publishers ISBN-10: 8187522089 ISBN-13: 978-8187522089
3.	Network Analysis	Van Valkenburg	PHI Learning ISBN-10: 9353433126 ISBN-13: 978-9353433123
4.	Networks and Systems	Choudhary D. Roy	NEW AGE; Second edition, 2013 ISBN-10: 9788122427677 ISBN-13: 978-81224276
5.	Electric Circuits and Network	Suresh Kumar, K S	Pearson Education ISBN: 978-8131713907
6.	Schaum's Outline of Electric Circuits (Schaum's Outline Series)	Nahvi, M; Edminister, Joseph	Tata McGraw Hill Education Private Ltd. ISBN: 978-1260011968
7.	Circuit Theory: Analysis and Synthesis	Chakrabarti, Abhijit	Dhanpat Rai & Co ISBN: 978-8177000009
8.	Fundamental of Electric Circuits	Charles K. Alexander, Matthew N.O. Sadiku	McGraw-Hill Education ISBN: 978-1259098598

(b) Online Educational Resources:

1. <https://nptel.ac.in/courses/108104139>
2. <https://archive.nptel.ac.in/courses/108/104/108104139/>
3. <https://archive.nptel.ac.in/courses/117/106/117106108/>
4. <https://alison.com/course/advanced-diploma-in-basic-electrical-circuits>
5. <https://archive.nptel.ac.in/courses/108/105/108105159/>

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. UNSW Handbook on Electric Circuits,2021
2. Introduction to Electric Circuits by Eur Ing RG Powell
3. Electric circuits simulation lab manuals

- A) **Course Code** : 2420302(T2420302/P2420302/S2420302)
- B) **Course Title** : Electrical Measurement and Instrumentation
- C) **Pre- requisite Course(s)** : Basic Mechanical Engineering, Basic Electrical Engineering
- D) **Rationale** :

The electrical engineering diploma engineers are expected to measure precisely voltage, current, power, energy, etc. by using different types of meters. Therefore, they should be competent to use, calibrate and maintain different types of electrical and electronics measuring instruments used in the industry and electrical systems. This course being the core course, demands a better understanding of the construction, materials used and principle of operation safe operating procedures of various types of measuring instruments. The students after passing this course should possess the knowledge, skill set not only to use appropriate measuring instruments correctly and precisely but also should be able to maintain the same.

- 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** Interpret the basic concepts of measurement and instrumentation for measuring instruments.
- CO-2** Measure current and voltage in an electrical system.
- CO-3** Measure power and energy in single and three phase systems.
- CO-4** Measure resistance, inductance, capacitance using bridges/meters.
- CO-5** Use various instruments/meters for measuring electrical parameters such as power factor, Phase sequence, circuit components.

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

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline-Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	2	3	2	1	-	2		
CO-2	3	2	2	2	1	1	2		
CO-3	3	2	2	2	2	1	2		
CO-4	3	2	2	2	1	1	2		
CO-5	3	2	3	2	1	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				
2420302	Electrical Measurement and Instrumentation	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)	
2420302	Electrical Measurement and Instrumentation	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, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

J) **Theory Session Outcomes (TSOs) and Units:T2420302**

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO.1.a	Explain basic concept and significance of measurements.	Unit-1.0 Basics of Measurement and Instrumentation 1.1 Measuring systems and requirements: Block diagram 1.2 Deflecting, controlling and damping torque 1.3 Accuracy, precision, Resolution, tolerance, sensitivity and repeatability 1.4 Errors in measurement 1.5 Types of errors- Limiting error, Gross error, systematic Error, Random Error, Guaranteed accuracy error 1.6 Classification of basic instruments -Indicating, Recording and Integrating type	CO1
TSO.1.b	Differentiate between deflecting, controlling and damping torque in an instrument.		
TSO.1.c	Explain the given terms related to measuring systems.		
TSO.1.d	Classify types of errors in measurement.		
TSO.1.e	Classify different types of instruments.		
TSO.2.a	Explain the general principle of measuring current, voltage in an electrical system.	Unit-2.0 Measurement of Voltage and Current 2.1 Current and voltage measurement: Principle 2.2 Galvanometer, Ammeter, Voltmeter 2.3 Calibration of ammeter and voltmeter 2.4 Range Extension of ammeter and voltmeter using: i. Shunts and Multipliers b. Current Transformer (CT) and Potential Transformer (PT) (Construction, working and applications) 2.5 Permanent Magnet Moving Coil (PMMC), Moving iron, Induction, Dynamometers type instruments: Working principle, construction, applications, merits and demerits 2.6 Essentials and advantages of electronic instruments 2.7 True RMS reading voltmeter. 2.8 Digital Voltmeters (DVM) and its types 2.9 Digital multimeters- Block diagram	CO2
TSO.2.b	Extend the range of ammeter and voltmeter using shunt, multipliers and Current Transformer and Potential Transformer		
TSO.2.c	Describe the calibration procedure of the given meters.		
TSO.2.d	Describe the construction and working principle of the given types of electromechanical measuring instruments.		
TSO.2.e	Explain the working principle of the given types of electromechanical measuring instruments.		
TSO.2.f	Explain the significance of using electronic instruments		
TSO.2.g	Explain the working of true rms voltmeter with block diagram.		
TSO.2.h	Explain the working of DVM with block diagram.		
TSO.2.i	Describe working and advantage of digital multi meter with block diagram.		
TSO.3.a	Explain the general principle of measuring power and energy in an electrical system	Unit-3.0 -Measurement of Power and Energy 3.1 Power and energy Measurement: Principle	CO3
TSO.3.b	Explain the working of induction and dynamometer type instruments.		

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO.3.c	Explain the general principle of measuring single and three phase power in an electrical system	3.2 Measurement of single and three phase power using wattmeter - one wattmeter and	
TSO.3.d	Apply the power measuring technique in distribution and transmission system.	3.3 two wattmeter method	
TSO.3.e	Describe the construction and working of single and 3 phase energy meters	3.4 Effect of power factor variation on wattmeter reading in two wattmeter method	
TSO.3.f	Determine errors and compensation in an energy meter.	3.5 Measurement of energy using single phase and three phase watt-hour/Energy meter	
TSO.3.g	Describe the standard procedure for calibration of the given equipment.	3.6 Errors and compensation in energy meter 3.7 Crippling and phantom loading in energy meter 3.8 Calibration of watt meters and energy meters 3.9 Digital energy meter: Block diagram, Working	
TSO.4.a	Classify the resistance into low, medium and high.	Unit 4.0-Measurement using Bridges/Meters	CO4
TSO.4.b	Explain the basic concept of bridge and bridge balancing.	4.1 Classification of resistances - Low, Medium and High	
TSO.4.c	Describe the procedure to measure unknown resistance (low, medium and high) using appropriate bridge/method.	4.2 Concept of bridge, balancing	
TSO.4.d	Describe the method of using Earth tester to measure earth resistance	4.3 Resistance measurement -Kelvins double bridge (Low), voltmeter - ammeter method, Wheatstone bridge, ohmmeter (Medium) and Megger (High).	
TSO.4.e	Describe the procedure to measure an unknown inductance by using appropriate bridge	4.4 Earth resistance	
TSO.4.f	Describe the procedure to measure the unknown Capacitance using appropriate bridge	4.5 Inductance measurement – Anderson, Maxwell inductance capacitance bridge	
TSO.4.g	Describe the procedure to measure an unknown frequency by using wein bridge/ Weston Frequency meter.	4.6 Capacitance Measurement- Schering bridge. 4.7 Frequency Measurement -Wein bridge, Weston Frequency meter.	
TSO.5.a	Describe the procedure to measure the power factor by using P.F meter.	Unit 5.0– Measurement of Other Electrical Parameters	CO5
TSO.5.b	Describe the procedure of using a Phase sequence indicator to determine the phase sequence	5.1 Dynamometer, Power Factor meter	
TSO.5.c	Explain the use of Synchroscope in synchronization	5.2 Phase sequence indicator: rotating type	
TSO.5.d	Describe functions of basic building blocks of CRO	5.3 Synchro scope	
TSO.5.e	Explain deflection systems of CRO	5.4 CRO-basic clock diagram, Cathode Ray Tube, Electrostatic and magnetic deflection, X & Y Amplifiers, Controls on CRO and their functions, Lissajous pattern	
TSO.5.f	Explain working of digital storage oscilloscope using block diagram.	5.5 Measurement of voltage, amplitude, time period, frequency and phase angle	
TSO.5.g	Describe the working of Q/ LCR meter using block diagram	5.6 Digital Storage Oscilloscope- Basic block diagram and working	
TSO.5.h	Explain the working of the given type of recorders with the help of a block diagram	5.7 Q/LCR meter, Digital LCR meter- Block diagram, Working principle	
		5.8 Analog/Digital recorders, Graphic recorder, Strip Chart recorder, XY recorder (Only block diagram)	
		5.9 Applications of Recorders.	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420302

