Curriculum

of

Diploma Programme

in

Electrical & Electronics Engineering

State Board of Technical Education (SBTE)
Bihar

Semester – III
Teaching & Learning Scheme

Board of Study	CourseCodes	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	**Electrical Circuit & Networks**	3	-	4	2	9	6
	2420302	**Electrical Measurements and Instrumentation**	3	-	4	2	9	6
	2420303	**DC Machines and Transformers**	3	-	4	2	9	6
	2420304	**Electrical Power Generation Transmission and Distribution**	2	1	-	2	5	4
	2439305	**Analog and Digital Electronics**	3	-	4	2	9	6
	2420306	**Summer Internship – I** (After 2nd Sem) (Common for all programmes)	-	-	2	2	4	2
Total			**14**	**1**	**18**	**12**	**45**	**30**

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

Board of Study	Course Codes	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	**Electrical Circuit & Networks**	30	70	20	30	20	30	200
	2420302	**Electrical Measurements and Instrumentation**	30	70	20	30	20	30	200
	2420303	**DC Machines and Transformers**	30	70	20	30	20	30	200
	2420304	**Electrical Power Generation Transmission and Distribution**	30	70	20	30	-	-	150
	2439305	**Analog and Digital Electronics**	30	70	20	30	20	30	200
	2420306	**Summer Internship – I** (After 2nd Sem) (Common for all programmes)	-	-	10	15	10	15	50
Total			**150**	**350**	**110**	**165**	**90**	**135**	**1000**

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 insingle 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/ Developmentof Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	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 respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	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				
Electrical Engineering	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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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:

Board of Study	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)	
Electrical Engineering	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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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)
TSO 1a. Classify the given components into active and passive. TSO 1b. Differentiate between the following: • Linear and nonlinear, • Unilateral and bilateral, • Lumped and distributed parameters, • Independent and dependent source TSO 1c. Describe the nature of the voltage-current characteristics of the given type of voltage source TSO 1d. Reduce the given passive network by using star-delta transformation TSO 1e. Determine the equivalent resistance by using star/delta transformation from voltage to current transformation and vice versa. TSO 1f. Apply Kirchhoff's Current and Voltage Law to analyze the given electric circuit(s). TSO 1g. Apply mesh analysis and nodal analysis to determine the ccurrent and voltage in a given circuit. TSO 1h. Explain Transient and steady state condition in a given circuit TSO 1i. Determine initial state and steady state of R, L & C in DC Circuit and give its application	**Unit-1.0 Basics of Electrical Circuits** 1.1 Definition of: • Linear and non-linear • Active and passive components • Unilateral and bilateral • Lumped and distributed parameters • Independent and dependent source 1.2 Concept of open circuit, closed circuit and short circuit, node, branch, mesh and loop 1.3 Star/Delta transformation of passive network 1.4 Source transformation 1.5 Kirchoff's Current Law (KCL) and Kirchoff's Voltage Law (KVL), Applications 1.6 Mesh Analysis and Nodal analysis of networks 1.7 Transient & steady state 1.8 Concept of initial and final conditions in switching circuits, Meaning of t =o-, t =o+, and t = infinite. R, L and C at initial and final conditions	**CO1**
TSO 2a. Solve a given complex linear active bilateral electrical circuit/network with multiple source using superposition theorem. 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. TSO 2c. Simplify a given linear complex electrical circuit/network to an equivalent circuit comprising of current source in parallel with resistance. TSO 2d. Transfer supply voltage and output current mutually in a linear passive electrical circuit/network by applying reciprocity theorem and also mention its applications TSO 2e. Determine the conditions for maximum power transfer across Load	**Unit-2.0 Network Theorems:** 2.1 Superposition theorem and its applications 2.2 Thevenin's theorem and its applications 2.3 Norton'stheorem and its applications 2.4 Reciprocity theorem and its applications 2.5 Maximum power transfer theorem 2.6 Application of theorems to solve DC networks	**CO1, CO2**
TSO 3a. Explain the behavior of AC voltage, current and power through pure resistance, pure inductance and pure capacitance with sketches	**Unit-3.0 Single Phase AC Circuits:** 3.1 Generation of an alternating EMF	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3b. Determine the current and voltage, impedance of thegiven series/parallel RL/RC/LC/ RLC circuit TSO 3c. Determine the active, reactive, apparent power and power factorof the given AC circuit Differentiate the given AC circuit quantities. TSO 3d. Represent the given AC circuit quantities in complex form. TSO 3e. Convert the given AC quantity in rectangular to polar and vice versa and other arithmetic operations. TSO 3f. Determine the current and voltage, impedance of the given series/parallel RL/RC/ RLC circuit TSO 3g. Determine the active, reactive, apparent power and power factor of the given AC circuit	3.2 AC circuit quantities: Peak value, RMS and Average value of a Sinusoidal voltage waveform 3.3 Vector representation of an alternating quantity, addition, subtraction, multiplication and division, Conversion from rectangular to polar and vice versa and exponential form 3.4 Waveforms, phasor diagram and expression of voltage, current and power in pure: Resistance, Inductance, Capacitance 3.5 AC Series and parallel circuits, Phasor diagrams and impedance triangle 3.6 Active, reactive, apparent power with examples, Power factor, lagging, leading and unity power factor, effects of poor power factor, power triangle	
TSO 4a. Explain the phenomena of resonance in the given RLC series and parallel circuit with sketches *TSO 4b.* Determine the resonant frequency of the given series RLC circuit *TSO 4c.* Explain the significance of quality factor of the given series RLCcircuit. *TSO 4d.* Determine the equivalent impedance and current magnitude ofthe given parallel RLCcircuit under resonance condition *TSO 4e.* Explain 2-port network and classify it. *TSO 4f.* Determine the Z, Y & T parameter using electrical circuits *TSO 4g.* Determine the conditions of symmetricity and reciprocity of two port networks	**Unit-4.0 Resonance and Two Port Network:** 4.1 Resonance and itsimportance in electrical circuit 4.2 Series & Parallel resonance: Resonant frequency, Quality factor, bandwidth and selectivity in series & Parallel RLC circuit. 4.3 Magnification in series and parallel resonant circuit 4.4 Comparison of series and parallel resonance and its applications 4.5 Significance of two port network and its types 4.6 Open Circuit (Z) parameter, Short Circuit (Y) parameter & Transmission parameter 4.7 T and Pie representation of circuits Symmetry and reciprocity of two port network	**CO3, CO4**
TSO 5a. Explain phase and time displacement of three phases. TSO.5.b Determine the current drawn by the given three phase balanced load connected in star/delta. TSO.5.c Explain the line and phase relation of current /voltage of three phase circuit. 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.	**Unit-5.0 Three phase AC circuits** 5.1 Generation of threephase voltage 5.2 Three phase three wire source and three phase four wire source, Phase sequence and phasor diagram 5.3 Line and phase relationship: Star/Delta 5.4 Three phase load -balanced and unbalanced Load 5.5 Measurement of power in three phase circuits	**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: 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 Kirchhoff 's Current law.	3.	Measurement of current and voltage in a branch of the given electrical circuit using Kirchhoff'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 Kirchhoff'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
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, C03
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, C03
LSO 3.3. Plot the waveform of voltage and current in a R-L load.	15.	Waveform of voltage and current in a R-L load.	CO2, C03
LSO 3.4. Plot the waveform of voltage and current in a R-L-C load.	16.	Waveform of voltage and current in a R-L-C load	CO2, C03
LSO 3.5. Measure the voltage, current in a series RLC circuit and calculate power	17.	Measurement of voltage, current, power and power factor in a series RLC circuit	CO2, C03