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1	Select Indicating, Recording and Integrating Instruments in your laboratory and write their specifications and features.	1.	Identification of Indicating, Recording and Integrating Instruments	CO1
LSO 2.1	Measure DC, AC voltage and current using analogue meter.	2.	Measurement of DC, AC voltage and current.	CO2
LSO 2.2	Convert a given galvanometer to DC/AC current- meter.	3.	Conversion of a given galvanometer to DC/AC current- meter.	CO2
LSO 2.3	Extend the range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.	4.	Extension of range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.	CO2
LSO 2.4	Measure high value of current and voltages using Current and Potential Transformer.	5.	Measurement of high value of current and voltages using Current and Potential Transformer.	CO2
LSO 2.5	Calibrate the given ammeter and voltmeter with a standard meter	6.	Calibration of ammeter and voltmeter	CO2
LSO 2.6	Interpret the working principle of moving iron and moving coil type instruments.	7.	Demonstration of working of Moving Iron and Moving Coil type instruments.	CO2
LSO 2.7	Interpret the working principle of Induction type and dynamometer type instruments	8.	Demonstration of the working of Induction type and dynamometer type instruments	CO2
LSO 2.8	Measure voltage, current, resistance using Digital Multimeter	9.	Measurement of voltage, current, resistance using Digital Multimeter	CO2
LSO 2.9	Perform continuity test using digital Multimeter	10.	Continuity test using digital Multimeter	CO2
LSO 3.1	Measure single and three phase power using one wattmeter	11.	Measurement of single and three phase power using one wattmeter	CO3
LSO 3.2	Measure 3 phase power using two and three wattmeter method	12.	Measurement of 3 phase power using two and three wattmeter method	CO3
LSO 3.3	Calibrate the given wattmeter with a standard meter.	13.	Calibration of wattmeter.	CO3
LSO 3.4	Calibrate the given single-phase energy meter with a standard meter.	14.	Calibration of single-phase energy meter.	CO3
LSO 3.5	Interpret the working of a digital energy meter	15.	Demonstration of the working of a digital energy meter	CO3
LSO 4.1	Use Kelvin's double bridge for measurement of low resistance	16.	Kelvin's double bridge for measurement of low resistance	CO4
LSO 4.2	Measure medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter	17.	Measurement of medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter	CO4
LSO 4.3	Use Megger to measure insulation resistance.	18.	Measurement of insulation resistance using Megger.	CO4
LSO 4.4	Measure insulation resistance using Megger.			
LSO 4.5	Using Earth tester to measure earth resistance.	19.	Measurement of earth resistance using Earth tester	CO4
LSO 4.6	Measure earth resistance using Earth tester.			

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 4.7 Use Anderson or Maxwell inductance capacitance bridge to measure unknown inductance. LSO 4.8 Measure unknown inductance using Anderson or Maxwell inductance capacitance bridge	20.	Measurement of unknown inductance using Anderson or Maxwell inductance capacitance bridge	CO4
LSO 4.9 Use Schering's Bridge to measure unknown capacitance. LSO 4.10 Measure unknown capacitance using Schering's Bridge.	21.	Measurement of unknown capacitance using Schering's Bridge	CO4
LSO 4.11 Use Wein bridge or Weston frequency meter to measure unknown frequency LSO 4.12 Measure unknown frequency using Wein bridge or Weston frequency meter.	22.	Measurement of unknown frequency using Wein bridge or Weston frequency meter	CO4
LSO 5.1 Measure power factor using a dynamometer PF meter	23.	Measurement of power factor using a dynamometer PF meter	CO5
LSO 5.2 Use phase sequence indicator to identify the phase sequence and reverse the phase sequence.	24.	Identification of phase sequence and reverse the phase sequence using the phase sequence indicator	CO5
LSO 5.3 Demonstrate the use of Synchroscope for Synchronization	25.	Demonstration of use of Synchroscope for Synchronization	CO5
LSO 5.4 Measure the amplitude, frequency, time period and Phase difference of different signals generated by function generator using CRO.	26.	Measurement of amplitude, Frequency, time period and Phase difference of different signals generated by function generator using CRO.	CO5
LSO 5.5 Measure Unknown frequency, phase angle using Lissajous patterns.	27.	Measurement of Unknown frequency, phase angle using Lissajous patterns.	CO5
LSO 5.6 Identify the various parts of digital storage oscilloscope.	28.	Demonstration of features of digital storage oscilloscope.	CO5
LSO 5.7 Us LCR meter to measure resistance, Inductance and Capacitance. LSO 5.8 Measure resistance, Inductance and Capacitance using LCR meter.	29.	Measurement of resistance, Inductance and Capacitance using LCR meter	CO5
LSO 5.9 Measure quality Factor of the given Inductor and Capacitor using LCR/Q Meter	30.	Measurement of quality Factor of Inductor and Capacitor using LCR/Q Meter	CO5
LSO 5.10 Interpret the working principle of various analog/digital recorders.	31.	Demonstration of the working of various analog/digital recorders.	CO5

L) **Suggested Term Work and Self Learning: S2420302** 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.
- Prepare a chart depicting symbols of various electrical measuring instruments.
 - Prepare a chart showing the production of deflecting, controlling and damping torque in measuring instruments.
 - Prepare a chart showing the construction and working principle of a PMMC, MI, Induction and dynamometer type of instruments
 - Use an Analog Voltmeter to Measure the Voltage at a Point Referenced to Ground.
 - Write the specifications of various electromechanical meters available in the market.

- vi. Prepare a chart depicting various DC and AC bridges, its uses and procedure to determine electrical parameter.
- vii. Prepare a chart depicting precisely the working of megger and earth tester
- viii. Prepare a chart depicting the construction and various control of CRO.
- ix. Observe the voltage waveform of a RC circuit switched on to DC supply using CRO and determine time constant.
- x. Identify the terminals of various types of meters and prepare a report on it
- xi. Determine the power factor with resistive and inductive load using 2 wattmeter method and comment on the result.

b. Micro Projects:

1. Search on internet for the information about latest trends in indicating, measuring and recording instruments in different field of applications and prepare detail report on it
2. Connect three phase circuit and measure active power using watt meters and prepare report on it.
3. Connect three phase circuit and measure reactive power using appropriate meters and prepare report on it.
4. Use a DMM to Measure the Voltage of a Point Referenced to Ground and submit report on it.
5. Use a DMM to Measure Voltage Drops in Series and Parallel Circuits and submit report on it.
6. Make a meter bridge by soldering the components and prepare a report on it.
7. Measure the Insulation Resistance values of a healthy and non-healthy DC machine and Transformer using Megger and prepare a report on the results obtained.
8. Prepare a report on use of various recorders for different applications
9. Prepare a detailed report on use of LCR meter
10. Observe supply current waveform in a tube light circuit using CRO and prepare a report on it.
11. Prepare a report on the special features of DSO.

c. Other Activities:**i. Seminar on –**

- Working of different types of electrical measuring instruments
- Different torques produced in an electrical measuring instrument
- Megger and its use
- Earth resistance and its measurement using earth tester
- Working of digital multimeter and its applications
- Working of LCR meter and its applications

ii. Survey –

- Carry out a market /internet survey to explore the specification of CRO
- Carry out a market/internet survey to explore the specification of DSO

iii. Visits-

- Visit a nearby industry where electrical instruments are manufactured /assembled.
- Visit a local supplier to get exposure to various ranges of measuring instruments.

d. Self-Learning Topics:

1. Use of basic measuring instruments in industrial applications
2. Use of basic measuring instruments in commercial field
3. Use of basic measuring instruments in research field
4. Specifications of available models of Ammeter, Voltmeter, Wattmeter, Energy meter in the market
5. Specifications of available models of DVM, DMM, CRO, DSO.LCR meter in the market.

- 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%	100 %	20%	20%	20%
CO-2	20%	20%	20%		20%	20%	20%
CO-3	20%	20%	20%		20%	20%	20%
CO-4	25%	25%	20%		20%	25%	20%
CO-5	20%	20%	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 (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Basics of Measurement and Instrumentation	6	CO1	10	3	4	3
Unit-2.0 Measurement of Voltage and Current	10	CO2	14	4	6	4
Unit-3.0 Measurement of Power and Energy	12	CO3	14	4	4	6
Unit-4.0 Measurement using Bridges/Meters	12	CO4	17	5	6	6
Unit- 5.0 Measurement of other Electrical Parameters	8	CO5	15	4	5	6
Total Marks	48	-	70	20	25	25

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identification of Indicating, Recording and Integrating Instruments	CO1	50	40	10
2.	Measurement of DC, AC voltage and current.	CO2	50	40	10
3.	Conversion of a given galvanometer to DC/AC current- meter.	CO2	50	40	10
4.	Extension of range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.	CO2	50	40	10
5.	Measurement of high value of current and voltages using Current and Potential Transformer.	CO2	50	40	10
6.	Calibration of ammeter and voltmeter	CO2	50	40	10
7.	Demonstration of working of Moving Iron and Moving Coil type instruments.	CO2	50	40	10
8.	Demonstration of the working of Induction type and dynamometer type instruments	CO2	50	40	10
9.	Measurement of voltage, current, resistance using Digital Multimeter	CO2	50	40	10
10.	Continuity test using digital Multimeter	CO2	50	40	10
11.	Measurement of single and three phase power using one wattmeter	CO3	50	40	10
12.	Measurement of 3 phase power using two and three wattmeter method	CO3	50	40	10
13.	Calibration of wattmeter.	CO3	50	40	10
14.	Calibration of single-phase energy meter.	CO3	50	40	10
15.	Demonstration of the working of a digital energy meter	CO3	50	40	10
16.	Kelvin's double bridge for measurement of low resistance	CO4	50	40	10
17.	Measurement of medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter	CO4	50	40	10
18.	Measurement of insulation resistance using Megger.	CO4	50	40	10
19.	Measurement of earth resistance using Earth tester	CO4	50	40	10
20.	Measurement of unknown inductance using Anderson or Maxwell inductance capacitance bridge	CO4	50	40	10
21.	Measurement of unknown capacitance using Schering's Bridge	CO4	50	40	10
22.	Measurement of unknown frequency using Wein bridge or Weston frequency meter	CO4	50	40	10
23.	Measurement of power factor using a dynamometer PF meter	CO5	50	40	10