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
and power factor and draw phasor diagram.			
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, C03
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, C03
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.	C03, 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	C03, 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	C03, CO4
LSO 5.1. Measure the he 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 (Cl) 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

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
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
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
11.	Rheostat	Nichrome wire wound rheostat on epoxy test or Class F insulating tube with two fixed and 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	
12.	Digital Multimeter	5 1/2 digits resolutions with all basic measurement facility like DC Voltage: 200 mV ~ 1000 V, DC Current: 200 µA ~ 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 MΩ, Capacitance Measurement: 2 nF ~ 10000µF, 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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
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 lng RG Powell
3. Electric circuits simulation lab manuals

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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/ Developmentof Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	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 respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	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				
Electrical Engineering	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:

Board of Study	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)	
Electrical Engineering	**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 thecompletion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

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. 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.	**Unit-1.0 Basics of Measurement and Instrumentation** • Measuring systems and requirements: Block diagram • Deflecting, controlling and damping torque • Accuracy, precision, Resolution, tolerance, sensitivity and repeatability • Errors in measurement • Types of errors- Limiting error, Gross error, systematic Error, Random Error, Guaranteed accuracy error • Classification of basic instruments -Indicating, Recording and Integrating type	**CO1**
TSO.2.a Explain the general principle of measuring current, voltage in an electrical system. 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.	**Unit-2.0 Measurement of Voltage and Current** • Current and voltage measurement: Principle • Galvanometer, Ammeter, Voltmeter • Calibration of ammeter and voltmeter • Range Extension of ammeter and voltmeter using: - Shunts and Multipliers - Current Transformer (CT) and Potential Transformer (PT) (Construction, working and applications) • Permanent Magnet Moving Coil (PMMC), Moving iron, Induction, Dynamometers type instruments: Working principle, construction, applications, merits and demerits • Essentials and advantages of electronic instruments • True RMS reading voltmeter. • Digital Voltmeters (DVM) and its types • Digital multimeters- Block diagram	**CO2**
TSO.3.a Explain the general principle of measuring power and energy in an electrical system TSO.3.b Explain the working of induction and dynamometer type instruments.	**Unit-3.0 -Measurement of Power and Energy** • Power and energy Measurement: Principle	**CO3**

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

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

J) 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)
LSOs 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**
LSOs 2.1 Measure DC, AC voltage and current using analogue meter.	2.	Measurement of DC, AC voltage and current.	**CO2**
LSOs 2.2 Convert a given galvanometer to DC/AC current- meter.	3.	Conversion of a given galvanometer to DC/AC current- meter.	**CO2**
LSOs 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**
LSOs 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**
LSOs 2.5 Calibrate the given ammeter and voltmeter with a standard meter	6.	Calibration of ammeter and voltmeter	**CO2**
LSOs 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**
LSOs 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**
LSOs 2.8 Measure voltage, current, resistance using Digital Multimeter	9.	Measurement of voltage, current, resistance using Digital Multimeter	**CO2**
LSOs 2.9 Perform continuity test using digital Multimeter	10.	Continuity test using digital Multimeter	**CO2**
LSOs 3.1 Measure single and three phase power using one wattmeter	11.	Measurement of single and three phase power using one wattmeter	**CO3**
LSOs 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**
LSOs 3.3 Calibrate the given wattmeter with a standard meter.	13.	Calibration of wattmeter.	**CO3**
LSOs 3.4 Calibrate the given single-phase energy meter with a standard meter.	14.	Calibration of single-phase energy meter.	**CO3**
LSOs 3.5 Interpret the working of a digital energy meter	15.	Demonstration of the working of a digital energy meter	**CO3**
LSOs 5.1 Use Kelvin's double bridge for measurement of low resistance	16.	Kelvin's double bridge for measurement of low resistance	**CO4**
LSOs 5.2 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**
LSOs 5.3 Us Megger to measure insulation resistance. LSOs 5.4 Measure insulation resistance using Megger.	18.	Measurement of insulation resistance using Megger.	**CO4**
LSOs 5.5 Using Earth tester to measure earth resistance. LSOs 5.6 Measure earth resistance using Earth tester.	19.	Measurement of earth resistance using Earth tester	**CO4**
LSOs 5.7 Use Anderson or Maxwell inductance capacitance bridge to measure unknown inductance.	20.	Measurement of unknown inductance using Anderson or Maxwell inductance capacitance bridge	**CO4**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 5.8 Measure unknown inductance using Anderson or Maxwell inductance capacitance bridge			
LSOs 5.9 Use Schering's Bridge to measure unknown capacitance. LSOs 5.10 Measure unknown capacitance using Schering's Bridge.	21.	Measurement of unknown capacitance using Schering's Bridge	**CO4**
LSOs 5.11 Use Wein bridge or Weston frequency meter to measure unknown frequency LSOs 5.12 Measure unknown frequency using Wein bridge or Weston frequency meter.	22.	Measurement of unknown frequency using Wein bridge or Weston frequency meter	**CO4**
LSOs 5.13 Measure power factor using a dynamometer PF meter	23.	Measurement of power factor using a dynamometer PF meter	**CO5**
LSOs 5.14 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**
LSOs 5.15 Demonstrate the use of Synchroscope for Synchronization	25.	Demonstration of use of Synchroscope for Synchronization	**CO5**
LSOs 5.16 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**
LSOs 5.17 Measure Unknown frequency, phase angle using Lissajous patterns.	27.	Measurement of Unknown frequency, phase angle using Lissajous patterns.	**CO5**
LSOs 5.18 Identify the various parts of digital storage oscilloscope.	28.	Demonstration of features of digital storage oscilloscope.	**CO5**
LSOs 5.19 Us LCR meter to measure resistance, Inductance and Capacitance. LSOs 5.20 Measure resistance, Inductance and Capacitance using LCR meter.	29.	Measurement of resistance, Inductance and Capacitance using LCR meter	**CO5**
LSOs 5.21 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**
LSOs 5.22 Interpret the working principle of various analog/digital recorders.	31.	Demonstration of the working of various analog/digital recorders.	**CO5**

K) 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 line with the targeted COs.

i. Prepare a chart depicting symbols of various electrical measuring instruments.
ii. Prepare a chart showing the production of deflecting, controlling and damping torque in measuring instruments.
iii. Prepare a chart showing the construction and working principle of a PMMC, MI, Induction and dynamometer type of instruments
iv. Use an Analog Voltmeter to Measure the Voltage at a Point Referenced to Ground.
v. 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.

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 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.

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)	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.

N) 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**	45	35	20
2.	Measurement of DC, AC voltage and current.	**CO2**	45	35	20
3.	Conversion of a given galvanometer to DC/AC current- meter.	**CO2**	45	35	20
4.	Extension of range of ammeter and voltmeter to measure high value of current and voltages using shunt and multiplier.	**CO2**	45	35	20
5.	Measurement of high value of current and voltages using Current and Potential Transformer.	**CO2**	45	35	20
6.	Calibration of ammeter and voltmeter	**CO2**	45	35	20
7.	Demonstration of working of Moving Iron and Moving Coil type instruments.	**CO2**	45	35	20
8.	Demonstration of the working of Induction type and dynamometer type instruments	**CO2**	45	35	20
9.	Measurement of voltage, current, resistance using Digital Multimeter	**CO2**	45	35	20
10.	Continuity test using digital Multimeter	**CO2**	45	35	20
11.	Measurement of single and three phase power using one wattmeter	**CO3**	45	35	20
12.	Measurement of 3 phase power using two and three wattmeter method	**CO3**	45	35	20
13.	Calibration of wattmeter.	**CO3**	45	35	20
14.	Calibration of single-phase energy meter.	**CO3**	45	35	20
15.	Demonstration of the working of a digital energy meter	**CO3**	45	35	20
16.	Kelvin's double bridge for measurement of low resistance	**CO4**	45	35	20
17.	Measurement of medium resistance using Wheatstone bridge or Voltmeter-Ammeter method or Ohmmeter	**CO4**	45	35	20
18.	Measurement of insulation resistance using Megger.	**CO4**	45	35	20
19.	Measurement of earth resistance using Earth tester	**CO4**	45	35	20
20.	Measurement of unknown inductance using Anderson or Maxwell inductance capacitance bridge	**CO4**	45	35	20
21.	Measurement of unknown capacitance using Schering's Bridge	**CO4**	45	35	20
22.	Measurement of unknown frequency using Wein bridge or Weston frequency meter	**CO4**	45	35	20
23.	Measurement of power factor using a dynamometer PF meter	**CO5**	45	35	20

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**	45	35	20
25.	Demonstration of use of Synchroscope for Synchronization	**CO5**	45	35	20
26.	Measurement of amplitude, Frequency, time period and Phase difference of different signals generated by function generator using CRO.	**CO5**	45	35	20
27.	Measurement of Unknown frequency, phase angle using Lissajous patterns.	**CO5**	45	35	20
28.	Demonstration of features of digital storage oscilloscope.	**CO5**	45	35	20
29.	Measurement of resistance, Inductance and Capacitance using LCR meter	**CO5**	45	35	20
30.	Measurement of quality Factor of Inductor and Capacitor using LCR/Q Meter	**CO5**	45	35	20
31.	Demonstration of the working of various analog/digital recorders.	**CO5**	45	35	20

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

P) 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
6.	Shunt Multiplier	for Experimentation and Demonstration purpose	4

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
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 ±1Slidewiredivisionwhicheverisgreater),Multiplier: 5Ranges(0.01,0.1,1,10 and100)	16
11.	Wheatstone bridge	Measuring Range-1.000Ω to 10.00MΩ, MeasuringArm-x 1mΩ,x10Ω+10Ωx10+100Ωx10+1000Ωx10(min.one step:1Ω), **Ratio Arms-** x0.001x0.01,x0.01,x0.1,x1,x10,100,x1000(M10,M100,M1000 Murray and Varley loop testing), **Galvanometer Power Source** -Three1.5V batteries(built-in), Range, ±0.1% of reading on 100Ω to 100kΩ Range, **Accuracy-** ±0.3% of reading on 10Ω to 1MΩ Range, ±0.6% of reading on 1Ωto 10MΩ 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: 0.001uF - 2.0uF. 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	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 ½ 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 µF, Resistance: Upto 20 MΩ 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 ± (0.09% + 2) Current AC Maximum 10 A Accuracy ± (0.09% + 1) Resistance, Max resolution 0.1 Ω	25,26
22.	Galvanometer	Current Sensitivity 0.9 µA/div ±10% Voltage sensitivity 270 µV/div ± 15% External Circuit resistance 200Ω	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: ±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 ± 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