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
24.	Identification of phase sequence and reverse the phase sequence using the phase sequence indicator	CO5	50	40	10
25.	Demonstration of use of Synchroscope for Synchronization	CO5	50	40	10
26.	Measurement of amplitude, Frequency, time period and Phase difference of different signals generated by function generator using CRO.	CO5	50	40	10
27.	Measurement of Unknown frequency, phase angle using Lissajous patterns.	CO5	50	40	10
28.	Demonstration of features of digital storage oscilloscope.	CO5	50	40	10
29.	Measurement of resistance, Inductance and Capacitance using LCR meter	CO5	50	40	10
30.	Measurement of quality Factor of Inductor and Capacitor using LCR/Q Meter	CO5	50	40	10
31.	Demonstration of the working of various analog/digital recorders.	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Moving Iron Ammeter Moving Coil Ammeter	0-2.5/5 Ampere 0-10/20Ampere 0-2 Ampere	1,2,3,6
2.	Moving Iron Voltmeter Moving Coil Voltmeter	0-75/150/300V 0-150/300/600V	1,2,4,5,6,7,8
3.	Wattmeter	0-2.5/5A, 75/150/300V 0-5/10A, 150/300/600V	11,12,13
4.	Energy Meter	Single phase	14
5.	Digital/energy meter	230V, Single phase	15

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
6.	Shunt Multiplier	for Experimentation and Demonstration purpose	4
7.	Current Transformer Potential Transformer	CT and PT for Engineering Laboratory Experimentation and Demonstration purpose	5
8.	Model of MI MC, Dynamometer and induction type meters	For demonstration purpose.	7,8
9.	Megger	Mains/battery pack operated analog/digital insulation tester with selectable ranges of 50V, 250V, 500 V, 1000 V, 2500 V, 5000 V.	18
10.	Kelvin's double bridge	Range: 0.2 Micro - Ohms to 11 ohms, Accuracy: 0.1%(or ± 1 Slide wire division whichever is greater), Multiplier: 5 Ranges (0.01, 0.1, 1, 10 and 100)	16
11.	Wheatstone bridge	Measuring Range-1.000 Ω to 10.00M Ω , Measuring Arm-x 1m Ω , x10 Ω +10 Ω x 10+ 100 Ω x 10+ 1000 Ω x10 (min. one step:1 Ω), Ratio Arms -x0.001x 0.01, x0.01, x0.1, x1, x10, 100, x1000 (M10, M100, M1000 Murray and Varley loop testing), Galvanometer Power Source -Three 1.5V batteries (built-in), Range, $\pm 0.1\%$ of reading on 100 Ω to 100k Ω Range, Accuracy - $\pm 0.3\%$ of reading on 10 Ω to 1M Ω Range, $\pm 0.6\%$ of reading on 1 Ω to 10M Ω Range	17
12.	Maxwell bridge	Maxwell's inductance and Maxwells inductance-capacitance bridge on single board to determine unknown inductance and its Q factor by comparison with either variable standard self-inductance or standard variable capacitance. by setting the null point	20
13.	Schering's Bridge	Four arms provided with suitable connectors, One 1 kHz oscillator of fixed amplitude to feed the input to the bridge. Measuring Range: 0.001 μ F - 2.0 μ F. Connector facility should be provided to view the output of the bridge externally by CRO, required patch Chords to measure unknown Capacitance, Input Voltage: 15V DC, Output Frequency :1kHz Output Voltage :2V AC Output Current :0.5 Amps	21
14.	Digital Multimeter	4 1/2 digit display, 9999 counts digital multimeter measuring: AC Voltage: 0-1000 V max DC Voltage: 0-24 V AC Current: 0-10/20 A Max DC Current: 0-10 A Max Resistance: 0 – 100 M ohm Capacitance measurement, component tester	9,10, and all
15.	D.C. Regulated power supply	230 Volt AC to 0-30Volt DC, 5Amp display for voltage and current.	26,27,28,29,30
16.	Cathode Ray Oscilloscope	30 MHz, Dual Trace	26,27
17.	Digital Storage Oscilloscope	2 Channel 70 MHz & 100 MHz	28
18.	LCR/Q meter	Hand held type 3 1/2 digit, 7 segment, LCD display	29,30

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		Ranges: Inductance: Upto 200 H, Capacitance: Upto 2000 μ F, Resistance: Upto 20 M Ω Useful for measurement of inductances, capacitances and resistances of inductors, capacitors, resistors, motors, transformers, coils, chokes, cables, wires	
19.	Earth resistance Tester	Portable analog/digital to measure up to 10 ohms	19
20.	Soldering Iron	Soldering iron 230V, 30/50W, Flux for soldering and Solder filler material.	All
21.	Digital Voltmeter	Voltage DC Accuracy \pm (0.09% + 2) Current AC Maximum 10 A Accuracy \pm (0.09% + 1) Resistance, Max resolution 0.1 Ω	25,26
22.	Galvanometer	Current Sensitivity 0.9 μ A/div \pm 10% Voltage sensitivity 270 μ V/div \pm 15% External Circuit resistance 200 Ω	3
23.	Digital Volt-Ohm Meter	Power Requirements: 100 or 115, 200 or 230 V AC (must be specified), 50 or 60 Hz. Power Consumption: 20 VA max Operating Temperature Range: 5 to 40°C (41 to 104°F).	17
24.	Function generator	Outputs: Square wave, sine wave, triangle wave, TTL pulse, positive and negative ramp, pulse and skewed sine wave, AM, and sweep functions Frequency ranges: 0.1 Hz to 11 MHz, up/down range switchable in eight-decade steps Dial accuracy: \pm 5% of full scale from 0.1 Hz to 10 MHz 11 MHz setting not less than 11 MHz (ambient temperature 20° C to 30° C)	26,27
25.	Phase sequence Indicator	Operating voltage (AC): 50-500 V	24
26.	Synchroscope	Frequency: 50 \pm 5% Synchronizing Condition: dark lamp method Accuracy: 2 degree or higher Angle of rotation: 360 degree Power consumption: less than 6VA Mounting: Flush Mounting	25

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	A course in electrical & electronic measurements and instrumentation	Sawhney, A.K.	Dhanpat rai & sons, Delhi: ISBN-13: 978-8177001006
2.	Electronic Instrumentation	Kalsi H. S.	Tata McGraw-Hill Education ISBN-13:978-0-07-070206-6
3.	A course in Electrical & Electronics Measurement	Gupta J.B.	S K Kataria and Sons; Reprint 2013 edition (1 January 2013) ISBN-10 : 8188458937 ISBN-13 : 978-8188458936

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
4.	Electronic instrumentation & measurement techniques	Cooper, W.D. & Helfrick, A.D.,	New Delhi: Prentice Hall of India ISBN- 13:9780132507219
5.	Electrical measurements & measuring instruments	Suryanarayana	New Delhi, Tata McGraw Hill ISBN- 0-07-451751-1
6.	Instrumentation for Engineering Measurements	Dally, J.W. et al;	John Wiley & Sons, New York ISBN - 9780471551928
7.	Electronic Instrumentation Fundamentals	Albert Paul Malvino	Tata McGraw Hill, New Delhi ISBN-13: 978-0070398474
8.	Instruments Devices and System	Rangan C. S.	Tata McGraw Hill Publications ISBN- 9780074633502
9.	Digital Instrumentation	Bouwens A. J	Tata McGraw Hill Publications ISBN-0070067120

(b) Online Educational Resources:

- Basics of Measurement & Measuring Instruments:
<https://www.youtube.com/watch?v=oV7TpfoiYNY>
- Electromechanical Measuring Instruments: -
<https://www.youtube.com/watch?v=k5Nzkyb8u4Y>
- Ammeter, Voltmeter and wattmeter: <https://www.youtube.com/watch?v=-tha5hKhC5Q>
- CT & PT: <https://www.youtube.com/watch?v=D-ctyWhKTh0>
- Measurements using Bridges/meters: <https://www.youtube.com/watch?v=nWWzKgEBqjA>
- Megger: <https://www.youtube.com/watch?v=XV6QITwobLo>
- Electronic instruments: <https://www.youtube.com/watch?v=TdUK6RPdIrA>
- True RMS meter: <https://www.youtube.com/watch?v=7ZzwIkIBbKc>
- Cathode Ray Oscilloscope : <https://www.youtube.com/watch?v=U1amW7S1fcl>
- Cathode Ray Oscilloscope: <https://www.youtube.com/watch?v=JsoZZM2Vc5Y>
- Lissajous pattern on CRO: <https://www.youtube.com/watch?v=pSyitNgy8hE>
- Digital Storage Oscilloscope : https://www.youtube.com/watch?v=FkWtPou_RGM

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:

- Learning Packages
- Users' Guide
- Manufacturers' Manual
- Lab Manuals

- A) **Course Code** : 2420303(T2420303/P2420303/S2420303)
 B) **Course Title** : DC Machines and Transformers
 C) **Pre- requisite Course(s)** : Basic Electrical Engineering
 D) **Rationale** :

The technological changes are taking place very rapidly all over the world and is turning towards a multidisciplinary one. Electrical Engineering diploma holders are expected to apply the principle of electromechanical energy conversion in operating, testing and troubleshooting different types of DC machines, single phase & three phase transformers and special purpose transformers. This course will enable them to develop requisite knowledge, skills and attitude for maintaining various types of DC machines, single phase transformers, three phase transformers and special purpose transformers taking appropriate safety measures during handling of these equipment. This course fundamentally aims at familiarizing the students with the fundamentals of various DC machines, single phase and three phase transformer and development of requisite skills for maintaining this equipment. This course will also provide a strong foundation of DC Machines and Transformers and will enable the students to take up the advance course in electrical machines in the subsequent 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** Test the performance of DC Generators.
CO-2 Control the speed of DC motors as per the requirement.
CO-3 Test the performance of Single-Phase transformers.
CO-4 Operate two three phase transformers in parallel as per the requirement.
CO-5 Use special purpose transformers as per the requirement.

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

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline-Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	2	-	2	2	1	2		
CO-2	3	2	2	2	-	1	2		
CO-3	3	2	2	2	2	1	2		
CO-4	3	2	2	2	2	2	2		
CO-5	3	2	2	2	-	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	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				
2420303	DC Machines and Transformers	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)	
2420303	DC Machines and Transformers	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, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

J) **Theory Session Outcomes (TSOs) and Units: T2420303**

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO.1.a	Describe the construction details of a DC machine.	Unit-1.0 DC Generators 1.1 DC Machine: Construction 1.2 DC Generator: Working Principle 1.3 Types of DC generators: Shunt, Series and Compound and their applications 1.4 EMF equation 1.5 Armature reaction and its effects. 1.6 Commutation. 1.7 Voltage build-up in DC Generators 1.8 Internal and External Characteristics. 1.9 Losses and Efficiency	CO1
TSO.1.b	Explain the working principle of the DC Generator.		
TSO.1.c	Classify DC Generator.		
TSO.1.d	Explain effect of armature reaction in a DC machine.		
TSO.1.e	Explain the process of commutation in DC Generator.		
TSO.1.f	Describe the procedural steps of voltage build up in the DC generator.		
TSO.1.g	Interpret the internal and external Characteristics of the given DC Generators.		
TSO.2.a	Explain the working principle of DC motor.	Unit-2.0 DC Motors 2.1 Working Principle. 2.2 EMF equation, significance of Back EMF 2.3 Torque and Speed 2.4 Characteristics of DC motors - Torque vs Speed, Flux vs Current - Torque vs current, Speed vs Current 2.5 Need of Starters -3-point and 4-point starters. 2.6 Losses and Efficiency 2.7 Speed Control of DC motors - Armature Control Method - Field Flux Control Method 2.8 Selection of DC Motors. 2.9 Applications of different types of DC motors	CO1, CO2
TSO.2.b	Determine the torque for a given DC motor		
TSO.2.c	Interpret the various characteristics of DC motor		
TSO.2.d	Describe the procedure to start the DC motor using given type of starters.		
TSO.2.e	Describe the procedure to control the speed of the given DC motor.		
TSO.2.f	Describe the procedure to select a particular DC motor for the given application.		
TSO.2.g	Enlist the applications of different types of motors including applications in modern transportation systems.		
TSO.3.a	Describe the constructional details of a single-phase transformer.	Unit 3.0 Single Phase Transformer 3.1 Construction. 3.2 Types -Shell type and core type. 3.3 Working Principle, Useful and leakage flux 3.4 EMF Equation, Transformation Ratio. 3.5 Losses – Core and copper 3.6 Ideal and Practical transformer. 3.7 Equivalent circuit and phasor diagram. 3.8 Per Unit (pu) system in transformers	CO3
TSO.3.b	Explain the working principle of transformer.		
TSO.3.c	Derive EMF equation of a single-phase transformer.		
TSO.3.d	Calculate various losses using Open circuit and Short circuit test.		
TSO.3.e	Differentiate Ideal and Practical transformer.		
TSO.3.f	Explain the performance with phasor diagram of the given transformer under no load and different loading conditions for unity, lagging and leading power factor		

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3.g Explain the importance of voltage regulation. TSO.3.h Explain the condition of maximum efficiency of a transformer. TSO.3.i Describe the procedure of performing the Polarity test, Open circuit, Short Circuit Test in the given transformer. TSO.3.j Enlist the essential and desirable conditions for parallel operation of two single phase transformers. TSO.3.k Differentiate between autotransformer and two winding transformers. TSO.3.l Explain the significance of Amorphous Metal Transformer (AMT).	3.9 Voltage Regulation -Condition for maximum, zero and minimum regulation. 3.10 Efficiency -Condition for Maximum Efficiency, All day efficiency and its significance 3.11 Polarity test, Open circuit, Short Circuit Test 3.12 Parallel operation of two single transformers. 3.13 Autotransformers -Construction, application, Inductive and conductive power transfer, Copper saving. 3.14 Energy efficient Amorphous Metal Transformer (AMT).	
TSO.4.a Describe the constructional details of 3-phase transformer. TSO.4.b Classify the different phasor groups of 3-phase transformer TSO.4.c Explain the working of open delta transformer. TSO.4.d Enlist the essential and desirable conditions for parallel operation of two 3-phase transformer. TSO.4.e Explain the Magnetization phenomenon in Transformer.	Unit 4.0 Three Phase Transformer 4.1 Bank of three single phase transformer and single unit of 3-phase transformer 4.2 Different parts of 3-phase transformers 4.3 Phasor groups of 3-phase transformers 4.4 Open Delta transformer 4.5 Parallel Operations of two 3-phase transformers 4.6 Magnetization phenomenon in Transformer.	CO3, CO4
TSO.5.a Explain the construction and working principle of the given special purpose transformers. TSO.5.b Describe the basic testing Procedure of the given special purpose transformers. TSO.5.c State the applications of the given special purpose transformers.	Unit 5.0 Special Purpose Transformers 5.1 Isolation Transformer 5.2 Grounding Transformer 5.3 Instrument transformer 5.4 Current Transformer 5.5 Potential Transformer 5.6 Welding transformer	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: P2420303

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify different parts of a DC machine.	1.	Identification of parts of a DC Machine by dismantling the cut section model of a DC machine	CO1
LSO 1.2 Interpret the effect of speed and field flux on generated voltage of DC shunt generator.	2.	Effect of speed and field flux on generated voltage of DC shunt generator	
LSO 1.3 Test the performance of DC shunt generator on the given load condition.	3.	Load test of DC shunt Generator	
LSO 1.4 Test the performance of DC series generator on the given load condition.	4.	Load test of DC series Generator	
LSO 2.1 Use appropriate DC motor starter for starting the given DC Motor.	5.	Starting of D. C shunt motor using 3-point /4-point starter	CO1, CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.2 Change e terminal connection of DC shunt motor and observe the direction of rotation	6.	Reversal of Direction of a DC Shunt motor	
LSO 2.3 Control speed of DC Shunt motor using field/flux control method (Above rated speed)	7.	Speed control of D.C shunt motor	
LSO 2.4 Control speed of DC Shunt motor using armature control method (Below rated speed).	8.	Speed control of a D.C. Shunt motor	
LSO 2.5 Test performance of DC shunt motor on the given load condition.	9.	Load test of D. C. shunt motor	
LSO 2.6 Test performance of DC series motor on the given load condition.	10.	Load test of D.C. series motor	
LSO 2.7 Apply direct method to brake the DC shunt motor.	11.	Brake test of D.C. shunt motor.	
LSO 3.1 Measure voltage and current ratio of a given single phase transformer	12.	Measurement of voltage and current ratio of a given single phase transformer.	CO3
LSO 3.2 Test polarity of the given single phase transformer.	13.	Polarity of a single-phase transformer	
LSO 3.3 Test performance of a given transformer by direct load test.	14.	Direct load test on a single-phase transformer	
LSO 3.4 Observe the no load waveform of a given transformer using CRO	15.	No load waveform of a transformer using CRO	
LSO 3.5 Perform Open Circuit and Short Circuit test on a single-phase transformer.	16.	Open Circuit and Short Circuit test on a single-phase transformer.	
LSO 3.6 Perform parallel operation of two 1-phase transformer having equal and unequal KVA rating under given load.	17.	Parallel operation of two single phase transformers.	
LSO 3.7 Test performance of an auto transformer and 1-phase two winding transformer of same rating.	18.	Auto transformer and 1-phase two winding transformer of same rating	
LSO 4.1 Perform parallel operation of two 3-phase transformer having equal and unequal load sharing for a given load.	19.	Parallel operation of two three phase transformers for equal and unequal load sharing.	CO3, CO4
LSO 5.1 Measure current ratio of the given Current transformer using ammeter/clamp meter.	20.	Current ratio of a Current transformer	CO4, CO5
LSO 5.2 Measure voltage ratio of the given Potential transformer using voltmeter.	21.	Voltage ratio of a Potential Transformer	CO4, CO5

L) **Suggested Term Work and Self-Learning: S2420303** 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.

- i. Prepare a chart to depict Flemings right hand rule as applicable to DC Generator and Flemings left hand rule as applicable to DC Motor with labeled sketches
- ii. Prepare a chart indicating detailed classification of DC machines with labeled sketches

- iii. Prepare a chart depicting the working of 3-Point DC shunt motor starter highlighting the inbuilt protective devices in the starter using a labeled sketch.
- iv. Prepare a chart depicting the working of 4-Point DC shunt motor starter highlighting the inbuilt protective devices in the starter using a labeled sketch.
- v. List the precautions to be taken while starting a DC series and shunt motor with reasons.
- vi. Prepare a chart depicting the various parts of a transformer drawing neat labeled sketch.
- vii. Draw core and shell type of transformers highlighting the difference between them.
- viii. List out the applications of single phase and three phase transformers, auto-transformer and welding transformer.
- ix. Collect the information (specification, and use) and prepare a report on three phase three winding transformers based on information collected from different manufacturers.
- x. Prepare a chart displaying the various routine tests performed on a three-phase transformer as per IS.
- xi. Compare a bank of 3 single phase transformers with that of 3 phase transformers.
- xii. List out the applications of single phase, three phase transformers, auto-transformer and welding transformer.

b. Micro Projects:

1. Fabricate single loop DC generator and observe the generated wave form on CRO.
2. Use suitable DC generator for arc welding purpose and Prepare a detailed report including selection of generator, connection and operation with safety precautions followed during use.
3. Prepare a report on strategies to start a given DC motor without conventional starters.
4. Build a Bridge rectifier using diodes of appropriate rating to provide supply to a DC Machine
5. Investigate whether OC & SC test or direct load test is preferred for determining the performance of a transformer
6. Fabricate and test a step-up or step-down transformer and submit detailed report on it.
7. Visit nearby sub-station and list out the main cause of brake-down of distribution transformer and propose strategies to reduce its failures.
8. Develop a three-phase transformer using three single phase transformer and compare its performance with a poly phase transformer.

c. Other Activities:

1. Seminar Topics-

- DC Generators and its application
- Characteristics of DC motors.
- Hysteresis and Eddy current loss
- Difference between power and distribution transformers
- Industrial Applications of DC generators
- Safety to be followed while using special transformers

2. Survey –

- Carry out a market survey for availability of transformers in market and list down the complete specifications of at least five transformers.
- Carry out a market survey for availability of DC generators in market and list down the complete specifications of at least five DC generators.