Q) 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:

1. Basics of Measurement & Measuring Instruments: https://www.youtube.com/watch?v=oV7TpfoiYNY
2. Electromechanical Measuring Instruments: - https://www.youtube.com/watch?v=k5Nzkyb8u4Y
3. Ammeter, Voltmeter and wattmeter: https://www.youtube.com/watch?v=-tha5hKhC5Q
4. CT & PT:https://www.youtube.com/watch?v=D-ctyWhKTh0
5. Measurements using Bridges/meters:https://www.youtube.com/watch?v=nWWzKgEBqjA
6. Megger: https://www.youtube.com/watch?v=XV6QlTwobLo
7. Electronic instruments: https://www.youtube.com/watch?v=TdUK6RPdIrA
8. True RMS meter:https://www.youtube.com/watch?v=7ZzwlklBbKc
9. Cathode Ray Oscilloscope :https://www.youtube.com/watch?v=U1amW7S1fcI
10. Cathode Ray Oscilloscope: https://www.youtube.com/watch?v=JsoZZM2Vc5Y
11. Lissajous pattern on CRO: https://www.youtube.com/watch?v=pSyitNgy8hE
12. 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:

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

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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 these 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** EngineeringTools	**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 respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	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				
Electrical Engineering	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:

Board of Study	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)	
Electrical, Engineering	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 thecompletion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

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

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1.a Describe the construction details of a DC machine. 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.	**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.2.a Explain the working principle of DC motor. 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.	**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.3.a Describe the constructional details of a single-phase transformer. 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 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	**Unit 3 – 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 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.	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
two winding transformers. TSO.3.l Explain the significance of Amorphous Metal Transformer (AMT).	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-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– 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)
LSOs 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**
LSOs 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	
LSOs 1.3 Test the performance of DC shunt generator on the given load condition.	3.	Load test of DC shunt Generator	
LSOs 1.4 Test the performance of DC series generator on the given load condition.	4.	Load test of DC series Generator	
LSOs 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**
LSOs 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	
LSOs 2.3 Control speed of DC Shunt motor using field/flux control method (Above rated speed)	7.	Speed control of D.C shunt motor	
LSOs 2.4 Control speed of DC Shunt motor using armature control method (Below rated speed).	8.	Speed control of a D.C. Shunt motor	

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 2.5 Test performance of DC shunt motor on the given load condition.	9.	Load test of D. C. shunt motor	
LSOs 2.6 Test performance of DC series motor on the given load condition.	10.	Load test of D.C. series motor	
LSOs 2.7 Apply direct method to brake the DC shunt motor.	11.	Brake test of D.C. shunt motor.	
LSOs 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**
LSOs 3.2 Test polarity of the given single phase transformer.	13.	Polarity of a single-phase transformer	
LSOs 3.3 Test performance of a given transformer by direct load test.	14.	Direct load test on a single-phase transformer	
LSOs 3.4 Observe the no load waveform of a given transformer using CRO	15.	No load waveform of a transformer using CRO	
LSOs 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.	
LSOs 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.	
LSOs 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	
LSOs 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**
LSOs 5.1 Measure current ratio of the given Current transformer using ammeter/clamp meter.	20.	Current ratio of a Current transformer	**CO4, CO5**
LSOs 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 line with 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 wielding 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 wielding 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 (Cl) 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 CosNumber (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	45	35	20
2.	Effect of speed and field flux on generated voltage of DC shunt generator	CO1	45	35	20
3.	Load test of DC shunt Generator	CO1	45	35	20
4.	Load test of DC series Generator	CO1	45	35	20
5.	Starting of D. C shunt motor using 3-point /4-point starter	CO2	45	35	20
6.	Reversal of direction of a DC Shunt motor	CO2	60	30	20
7.	Speed control of D.C shunt motor	CO2	50	40	20
8.	Speed control of a DC Shunt motor	CO2	50	40	20
9.	Load test of D. C shunt motor	CO2	45	35	20
10.	Load test of D.C. series motor	CO2	45	35	20
11.	Brake test of D.C. shunt motor.	CO2	45	35	20
12.	Measurement of voltage and current ratio of a given single phase transformer.	CO3	45	35	20
13.	Polarity of a single-phase transformer	CO3	60	30	20
14.	Direct load test on a single-phase transformer	CO3	45	35	20
15.	No load waveform of a transformer using CRO	CO3	45	35	20
16.	Open Circuit and Short Circuit test on a single-phase transformer.	CO3	50	40	20
17.	Perform Parallel operation of two single phase transformers.	CO3	50	40	20
18.	Auto transformer and 1-phase two winding transformer of same rating	CO	50	40	20
19.	Parallel operation of two three phase transformers for equal and unequal load sharing	CO4	50	40	20
20.	Current ratio of a Current transformer	CO5	45	35	20
21.	Voltage ratio of a Potential Transformer	CO5	45	35	20

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	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
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, 4th 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., 9th 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

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A) Course Code : **2420304(T2420304/S2420304)**

B) Course Title : Electrical Power Generation, Transmission and Distribution

C) Pre- requisite Course(s) : Basic Electrical Engineering, Electrical Circuit & Networks, DC Machines and Transformers

D) Rationale :

Electrical power plays a significant role in the development of industries and agriculture. With growing demand of electric power and diminishing fossil fuels, it has become imperative to generate power more efficiently. This course therefore deals in detail not only about generation of electric power using thermal (coal), hydro, nuclear fuel and diesel but also about transmission and distribution and also about deregulation of power system. The generating power plants needs highly skilled technicians who are capable of operating and maintaining various control equipment to generate, transmit and distribute power effectively and efficiently. This course attempts to develop the basic cognitive skills required to take appropriate steps/decisions to maintain the various and auxiliary equipment of power plants, transmission and distribution system.

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 Maintain Thermal, Hydro, Nuclear and Gas based Electrical Power Generating plants for its efficient operation.

CO-2 Maintain Electrical Power Generating Plants based on Renewable Energy Sources for its efficient operation.

CO-3 Maintain Electrical Power Transmission System.

CO-4 Maintain Electrical Power Distribution System.

CO-5 **I**nterpret the restructuring process and structure of Deregulated Power System.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Board of Study	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				
Electrical Engineering	2420304	Electrical Power Generation, Transmission and Distribution	02	01	-	02	05	04

Legend:

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

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

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

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

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

C: Credits = (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:

Board of Study	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)	
Electrical Engineering	2420304	Electrical Power Generation, Transmission and Distribution	30	70	20	30	-	-	150

Legend:

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

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

Note:

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

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

J) Theory Session Outcomes (TSOs) and Units: T2420304

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Describe the layout of the given type of power plant for electric power generation with labeled block diagram. TSO 1b. Explain the working of the given type of power plant with sketches. TSO 1c. Describe the criteria considered for site selection of the given power plant. TSO 1d. State the functions of different components of the given type power plant. TSO 1e. Explain the properties of the fuel used in the specified thermal power plants. TSO 1f. Describe the energy conversion process in the given type of power plants TSO 1g. State the given terms related to Power generation plants. TSO 1h. Explain the given factors which affects the economics of electric power generation.	**Unit-1.0 Generation of Electrical Power** **1.1 Thermal Power Plant**: Lay out, working and Site selection. • Major Auxiliaries: Functions • Properties of conventional fuels used in Thermal Power Plants **1.2 Hydro Power Plants:** Elements of Hydro power plant, Energy conversion process, Layout, and Site selection, Classification **Nuclear power Plant**: Lay out, working and site selection Properties of conventional fuels used in nuclear power plants, safe practices in nuclear power plants, Types of nuclear reactors, Disposal of nuclear waste and nuclear shielding. **1.4 Gas power plant**: Lay out, working and site selection Other features of Power generation Plants: Connected load, firm power, cold reserve, hot reserve, spinning reserve. Factors affecting cost of generation: Average demand, maximum demand, demand factor, plant capacity factor, plant use factor, diversity factor, load factor and plant load factor. Base load and peak load plants; Load curve, load duration curve, integrated duration curve.	**CO1**
TSO 2a. Describe with sketches the layout and working of the solar energy power plant. **TSO 2b.** Describe with sketches the layout and working of the wind energy power plant. **TSO 2c.** Describe with sketches the layout and working of the Bio-mass based power plants. **TSO 2d.** Describe with sketches the layout and working of the Geo-thermal energy power plant. **TSO 2e.** Describe with sketches the layout and working of the Ocean energy power plant. **TSO 2f.** Describe the layout and working of the Fuel cell with sketches.	**Unit-2 Renewable Energy Sources** **2.1** Types of Renewable Energy Sources. **2.2** Solar Energy: Potential of solar energy, Photovoltaic effect, Construction & materials used in solar photo-voltaic cells, working & applications of solar energy. **2.3** Wind Energy: Selection of site for wind mills, Working Principle, Block diagram, Applications **2.4** Bio-Mass & Bio-Gas Energy: Composition of Bio-Gas & its calorific value, Traditional and non-traditional Biogas plants, Bio-mass based power generation plants, their capacities and applications **2.5** Geo-thermal Energy: Working Principle, Block Diagram and applications. **2.6** Ocean Energy: Ocean Thermal Electric Conversion, Energy from Tides, Site requirements, Advantages and Limitations of Tidal power generation. 2.7 Fuel Cells: Construction, working types and applications	**CO1, CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3a. Explain the effects of R, L and C on the given transmission line. **TSO 3b.** Explain the features of given type of transmission lines **TSO 3c.** State the features of different types of conductors. **TSO 3d.** State the need for different types of insulators and calculate string efficiency of given type of insulators. **TSO 3e.** Describe the given method of improving string efficiency of insulators. **TSO 3f.** Explain the criteria for spacing of conductors **TSO 3g.** Calculate sag in given type of transmission system. **TSO 3h.** Explain the phenomena of corona and factors affecting it in given type of transmission line. **TSO 3i.** Explain different phenomena occurred in given transmission line. **TSO 3j.** Calculate the performance parameters single phase short transmission line. **TSO 3k.** Explain the importance and functions of the load dispatch Centre. State the salient features of the given EHV transmission system.	**Unit-3.0 Transmission of Electrical Power** **3.1** Transmission Line Parameters: Resistances, Inductances and Capacitances **3.2** Classification of Transmission Lines: short, medium and long **3.3** Comparison of different types of transmission systems. **3.4** Types of Conductors-Copper, Aluminum: Solid, stranded and bundled conductors. **3.5** Line Insulators – requirements, types, Failure of insulator. **3.6** String Efficiency, string efficiency improvement method: By using longer cross arm, By grading the insulator and By using guard ring **3.7** Spacing between Conductors, span length and sag calculation. **3.8** Corona – corona formation, advantages & disadvantages, factors affecting corona **3.9** Skin effect, proximity effect, Ferranti effect and Transposition of conductors. **3.10** Losses, efficiency, regulation and Effect of load power factor **3.11** Load dispatch Centre **3.12** Issues of Distributed Generation Integrated to distribution Grid. **3.13** Requirement of EHV transmission. - HVAC Transmission - HVDC Transmission	**CO2, CO3**
TSO 4a. State the need for distribution system. **TSO 4b.** Describe the various connection schemes of the distribution system with sketches. **TSO 4c.** Calculate voltage drop and minimum potential point using the given methods for 1-phase and 3-phase distribution system. **TSO 4d.** Describe the measures to be adapted to take of the distributed generation in the distribution system. **TSO 4e.** State the need for electrical substations and relevant site for given substation. **TSO 4f.** Sketch the elevation layout of a typical 11/33kV electrical substation with various switchgear and typical spacing between them and the ground level as well. **TSO 4g.** Describe the installation procedure of substation equipment's. **TSO 4h.** State the features of unarmored and armored underground cables **TSO 4i.** Describe the given laying procedure for underground cable.	**Unit-4.0 Electrical Power Distribution System** **4.1** Distribution system and its Requirements. **4.2** Connection schemes of distribution system. **4.3** A.C. distribution: Voltage drop, sending end voltage, receiving end voltage, point of minimum potential, minimum potential value and power loss **4.4** Power factor referred to receiving end voltage and power factor referred to respective load voltage. **4.5** Substation: Classification of substations based on; voltage level and Type of installation. **4.6** Selection and location of site for substation. **4.7** Installation of substation equipment. **4.8** Underground Cables**:** Requirements, classification, construction, comparison with overhead lines. **4.9** Laying of underground cable: Direct laying, Draw in system and Solid system	**CO3, CO4**
TSO 5a. State the concept and purpose of deregulation in power industry. **TSO 5b.** State the reasons for adopting deregulation in	**Unit-5.0 Deregulated Power system** **5.1** Introduction. **5.2** Reasons for restructuring/ deregulation of	**CO4, CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
development of power industry. **TSO 5c.** Explain the process involved in restructured power system. **TSO 5d.** State the functions of the given ancillary support system. **TSO 5e.** State issues involved in deregulation process.	power system. **5.3** Objectives of deregulation of various power system across the world. **5.4** Restructuring process **5.5** Ancillary services: Frequency support ancillary services, voltage control ancillary services and black start ancillary services **5.6** Issues involved in deregulation.	