- Carry out a market survey for availability of DC motors in market and list down the complete specifications of at least five DC motors.
- Carry out internet survey to find out the types of insulation used between HV and LV winding and between winding and core for a HV, EHV and UHV transformer

3. **Visits-** Visit nearby substation and collect the name -plate specifications of sub-station transformers.

d. Self-Learning Topics:

1. Types of motors used in Metro, Mono rail and traction
2. Soft starters
3. Dry transformers.
4. Energy efficient DC Motors.
5. Insulation material used for HV and LV winding of transformers.
6. Industrial/commercial applications of special transformers
7. Advances in Transformers- Amorphous Metal Transformer

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%	20%	20%	30%	30%	20%	20%
CO-2	20%	25%	20%	30%	20%	25%	20%
CO-3	25%	20%	20%	20%	20%	25%	20%
CO-4	25%	20%	20%	20%	30%	15%	20%
CO-5	15%	15%	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 (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 DC Generators	8	CO1	14	4	3	5
Unit-2.0 DC Motors	12	CO2	16	4	2	4
Unit-3.0 Single Phase Transformer	10	CO3	14	5	5	9
Unit-4.0 Three Phase Transformer	10	CO4	14	2	3	5
Unit- 5.0 Special purpose Transformers	8	CO5	12	5	5	9
Total Marks	48	-	70	20	18	32

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 parts of a DC Machine by dismantling the cut section model of a DC machine	CO1	50	40	10
2.	Effect of speed and field flux on generated voltage of DC shunt generator	CO1	50	40	10
3.	Load test of DC shunt Generator	CO1	50	40	10
4.	Load test of DC series Generator	CO1	50	40	10
5.	Starting of D. C shunt motor using 3-point /4-point starter	CO2	50	40	10
6.	Reversal of direction of a DC Shunt motor	CO2	50	40	10
7.	Speed control of D.C shunt motor	CO2	50	40	10
8.	Speed control of a DC Shunt motor	CO2	50	40	10
9.	Load test of D. C shunt motor	CO2	50	40	10
10.	Load test of D.C. series motor	CO2	50	40	10
11.	Brake test of D.C. shunt motor.	CO2	50	40	10
12.	Measurement of voltage and current ratio of a given single phase transformer.	CO3	50	40	10
13.	Polarity of a single-phase transformer	CO3	50	40	10

S. No.	Laboratory Practical Titles	Relevant Cos Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
14.	Direct load test on a single-phase transformer	CO3	50	40	10
15.	No load waveform of a transformer using CRO	CO3	50	40	10
16.	Open Circuit and Short Circuit test on a single-phase transformer.	CO3	50	40	10
17.	Perform Parallel operation of two single phase transformers.	CO3	50	40	10
18.	Auto transformer and 1-phase two winding transformer of same rating	CO3	50	40	10
19.	Parallel operation of two three phase transformers for equal and unequal load sharing	CO4	50	40	10
20.	Current ratio of a Current transformer	CO5	50	40	10
21.	Voltage ratio of a Potential Transformer	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	DC Ammeter	Range (0-5-10A), (0-2 A), Portable analog, PMMC type as per relevant BIS standard	2-4,6-11
2.	DC Voltmeter	Range (0-150/300V), (0-15/30/75 V), Portable analog PMMC type as per relevant BIS standard	1-11
3.	AC Ammeter	Range (0-2.5-5-10A), Portable analog MI type as per relevant BIS standard	12-20
4.	AC Voltmeter	Range (0-75/150/300V), Portable analog MI type as per relevant BIS standard	12-21
5.	Lamp Load	10 -20 A	As applicable
6.	Rheostat	0-500 Ohm, 1.2A); (0-100 Ohm, 5A); (0- 50 Ohm, 10A); (0-350 Ohm,1.5A); Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact	As applicable

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
7.	DC Supply	230V DC, 50A supply (with inbuilt rectifier to convert AC to DC)	2-11
8.	Single phase transformer	Of suitable rating (500 VA to 2kVA)	12-18
9.	Single phase auto transformer	230V/0-270 V, 4/8/15 A	12-19
10.	Wattmeter (LPF and UPF) Single phase 3 phase	0-150/300/600V, 2.5/5 A 0-300/600 V, 10/20 A	12-19
11	DC Series Motor - Gen Set	Motor – 5 HP, Generator- 3 kW	4,10
12.	DC Shunt Motor - Gen Set	Motor – 5 HP, Generator- 3 kW	2,3,9,10
13.	DC motor Starter	3 Point/4 Point starter	5
14.	Current Transformer	Appropriate rating	20
15.	Potential Transformer	Appropriate rating	21
16.	Tachometer	Digital	2-11
17	Three phase transformers	Experimental setup/software for performing 3 phase transformer parallel operation	19

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Electrical Machines	Kothari, D.P. & Nagrath, I.J.	Tata McGraw Hill Education Pvt. Ltd. New Delhi, 4 th Edition, ISBN: 9780070699670
2.	Electric Machines	Ashfaq Husain	Dhanpat Rai & Company, Latest Edition, ISBN: 6700000000432
3.	Electrical Technology, Volume – II (AC & DC Machines)	Theraja B.L.	S. Chand and Co. Ltd., New Delhi , Latest Edition, ISBN:9788121924375
4.	Electrical Machinery	Dr. P.S. Bhimbra	Khanna Publications, Latest Edition ISBN: 8174091734
5.	Basic Electrical Engineering (Hindi)	Mehta & Gupta	Dhanpat Rai Publishing Company(P) Ltd., 9 th Edition, 2013, ISBN: 978938437826
6.	Electrical Machines	Bhattacharya S. K.	Tata McGraw Hill Education Pvt. Ltd., New Delhi ISBN:9789332902855
7.	Electrical Machines (AC & DC)	Gupta J. B.	S. K. Kataria & Sons, New Delhi, ISBN:9788188458141
8.	Electrical Machines	Kothari, D.P. & Nagrath, I.J.	Tata McGraw Hill Education Pvt. Ltd. New Delhi, ISBN:9780070699670
9.	Basic Electrical Engineering	Mittle V.N. and Mittal Arvind	Tata McGraw Hill Education Pvt. Ltd. New Delhi, ISBN:9780070593572
10.	Electric Machinery	Arthur Eugene Fitzgerald and Charles Kingsley	Tata McGraw Hill Education Publications ISBN13: 9780070530393
11.	Electrical Engineering Fundamentals	Vincent Del Toro	Prentice hall Publications ISBN-13 :9780132475525

(b) Online Educational Resources:

- 1) www.nptel.com/iitm/
- 2) www.vlab.com/
- 3) Electrical Machines: - <http://www.eeeuniversity.com/2013/07/animation-of-electric-machines.html>
- 4) Transformer: -https://www.youtube.com/watch?v=vh_aCAHThTQ
- 5) AC /DC Motor and Generator: -<https://www.youtube.com/watch?v=4texz0Gn7cw>
- 6) DC Motor & Generator: -<https://www.youtube.com/watch?v=LAtPHANefQo>
- 7) AC DC motors: <https://www.youtube.com/watch?v=unxTKC01CBQ>

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 related to D. C. Machines and Transformers
2. Users' Guide for D.C. Machines and Transformers
3. Manufacturers' Manual for D.C. Machines and Transformers
4. Lab Manuals for D.C. Machines and Transformers

- A) **Course Code** : 2469304(T2469304/S2469304)
 B) **Course Title** : Automobile Control Engineering
 C) **Pre- requisite Course(s)** :
 D) **Rationale** :

Automobile control engineering play a pivotal role in modern vehicles, overseeing crucial components like the transmission, brakes, and steering to ensure the vehicle operates efficiently, safely, and reliably. By optimizing performance, these systems improve operating economy and reduce harmful emissions, addressing the escalating environmental concerns and the imperative to cut down greenhouse gas emissions.

- 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/ workshop/ field/ industry.

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

- CO- 1** Apply the concept of open and closed loop system in different automobile control systems
CO- 2 Choose suitable braking control system for different types of vehicles.
CO- 3 Examine conditions of given steering gear-box, steering mechanism and its linkages for better control of the vehicles
CO- 4 Identify relevant suspension system for stability of different types of vehicles
CO- 5 Diagnose sensor and actuators related issues which affects the performance, operating economy and greenhouse gas emissions problems of the vehicles.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & 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				
2469304	Automobile Control Engineering	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 (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2469304	Automobile Control Engineering	30	70	20	30	-	-	150

Legend:

PTA: Progressive Theory Assessment in classroom (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 & 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), 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: T2469304

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p>TSO1.a Describe the different types of control systems used in automobiles</p> <p>TSO1.b Differentiate between Open-loop vs. closed-loop control systems</p> <p>TSO1.c Explain the different component of an automobile control system</p>	<p>Unit-1.0 Introduction to Automobile Control Systems</p> <p>1.1 Basics of control systems</p> <p>1.2 Types of control systems used in automobiles</p> <p>1.3 Open-loop vs. closed-loop control systems</p> <p>1.4 Components of an automobile control system</p>	CO1
<p>TSO 2a. Classify the different types of brakes.</p> <p>TSO 2b. Describe the properties of brake fluid.</p> <p>TSO 2c. Draw the sketches of given brakes.</p> <p>TSO 2d. List the advantages of Antilock brake system over the others braking system.</p> <p>TSO 2e. Explain the different component of Brakes.</p> <p>TSO 2f. Suggest the suitable friction materials for a given type of brakes.</p>	<p>Unit-2.0 Brake and Braking Control System</p> <p>2.1 Purpose and requirement of brakes</p> <p>2.2 Layout of braking system</p> <p>2.3 Component of brake</p> <p>2.4 Construction and working of mechanical, hydraulic, Air braking system and Exhaust brake.</p> <p>2.5 Construction and working of Disc brake and drum brake and their materials</p> <p>2.6 Brake fluid, Brake shoes and brake clearance.</p> <p>2.7 Friction materials and its characteristics.</p> <p>2.8 Braking Control Systems:</p> <p>2.9 Antilock braking system (ABS)</p> <p>2.10 Electronic Brake-force Distribution (EBD)</p> <p>2.11 Traction Control System (TCS)</p>	CO1, CO2
<p>TSO 3a. Draw and explain the given types of front Axle.</p> <p>TSO 3b. Describe the given types of stub Axle.</p> <p>TSO 3c. Explain the given type of steering gear box.</p> <p>TSO 3d. Draw the various parts of steering geometry.</p> <p>TSO 3e. Suggest the suitable type of front axle for given vehicle.</p>	<p>Unit-3.0 Steering and front axle</p> <p>3.1 Purpose and requirement</p> <p>3.2 Steering mechanism and function.</p> <p>3.3 Steering geometry- camber, caster, king pin inclination, toe in and toe out.</p> <p>3.4 Ackerman principle of steering mechanism</p> <p>3.5 Constructional details of steering gear box - Rack& pinion and Re-</p>	CO1, CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 3j.</i> List the advantages of power steering over the manual steering.</p>	<p>circulating ball type, Worm and roller types' steering gear box.</p> <p>3.6 Power steering necessity, construction and working.</p> <p>3.7 Types of front axle- Dead axle, Live axle</p> <p>3.8 Types of stub axle arrangements- Elliot, Reverse Elliot, Lemoine type</p>	
<p><i>TSO 4a.</i> Describe the necessity of suspension system.</p> <p><i>TSO 4b.</i> Draw and explain the given types of suspension system.</p> <p><i>TSO 4c.</i> List the advantages of Air suspension system over spring suspension system.</p> <p><i>TSO 4d.</i> Identify the different parts of a given suspension system.</p> <p><i>TSO 4e.</i> Explain the working of Electronic Stability Control (ESC) and Adaptive Suspension Systems</p> <p><i>TSO 4f.</i> Suggest the suitable suspension control system for the given vehicle.</p>	<p>Unit-4.0 Suspension and its Control System</p> <p>4.1 Purpose and function of suspension system.</p> <p>4.2 Classification of suspension system.</p> <p>4.3 Types- Rigid and independent suspension system</p> <p>4.4 Shock absorber construction and working</p> <p>4.5 Different type of spring- Torsion bar, Air-spring, Leaf spring, Coil spring, Hydrodynamic spring.</p> <p>4.6 Air suspension system</p> <p>4.7 Suspension Control Systems:</p> <p>4.8 Electronic Stability Control (ESC)</p> <p>4.9 Adaptive Suspension Systems</p>	CO4
<p><i>TSO 5a.</i> Explain the function and application of sensors used in automobiles such as speed, temperature, pressure, position sensors etc.,</p> <p><i>TSO 5b.</i> Identify the location of various sensors used in modern vehicle</p> <p><i>TSO 5c.</i> Explain the function and application of actuators used in automobiles</p> <p><i>TSO 5d.</i> Diagnose sensor and actuators related issues</p>	<p>Unit - 5.0 Sensors and Actuators</p> <p>Role and types of sensors used in</p> <p>5.1 Automobiles (e.g., speed sensors, temperature sensors, pressure sensors,</p> <p>5.2 Position sensors, Air flow measurement</p> <p>5.3 sensor, Combustion knock sensors, Exhaust</p> <p>5.4 Oxygen level sensor etc.)</p> <p>5.5 5.2 Actuators and their functions (e.g., fuel injectors, throttle actuators, brake actuators, etc.)</p>	CO5

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

K) Suggested Term Work and Self Learning: S2469304 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:**

- Collect the different types of Braking system used in vehicle and compare it.
- Collect the data of different types of Steering mechanism used in vehicle with their comparison.
- Collect the data of different types of suspension system used in vehicle from market.
- Prepare a list of different Sensors and actuators used in a vehicle along with their applications.
- Develop a prototype for a smart braking system that utilizes sensors and actuators to improve vehicle safety and stability.
- Develop a driver assistance system that uses sensors and cameras to detect obstacles and provide alerts to the driver.
- Develop an automatic parking system that uses ultrasonic sensors and actuators to guide a vehicle into a parking spot.

c) **Other Activities:**

• **Seminar Topics:**

- Working of Antilock Braking system.
- Visual representation of different types of Suspension control system being used in vehicle.
- Application of different sensors in a vehicle.
- Power steering.

- **Visits:** Visit nearby Automobile/EV manufacturing industry/Auto workshop to gain practical knowledge about Suspension control system, braking system, steering mechanism and sensors & Actuators and prepare report on it.

• **Self-Learning Topics:**

- Identify the parts of front Axle.
- Identify different sensors used in a given vehicle engine
- Identify the parts of power steering.

- 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	25%	25%	25%	25%	25%	-	-
CO-3	20%	20%	20%	25%	25%	-	-
CO-4	25%	25%	25%	25%	25%	-	-
CO-5	20%	20%	20%	25%	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 percentages 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.

- 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 (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Under Standing (U)	Application & above (A)
Unit-1.0 Introduction to Automobile Control Systems	6	CO1	7	3	2	2
Unit-2.0 Brake and Braking control system	12	CO1, CO2	18	5	8	5
Unit-3.0 Steering and front Axle	10	CO3	14	4	6	4
Unit-4.0 Suspension and its Control System	12	CO4	17	4	8	5
Unit-5.0 Sensors and Actuators	8	CO5	14	4	4	6
Total	48	-	70	20	28	22

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, 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.

O) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Automobile Engineering	Singh , Kripal	Standard Publication, New Delhi,2008 ISBN 13 : 9788180141034
2.	Automobile Engineering	Chikara , Anil	Satya Prakashan, New Delhi, 2007, ISBN: 9788176843515
3.	Automobile Engineering	Jain K. K., Asthana R. B.	Tata Mc-Graw Hill Publishing Co. Ltd. ISBN-13 : 978- 0070445291
4.	Automobile Mechanics	Srinivisan ,S	McGraw- Hill, New Delhi,2003 ISBN-10: 0070494916
5.	Automobile Technology	Giri , N.K.	Khanna Publication, New Delhi, 2009 ISBN : 9788174091789
6.	Automotive Sensors	John Turner	SAE International; 1st Edition (ISBN-10: 0768010518)
7.	Automotive Technology: Principles, Diagnosis, and Service	James D. Halderman	Pearson Education; 5th Edition (ISBN-10: 0133994619)

(b) Online Educational Resources:

- www.nptel.swayam
- https://youtu.be/Twga0R_9qrE
- <https://youtu.be/UXn5lgtqrpA>
- <https://youtu.be/ltufRS3xj30>
- <https://youtu.be/kR-SLTNrnjQ>

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:

- Lab Manuals
- Users' Guide
- Manufacturers' Manual
- Learning Packages

- A) **Course Code** : **2418305(T2418305/P2418305/S2418305)**
- B) **Course Title** : Python Programming
(CE, CSE, AIML, ME, ME (Auto)., ELX, ELX (R), MIE, FTS, CRE, CHE, TE, CACDDM, GT, RE)
- C) **Pre- requisite Course(s)** :
- D) **Rationale** :

Python programming has emerged as a popular programming language across wide range of application segments from Scientific to Machine Learning to mobile app development, and so on. Python is a high-level general-purpose programming language. Because code is automatically compiled to byte code and executed, Python is suitable as a scripting language, Web application implementation language, etc. In Python there are multiple levels of organizational structure: functions, classes, modules, and packages. These assist in organizing code. An excellent and large example is the Python standard library. The Object-oriented Python provides a consistent way to use objects: in Python it is easy to implement new object types (called classes in object-oriented programming). This introductory course to learn basic Python programming features which can be used as building blocks to develop different kind of applications using Python 3.

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

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

- CO-1** Use various data types and operators in formation of expressions.
- CO-2** Write and execute programs using control statements.
- CO-3** Perform relevant operations on Sequence data types
- CO-4** Create functions in modules
- CO-5** Use numpy in writing python programs
- CO-6** Handle data files and exceptions.

- 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	1	-	1	-	-	-	-		
CO-2	1	2	2	1	-	1	-		
CO-3	1	2	2	1	-	1	-		
CO-4	1	2	2	1	-	1	2		
CO-5	1	2	2	1	-	1	-		
CO-6	1	2	2	1	-	1	1		

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2418305	Python Programming	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)	
2418305	Python Programming	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: T2418305

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
<p><i>TSO 1a.</i> Differentiate between Procedure Oriented P and Object Oriented Programming approach with example.</p> <p><i>TSO 1b.</i> Use the concept of Lvalue and Rvalue</p> <p><i>TSO 1c.</i> Write python program using various data types and operators</p>	<p>Unit 1.0 Fundamentals of Python Programming Syntax</p> <p>1.1 Introduction to Python Character Set, Python Tokens, Variables, Lvalue and Rvalue Concepts, and the Use of Comments.</p> <p>1.2 Overview of Data Types:</p> <ul style="list-style-type: none"> • Number Types: Integer, Floating Point, Complex • Boolean Type • Sequence Types: String, List, Tuple • None Type • Mapping Type: Dictionary • Distinction between Mutable and Immutable Data Types <p>1.3 Understanding Operators:</p> <ul style="list-style-type: none"> • Arithmetic Operators • Relational Operators • Logical Operators • Assignment Operator • Augmented Assignment Operators • Expressions and Statements • Type Conversion and Input/Output Mechanisms • Precedence of Operators • Expression Evaluation 	CO-1
<p><i>TSO.2.a</i> Write Python program using decision making statements</p> <p><i>TSO.2.b</i> Write Python program using loop structure to solve iterative problems</p>	<p>Unit-2.0 Conditional and Iterative statements</p> <p>2.1 Conditional statements:</p> <ul style="list-style-type: none"> • simple if statement • if- else statemen • if-elif-else statement <p>2.2 Iterative statements:</p> <ul style="list-style-type: none"> • while loop • for loop • range function • break and continue statements • nested loops 	CO-2
<p><i>TSO 3a.</i> Perform various operations on string using string operators and methods</p> <p><i>TSO 3b.</i> Perform various operations on List using list operators and methods</p> <p><i>TSO 3c.</i> Perform various operations on tuples using tuples operators and methods</p> <p><i>TSO 3d.</i> Perform various operations on set using set methods</p> <p><i>TSO 3e.</i> Perform various operations on dictionary using dictionary methods</p>	<p>Unit-3.0 String, List, Tuples, set and Dictionary</p> <p>3.1 String:</p> <ul style="list-style-type: none"> • Indexing • string operations (concatenation repetition, membership & slicing) • traversing a string using loops • built-in functions. <p>3.2 Lists:</p> <ul style="list-style-type: none"> • Introduction • Indexing in list 	CO-3