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

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

L) Suggested Term Work and Self Learning: S2420304 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) Enlist the merits and demerits of Thermal Power Plant over Hydroelectric plant.
b) Draw the layout of a typical thermal, Hydro and Nuclear plant
c) Prepare the current installed and generating capacity of various renewable energy sources in India
d) Sketch different components of transmission line and explain the purpose of each in detail.
e) Calculate inductance value of a given transmission line.
f) Calculate capacitance value of a given transmission line.
g) Solve problems on string efficiency and sag.
h) Prepare report on Power Cable Jointing procedure of unarmoured and armoured power cable.
i) Calculate the performance of given transmission line.
j) Estimate the string efficiency of the given type of insulators.
k) Illustrate the ancillary services, reform initiatives and open access issues in Deregulated Power Industry

b. Micro Projects:

I. Identify the different parts of thermal power plant using video/ site visit etc. and Prepare a report on generating capacity of any Thermal Power Plant describing installed capacity of turbine, Generator etc.
II. Observe the operation of thermal power plant using video programme and prepare report on it.
III. Identify the different parts of Nuclear power plant using video/ site visit etc. and Prepare a report on generating capacity of any Nuclear Power Plant describing installed capacity of turbine, Generator etc.
IV. Observe the operation of Nuclear power plant using video programme and prepare report on it.
V. Identify the different parts of Hydro power plant using video/ site visit etc. and Prepare a report on generating capacity of any Hydro Power Plant describing installed capacity of turbine, Generator etc.
VI. Observe the operation of Hydro power plant using video programme and prepare report on it.
VII. Identify the different parts of Wind power plant using video/ site visit etc. and Prepare a report on generating capacity of any Wind Power Plant describing installed capacity of Generator etc.
VIII. List the types of Insulators used in Power Transmission and Distribution System and prepare chart on its uses.
IX. Collect the data from nearest power station/substation for load curve preparation and interpret it.

X. Prepare a report on different type of insulators and conductors used in transmission system with their specifications.
XI. Prepare a chart on different types of power cables used in transmission and distribution system showing its classification and specific applications.
XII. Find out the availability of the various transmission and distribution components and comparison of their specification and prices after market survey.
XIII. Prepare a model of a substation.
XIV. Prepare a model for generation of electricity using wind power.
XV. Prepare a model for generation of electricity using solar power
XVI. Prepare technical report after visiting a nearby Solar PV station.
XVII. Prepare technical report after visiting a nearby Wind Power station.

c. Other Activities:

a) Seminar Topics:

- Types of Turbine used in Thermal and Hydro Power Plant.
- Types of alternators used in Thermal and Hydro Power Plant.
- HVAC and HVDC Transmission System.
- Power transmission by BSPTCL
- Ancillary Services.

b) Visits:

- Visit a nearby Solar Power Plant and draw a general layout of the solar PV system Installation and prepare report on the Installation arrangement of different parts/components of it.
- Visit a nearby power station/ substation and draw a general layout of the electrical power system and prepare a report on types of supporting structure used in transmission and distribution system with their power ratings.
- Visit to nearby power station/substation. Prepare report of visit with special comments on transmission and distribution line components used, technique used, material used and unit charge of energy produced.
- Visit to 66 kV distribution sub-station and draw line diagram with equipment specifications.
- Visit 132/220/400kV transmission sub-station and draw line diagram with equipment specifications.
- Visit to a nearby Load Dispatch Centre and prepare Technical Report on it.
- Visit to nearby Electrical Power Generation Station and prepare Technical report on it.

c) Self- Learning Topics:

- Flexible AC Transmission Line
- Dry Transformers.
- DC Distribution System.
- Gas Insulated Substation
- Flexible Ac transmission line
- Smart grid
- Underground Transformer Installation.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	30%	30%	10%	100%	20%	-	-
CO-2	20%	20%	10%		20%	-	-
CO-3	20%	20%	40%		20%	-	-
CO-4	20%	20%	30%		20%	-	-
CO-5	10%	10%	10%		20%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**-**	**-**
			50				

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

Note:

- 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 Generation of Electrical Power.	10	CO1	20	5	7	8
Unit-2.0 Renewable Energy Sources.	7	CO2	14	4	5	5
Unit-3.0 Transmission of Electrical Power	8	CO3	14	4	5	5
Unit-4.0 Electrical power Distribution System	7	CO4	14	4	5	5
Unit-5.0 Deregulated Power system	4	CO5	08	3	3	2
Total Marks	36	-	**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): (Not Applicable)

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

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

S. No.	Name of Equipment,Tools and Software	Broad Specifications
1.	Simulation model/software for demonstrating the parts and working of various power generating plants	Thermal, Hydro, Nuclear, Solar, Wind
3.	Transmission line simulator (Short, Medium and Long)	• Single-phase and three-phase lines • Six-section three-phase line • Resistive, inductive and capacitive loads • Over current protection relay
4.	Different types of overhead line Insulators	Disc type, pin type, shackle type
5.	Different types of underground cables	Armoured and un armoured