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	<ul style="list-style-type: none"> • list operations: concatenation, repetition, membership & slicing, traversing a list, built- in list functions, linear search on list of numbers and counting the frequency of elements in a list <p>3.3 Tuples: Creating, initializing, accessing elements, tuple assignment, performing operations on tuples, tuple methods and built-in functions, nested tuples</p> <p>3.4 Set: Creating set, traversing, adding, removing data in set, performing set operations like join, Union intersection, difference</p> <p>3.5 Dictionary: accessing items in a dictionary using keys, mutability of dictionary: adding a new item, modifying an existing item, built-in dictionary functions.</p>	
<p><i>TSO 4a.</i> Create and use user defined functions to implement modular programming approach</p> <p><i>TSO 4b.</i> Differentiate variable scope with example.</p> <p><i>TSO 4c.</i> Import and use Python modules, libraries</p>	<p>Unit-4.0 Python Functions, Modules and packages</p> <p>4.1 Functions: types of function (built- in functions, functions defined in module, user defined functions), creating user defined function, arguments and parameters, default parameters, positional parameters, Lambda functions, returning value, scope of a variable: global scope, local scope</p> <p>4.2 Modules and Packages: Importing module using 'import' Regular Expressions, Exception Handling, PyPI Python Package Index, Pip Python package manager, Importing Libraries and Functions</p>	<p>CO-4</p>
<p><i>TSO 5a.</i> Write simple Python programs using numpy</p> <p><i>TSO 5b.</i> Use Numpy array in python program</p> <p><i>TSO 5c.</i> Use Numpy to solve linear algebra problem.</p>	<p>Unit-5.0 Numpy</p> <p>5.1 Introduction to NumPy</p> <p>5.2 Installation of NumPy</p> <p>5.3 NumPy Arrays:</p> <ul style="list-style-type: none"> • Understanding the NumPy array • The fundamental data structure in NumPy. • Creation of arrays using different methods: np.array(), np.zeros(), np.ones(), etc. • Exploring array attributes like shape, size, and dimensions. <p>5.4 Array Indexing and Slicing:</p> <ul style="list-style-type: none"> • Accessing elements and subarrays in NumPy arrays using indexing and slicing. • Demonstration of the difference between one-dimensional and multi-dimensional array indexing. <p>5.5 Array Operations:</p>	<p>CO-5</p>

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	<ul style="list-style-type: none"> Performing element-wise operations on NumPy arrays. Exploring universal functions (ufuncs) for mathematical operations. 5.6 Linear Algebra with NumPy: <ul style="list-style-type: none"> Introduction to linear algebra operations using NumPy. Matrix multiplication, determinant, inverse, and solving linear equations. 5.7 File input and output with Numpy 5.8 Broadcasting in Numpy	
<p><i>TSO 6a.</i> Explain different types of Exceptions in python</p> <p><i>TSO 6b.</i> Write Python programs for exception handling in Python</p> <p><i>TSO 6c.</i> Differentiate different modes of file opening.</p> <p><i>TSO 6d.</i> Perform read, Write, Append operations in files</p>	<p>Unit 6: Exception and File Handling in Python</p> <p>6.1 Exception Handling: syntax errors, exceptions, need of exception handling, user-defined exceptions, raising exceptions, handling exceptions, catching exceptions, Try - except - else clause, Try - finally clause, recovering and continuing with finally, built-in exception classes.</p> <p>6.2 File Handling: text file and binary file, file types, open and close files, reading and writing text files, reading and writing binary files, file access modes</p>	CO-6

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2418305

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 1.1.</i> Write, execute and debug simple Python program using Integrated Development and Learning Environment (IDLE)</p> <p><i>LSO 1.2.</i> Write and execute simple 'C' program using variables, arithmetic expressions.</p>	1.	a) Download and Install IDLE. Write and execute Python program to- b) Calculate the Area of a Triangle where its three sides a, b, c are given. $s=(a+b+c)/2$, Area=square root of $s(s-a)(s-b)(s-c)$ (write program without using function) c) Swap Two Variables d) Solve quadratic equation for real numbers.	CO-1
<p><i>LSO 2.1.</i> Write and execute python programs using conditional statements.</p> <p><i>LSO 2.2.</i> Write and execute python programs using various types of Loop statements</p>	2.	Write and execute Python program to- a) Check if a Number is Positive, Negative or zero. b) Check whether the given year is a Leap Year. c) Print all Prime Numbers in an Interval. d) Display the multiplication Table based on the given input. e) Print the Fibonacci sequence. f) Find the Factorial of a Number.	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<i>LSO 3.1.</i> Write and execute Python program to perform various operations on string using string operators and methods	3.	Write and execute Python program to- a) Check whether the string is Palindrome b) Reverse words in a given String in Python c) identify in a strings the name, position and counting of vowels. d) Count the Number of matching characters in a pair of string (set) e) Python program for removing i-th character from a string	CO-2, CO-3
<i>LSO 4.1.</i> Write and execute Python program to perform various operations on List using List operators and methods	4.	Write and execute Python program to- a) find largest number in a given list without using max(). b) find the common numbers from two lists. c) create a list of even numbers and another list of odd numbers from a given list. d) To find number of occurrences of given number without using built-in methods.	CO-2, CO-3
<i>LSO 5.1.</i> Write and execute Python program to perform various operations on Tuple using Tuple operators and methods.	5.	Write and execute Python program to- a) find the index of an item of a tuple. b) find the length of a tuple. c) to reverse a tuple. d) Write a Python program to sort a list of tuple by its float element. Sample data: [('item1', '12.20'), ('item2', '15.10'), ('item3', '24.5')] Expected Output: [('item3', '24.5'), ('item2', '15.10'), ('item1', '12.20')]	CO-2, CO-3
<i>LSO 6.1.</i> Write and execute Python program to perform various operations on sets using set methods.	6.	Write and execute Python program to- a) create an intersection of sets. b) create a union of sets. c) create set difference. d) check if two given sets have no elements in common.	CO-2, CO-3
<i>LSO 7.1.</i> Write and execute Python program to perform various operations on Dictionary using Dictionary methods	7.	Write and execute Python program to- a) Write a Python script to concatenate two dictionaries to create a new one b) Write a Python script to merge two Python dictionaries. c) Write a Python program to combine two dictionary adding values for common keys. d1 = {'a': 100, 'b': 200, 'c':300} d2 = {'a': 300, 'b': 200, 'd':400} Sample output: d({'a': 400, 'b': 400, 'd': 400, 'c': 300})	CO-2, CO-3
<i>LSO 8.1.</i> Write and execute Python program to create user defined functions and call them.	8.	Write and execute Python program to- a) Write a Python function for reversing a string and call it. b) Write a Python function for calculating compound interest and call it. c) Write a Python function for calculating the factorial of a number and call it to calculate $n!/r!(n-r)!$ where symbol "!" stands for factorial.	CO-2, CO-4
<i>LSO 9.1.</i> Write and execute Python program to define a numpy array.	9.	a) Write a python program to create a Numpy array filled with all zeros	CO-2, CO-5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
<p><i>LSO 9.2.</i> Develop and execute Python program Using various types of Numpy operation.</p>		<p>b) Write a python program to check whether a Numpy array contains a specified row c) Write a python program to Remove rows in Numpy array that contains non-numeric values d) Write a python program to Find the number of occurrences of a sequence in a NumPy array e) Write a python program to Find the most frequent value in a NumPy array f) Write a python program to Combine a one and a two-dimensional NumPy Array g) Write a python program to Flatten a Matrix in Python using NumPy h) Write a python program to Interchange two axes of an array</p>	
<p><i>LSO 10.1.</i> Develop and execute Python program to handle various type of exceptions. <i>LSO 10.2.</i> Develop and execute Python program to perform file operations.</p>	10.	<p>a) Using exception handling feature such as try...except, try finally- write minimum three programs to handle following types of exceptions. i. Type Error ii. Name Error iii. Index Error iv. Key Error v. Value Error vi. IO Error vii. Zero Division Error b) Write Python program to demonstrate file operations.</p>	CO-6, CO-1, CO-2,

Note: in addition to above listed practical, students are suggested to practice all the examples covered by the teacher during theory sessions.

L) **Suggested Term Work and Self Learning: S2418305** 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. Create a shop billing system
2. Create income tax calculation system.
3. Develop number guessing game (random integer will be selected by the system and the user has to guess that integer in the minimum number of guesses. Maximum 5 guess allowed.)
4. Assign numbers to alphabet a-z as (1-26). User will input a word. System will convert it to a number by adding all the individual alphabets of that word.
5. Design a basic calculator program that performs arithmetic operations like addition, subtraction, multiplication, and division based on user input.
6. Any other micro-projects suggested by subject faculty on similar line.

(Students may use file and sequence data types to develop above listed applications)

c. **Other Activities:**

1. Seminar Topics:
 - Tkinter widgets in python
 - Python date/time module and its applications
 - wxPython and its applications

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%	15%	16%	16%	10%	16%
CO-2	15%	15%	15%	16%	16%	15%	16%
CO-3	25%	25%	20%	18%	18%	25%	18%
CO-4	15%	15%	15%	16%	16%	15%	16%
CO-5	25%	25%	25%	18%	18%	25%	18%
CO-6	10%	10%	10%	16%	16%	10%	16%
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 Basics of Python Programming syntax	4	CO-1	7	3	2	2
Unit-2.0 Conditional and Iterative statements	6	CO-2	10	3	3	4
Unit-3.0 String, List, Tuples, set and Dictionary	12	CO-3	18	5	3	10
Unit-4.0 Python Functions, Modules and packages	7	CO-4	10	3	3	4
Unit-5.0 Numpy	12	CO-5	18	4	5	9
Unit-6.0 Exception and File Handling in Python	7	CO-6	7	2	2	3
Total	48	-	70	20	18	32

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Write and execute Python program to- a) Calculate the Area of a Triangle where its three sides a,b,c are given. $s=(a+b+c)/2$, Area=square root of $s(s-a)(s-b)(s-c)$ (write program without using function) b) Swap Two Variables c) Solve quadratic equation for real numbers.	CO-1	40	50	10
2.	Write and execute Python program to- a) Check if a Number is Positive, Negative or zero. b) Check whether the given year is a Leap Year. c) Print all Prime Numbers in an Interval. d) Display the multiplication Table based on the given input. e) Print the Fibonacci sequence. f) Find the Factorial of a Number.	CO-2	40	50	10
3.	Write and execute Python program to- a) Check whether the string is Palindrome b) Reverse words in a given String in Python c) identify in a strings the name, position and counting of vowels. d) Count the Number of matching characters in a pair of string (set) e) Python program for removing i-th character from a string	CO-2, CO3	40	50	10
4.	Write and execute Python program to- a) find largest number in a given list without using max().	CO-2, CO-3	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
	b) find the common numbers from two lists. c) create a list of even numbers and another list of odd numbers from a given list. d) To find number of occurrences of given number without using built-in methods.				
5.	Write and execute Python program to- a) find the index of an item of a tuple. b) find the length of a tuple. c) to reverse a tuple. d) Write a Python program to sort a list of tuple by its float element. Sample data: [('item1', '12.20'), ('item2', '15.10'), ('item3', '24.5')] Expected Output: [('item3', '24.5'), ('item2', '15.10'), ('item1', '12.20')]	CO-2, CO-3	40	50	10
6.	Write and execute Python program to- a) create an intersection of sets. b) create a union of sets. c) create set difference. d) check if two given sets have no elements in common.	CO-2, CO-3	40	50	10
7.	Write and execute Python program to- a) Write a Python script to concatenate two dictionaries to create a new one b) Write a Python script to merge two Python dictionaries. c) Write a Python program to combine two dictionary adding values for common keys. d1 = {'a': 100, 'b': 200, 'c':300} d2 = {'a': 300, 'b': 200, 'd':400} Sample output: d({'a': 400, 'b': 400, 'd': 400, 'c': 300})	CO-2, CO-3	40	50	10
8.	Write and execute Python program to- a) Write a Python function for reversing a string and call it. b) Write a Python function for calculating compound interest and call it. c) Write a Python function for calculating the factorial of a number and call it to calculate $n/((n-r) * (n-r))$ where symbol "!" stands for factorial.	CO-2, CO-4	40	50	10
9.	Write a python program to create a Numpy array filled with all zeros a) Write a python program to check whether a Numpy array contains a specified row b) Write a python program to Remove rows in Numpy array that contains non-numeric values c) Write a python program to Find the number of occurrences of a sequence in a NumPy array d) Write a python program to Find the most frequent value in a NumPy array e) Write a python program to Combine a one and a two-dimensional NumPy Array	CO-2, CO-5	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
	f) Write a python program to Flatten a Matrix in Python using NumPy g) Write a python program to Interchange two axes of an array				
10.	Using exception handling feature such as try...except, try finally-write minimum three programs to handle following types of exceptions. a) TypeError b) NameError c) IndexError d) KeyError e) ValueError f) IOError g) ZeroDivisionError	CO-2, CO-6	40	50	10
11.	Write and execute Python program to- a) Calculate the Area of a Triangle where its three sides a,b,c are given. $s=(a+b+c)/2$, Area=square root of $s(s-a)(s-b)(s-c)$ (write program without using function) b) Swap Two Variables c) Solve quadratic equation for real numbers.	CO-1	40	5 0	1 0

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.	Computer system	Processor Intel Core i5, 4 GB RAM, 15 GB free disk space	All
2.	Integrated Development and Learning Environment (IDLE)	S/w to be downloaded for python 3.11.3 or higher	All

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

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Computing and Problem-Solving using Python	E. Balagurusamy	McGraw Hill Education (India) Pvt. Ltd. 1 st Edition /2016
2.	Learning Python Programming	Jeffrey Elkner, Allan B. Downey, Chris Meyers	Samurai Media Limited. 2016
3.	Python Programming	Ashok Namdev Kamthane and Amit Ashok Kamthane	McGraw Hill Education (India) Pvt. Ltd. 2020, 2 nd Edition
4.	Programming in Python	Dr. Pooja Sharma	BPB Publications 2017

(b) Online Educational Resources:

1. <https://docs.python.org/3/tutorial/>
2. <https://www.w3schools.com/python/>
3. <https://www.tutorialspoint.com/python/index.htm>

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

- A) **Course Code** : 2420306(P2420306/S2420306)
 B) **Course Title** : Summer Internship -I (Common For all Programmes)
 C) **Pre- requisite Course(s)** :
 D) **Rationale** :

Diploma students are required to give exposure of their own diploma programme related industrial hardware, software and practices, just after completing one semester, so that they can correlate this industrial exposure with the concept being taught in the branch specific specialized engineering courses in forthcoming semesters. Mentors/ s/ Teachers need to map the academic contents of the programme of study with the activities of this industrial exposure and are advised to follow the 'Whole to Part' approach to make the students aware about the potential industry's expected outcomes & setup ('Whole') from the diploma programme – and then teaching the related concepts ('Part') of the same in subsequent semesters. In this way before actually being exposed to academic input specific to diploma programmes, the students need to be sent to the nearby/local industries and also may be advised to explore information related to their programme of study using different sources related to potential employment opportunities of both wage and self-employment, job function, job position, nearby relevant industries and so on.

The summer internship will provide the direction to the students and also help in mind mapping to plan their futuristic course of action, after passing the diploma. This would also bridge the gap between their virtual imagination about the outcome of the programme and real happenings related to the diploma programme.

- 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** Comprehend the practices of identified industry or world of work related to diploma engineering programme of study.
CO -2 Map real equipment, processes, product, management, operations etc. to the course of study through various glimpses of input, process and output in different type of industries.
CO -3 Identify the probable enterprises /startups for futuristic planning and self-growth.
CO -4 Identify the probable job function and job position in their relevant programme of study.

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

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2
CO-1	3	-	-	1	-	-	1		
CO-2	3	-	-	1	-	-	1		
CO-3	3	-	-	-	1	-	2		
CO-4	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	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				
2420306	Summer Internship -I	-	-	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)	
2420306	Summer Internship -I	-	-	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 Instructional/Implementation Strategies:** Mentors/ Coordinators/ Teachers need to plan and implement the summer internship in their respective programme as per the outcome expected from the programme. However in general, summer internship would help in exploring and exposing the student to the below mentioned dimensions of the world of work. These dimensions can further be explored in depth as per the need and advancement in respective programmes in later stages. Mentors/ coordinators/ Teachers need to map the academic contents of the programme of study with the activities of this industrial exposure and are advised to follow the whole to part approach to make the students aware about the potential industry's expected outcomes & setup ('Whole')

from the specific diploma programme and then teaching the related concepts ('Part') of the same in subsequent semesters.

- Industrial Layout
- Organizational Structure
- Corporate Communications
- Strategic, Rolling and Developmental plans
- Maintenance Procedures
- Inventory Control and Management System
- Purchase and Store Procedures
- Major Machinery, Tools, Equipment, Devices, Software, Control System etc.
- Product Development, Manufacturing, Packaging and Delivery
- Project Management
- Operation and Maintenance
- Warehouse Management
- Assembly Line
- Quality Assurance and Testing Cell
- Process/ Software Development/ Fabrication/ Construction Work Management
- Testing and Quality Assurance Practices
- Total quality management
- Callibration and Certification practices
- Safety Practices
- Industrial Acts
- Industrial Grievances
- Behavioural Aspects
- Conduction of Meetings and Discussions
- Sales and Marketing Strategies
- Forecasting and Target Setting
- Production Planning and Control
- Storage Retrieved and Material handling Practices
- Automation and Control Facilities
- Enterprise Resource Planning (ERP)
- Supply Chain
- Customer Satisfaction Strategies
- Finance and Accounts
- Research and Development
- Promotion and Capacity Building Schemes
- Reduce, Reuse and Recycling Efforts and Policies
- Recognitions and Rewards
- After Sale Services
- Promotional Avenues
- Social Corporate responsibilities

J) Assessment of Summer Internship -I

S. No.	Criteria of Assessment	% of Weightage
1.	Maintaining the log book after having exposure to different types of industry/ world of work	15
2.	Preparing the list of job functions and job positions of relevant programme	20
3.	Identify the probable enterprise/ startup for futuristic planning	15
4.	Report writing of summer internship as per the prescribed format	30
5.	Presentation of Report	20
Total		100

Note: S. no. 1 to 3 shall be considered for progressive assessment. While S. No. 4 & 5 shall be considered for end term assessment