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Power Plant Engineering	P K Nag	McGraw Hill, New Delhi, ISBN:978-9339204044
2.	A Course in Electrical Power	JB Gupta	S K Katarina and Sons, New Delhi.2014, ISBN:9789350143742
3.	Generation of Electrical Energy	B.R. Gupta	Chand &Co New Delhi, 2010 ISBN: 9788121901024
4.	Electrical Power Systems	Dr. S.L. Uppal and Prof. Sunil S. Rao	Khanna Publishers ISBN: 978-8174092380
5.	A Course in Electrical Power	Sony, Gupta, Bhatnagar	Dhanpat Rai and Sons, New Delhi, 2010 ISBN: 9789350143742
6.	Principles of Power System: including generation, transmission, distribution switchgear and protection	Mehta V K Rohit Mehta	S. Chand & Company Pvt. Ltd., New Delhi ISBN: 978-8121924962
7.	A Textbook of Electrical Technology Vol. III	Theraja, B.L.; Theraja, A.K.	S.Chand and Co. New Delhi ISBN: 9788121924900
8.	Power System Engineering	D.P. Kothari & I.J. Nagrath	McGraw-Hill; ISBN: 978-0070647916
9.	Operation of Restructured Power Systems (Power Electronics and Power Systems)	Kankar Bhattacharya, Jaap E. Daadler, Math H. J. Boolen, Kluwer	Springer; 2001 edition (October 26, 2012) ISBN-10 : 1461355672 ISBN-13 : 978-1461355670

(b) Open Educational Resources:

1. https://archive.nptel.ac.in/courses/112/107/112107291/
2. https://archive.nptel.ac.in/courses/108/102/108102047/
3. http://www.nptelvideos.in/2012/11/power-sys-generation-transmission.html
4. http://www.nptelvideos.in/2012/11/energy-resources-and-technology.html
5. www.tpud.org/.../An_Introduction_to_Electric_Power_Transmission_Presentation.pdf
6. www.nct-tech.edu.lk/Download/.../Performance%20of%20Transmission%20Lines..pd.
7. https://www.electrical4u.com/performance-of-transmission-line/
8. https://energy.gov/sites/prod/files/2013/07/f2/Transmission_Woodall_0.pdf
9. https://www.youtube.com/watch?v=_HxM6DAYQ4U
10. https://www.youtube.com/watch?v=CLEptMD9-EI
11. https:// https://www.youtube.com/watch?v=ns7FrGHBAFw
12. https://www.academia.edu/22504154/Power_System_Generation_Transmission_and_Distribution
13. http://nptel.iitm.ac.in/courses/108101005

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. Electric power engineering handbook on Electric Power Generation, Transmission and Distribution, CRC Press
2. Users' Guide
3. Manufacturers' Manual of power plant equipment
4. Lab Manuals

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A) Course Code : **2439305(T2439305/P2439305/S2439305)**

B) Course Title : Analog and Digital Electronics

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

D) Rationale :

A course in analog and digital electronics is essential for students enrolled in a Diploma in Electrical and Electronics Engineering program for various reasons. Analog and digital electronics provides a foundational knowledge of electronic circuits and devices, which is essential for designing and analyzing circuits. It is also highly relevant to various industries and provides students with practical hands-on experience, critical thinking skills, and problem-solving skills. Additionally, an analog and digital electronics course prepares students for further study in more advanced areas of electronics engineering. As such, the analog and digital electronics course is an integral part of the diploma in the electrical and electronics engineering curriculum, providing students with the necessary skills and knowledge to succeed in the electronics industry.

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

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

CO-1 Measure the stability of a transistor for different types of biasing methods.

CO-2 Use a transistor as a low-frequency amplifier and feedback amplifier.

CO-3 Use a transistor for Oscillator and multivibrator for various applications.

CO-4 Troubleshoot various Op-Amp circuits for a given application.

CO-5 Use appropriate logic family for digital electronics applications.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	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				
Electrical & Electronics Engineering	**2439305**	Analog and Digital Electronics	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 the teacher to ensure the outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						
			Theory Assessment (TA)		Term Work & Self Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electronics Engineering	**2439305**	Analog and Digital Electronics	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

- 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 assignments, micro-projects, seminars, 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 for internal as well as external assessment may vary as per the requirement of the respective course. For valid and reliable assessment, the internal faculty should prepare a 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 the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS), and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2439305

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the working of given diode. TSO 1b. Use the diode as a clipper and clamper circuit. TSO 1c. Explain the need for Transistor Biasing. TSO 1d. Calculate the Current and Voltage in different types of Biasing circuit TSO 1e. Calculate the Stability factor of different Types of Biasing circuits. TSO 1f. Explain the effect of temperature on transistor parameters TSO 1g. Compare the Stability factors of different types of circuits used for transistor biasing.	**Unit-1. Diode and Transistor Biasing** 1.1 Different types of Diode:- Light Emitting Diode, Schottky Diode, Tunnel Diode, Varactor Diode, Point Contact Diode, Photo Diode 1.2 Diode Application: Clipper Circuit, Clamper Circuit, 1.3 Need for Transistor Biasing 1.4 Transistor parameters Considered for basing 1.5 Stabilization and Stability Factor 1.6 Effects of Temperature on reverse saturation current 1.7 Transistor Biasing Methods: Base Resistor, Emitter Bias, Voltage Divider, Collector to base bias.	**CO1**
TSO2.a Explain the working of single stage transistor amplifier. TSO2.b Sketch the D.C. equivalent circuit of the transistor amplifier and describe it. TSO2.c Calculate the voltage gain of CE Amplifier. TSO2.d Calculate the Input and Output Impedance, voltage gain, current gain, and stability factor of CE Amplifier. TSO2.e Explain the effect of feedback on different amplifier parameters. TSO2.f Determine the input & output impedance of the given feedback amplifier. TSO2.g Calculate the voltage gain of the positive and negative feedback amplifier	**Unit-2. Amplifiers** 2.1 Single Stage Transistor amplifier. 2.2 D.C and A.C Equivalent Circuits of Transistor Amplifier 2.3 Load Line Analysis 2.4 Voltage Gain of CE Transistor Amplifier, without C_E, Input and Output Impedanceof CE Amplifier. 2.5 Feedback: Negative and Positive Feedback, Derivation of Gain, Advantages, Dissaving'sand Application of Feedback 2.6 Feedback Topology: Voltage series, current Series, Voltage Shunt, Current shunt 2.7 Calculate Gain, Input and Output Impedance 2.8 Comparison of Topology on different Parameters	**CO2**

TSO3.a Explain Barkhausen's Criteria. TSO3.b Describe the working principle of a given Oscillator. TSO3.c Describe the working of given multivibrator.	**Unit-3. Oscillators and Multivibrator** 3.1 Introduction of Oscillator 3.2 Different types of Oscillators:- RC Phase shift Oscillator, Wein Bridge Oscillator, Hartley Oscillator, Colpitt's Oscillator, Crystal Oscillator- Construction and Working 3.3 Multivibrator: Bistable, Monostable and Astable multivibrator using transistor- Construction and Working (No Derivation)	**CO3**
TSO 4a. Describe with sketches the working of Op-Amp in various configurations. TSO 4b. Define the given Op-Amp parameter. TSO 4c. Calculate the output voltage of the given Inverting and Non-Inverting Op-amp. TSO 4d. Calculate the output voltage of the given arithmetic circuit containing Op-Amp. TSO 4e. Explain with sketches the output of integrator and differentiator TSO 4f. Explain with sketches the output of a Logarithmic amplifier using diode.	**Unit-4 Op-Amp and its application** 4.1 Operational Amplifier:- Equivalent Circuit, Symbol, and basic terminology 4.2 Op-Amp IC 741 pin diagram and description 4.3 Op-Amp Configuration: Open Loop and Closed Loop, virtual ground concept 4.4 Op-Amp parameters: Input offset voltage, input offset current, input bias current, input resistance, Output Resistance, Open Loop voltage gain (Differential gain), Common mode gain, Common Mode Rejection Ratio (CMRR), Maximum output voltage Swing, Slew Rate 4.5 Parameters of Ideal and Practical Op-Amp 4.6 Modes of operations: Inverting and Non-Inverting 4.7 Arithmetic Operations Circuit: Adder, Subtractor 4.8 Integrator and Differentiator 4.9 Logarithmic Amplifier and Anti-Logarithmic Amplifier using diodes	**CO4**
TSO5.a Explain the effect of feedback on different amplifier parameters. TSO5.b Determine the input & output impedance of the given feedback amplifier. TSO5.c Calculate the voltage gain of the positive and negative feedback amplifier TSO5.d Compare the given logic family on the basis of given parameter.	**Unit-5 Overview of Combinational , Sequential Circuits and Logic family** 5.1 Codes: Gray code, BCD code, Excess-3 Code 5.2 Introduction of Combinational circuit 5.3 Code Converter: Binary to Gray and Gray to Binary code 5.4 Overview of Flip-flop 5.5 Conversion from one flip-flop to another flip-flop 5.6 Overview of Synchronous and Asynchronous Counter 5.7 Decade Counter and Johnson Counter 5.8 Terminology of Logic Family: Propagation delay, Power Dissipation, Figure of Merit, fan-in, fan-out, Noise margin 5.9 Resistor-Transistor logic (RTL), Direct Coupled Transistor logic (DCTL), Integrated Injection logic (I^2L), Diode - Transistor logic (DTL), High Threshold logic (HTL), Transistor -Transistor logic (TTL) and Emitter Coupled logic (ECL), Complementary Metal Oxide Semiconductor (CMOS)	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2439305

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO1.1 Plot the V-I characteristic of Point contact diode.	1.	To study and verify the functionality of a Point contact diode.	CO1
LSO2.1 Plot the V-I characteristic of Photo diode/LED.	2.	Plot the V-I characteristic of Photo diode/LED.	CO1
LSO3.1 Plot the wave forms and transfer characteristics of given clippers.	3.	To study and verify the functionality of PN junction diode as series and shunt clippers.	CO1
LSO4.1 Plot the wave forms and transfer characteristics of given clamper.	4.	To study and verify the functionality of PN junction diode as clamper.	CO1
LSO5.1 Test the Input and output characteristicsof the CE amplifier.	5.	Build the CE amplifier circuit and verify the Input and output characteristics.	CO2
LSO6.1 Test the Input and output characteristicsof the CC amplifier	6.	Build the CC amplifier circuit and verify the Input and output characteristics.	CO2
LSO7.1 Test the performance of the CB amplifier.	7.	Build the CB amplifier circuit and verify the Input and output characteristics.	CO2
LSO8.1 Measure the output voltage and output Current.	8.	Build the CE amplifier circuit and measure the voltage gain & current gain of the CE amplifier.	CO2
LSO9.1 Measure the Output voltage and outputCurrent.	9.	Construct the CC amplifier circuit and measure the voltage & current gain of the CCamplifier.	CO2
LSO10.1 Measure the output voltage, output current.	10.	Construct the CB amplifier circuit and measure the voltage & current gain of the CE amplifier.	CO2
LSO11.1 Measure the frequency of the RC-coupled CE amplifier.	11.	Build the RC-coupled CE amplifier circuit and measure the operating frequency of the RC-coupled CE amplifier.	CO2
LSO12.1 Measure the operating frequency of oscillation of the Wien-bridge Oscillator circuit.	12.	Build the Wien-bridge oscillator circuit on a breadboard/ trainer kit.	CO3
LSO13.1 Measure the operating frequency of oscillation of the RC phase shift Oscillator circuit.	13.	Build the RC phase shift oscillator circuit on a breadboard/ trainer kit.	CO3
LSO14.1 Plot the output waveform of astable multivibrator circuit. LSO14.2 Calculate the time period and duty cycle of the output waveform.	14.	Build an Astable multivibrator circuit using transistor.	CO3
LSO15.1 Measure input and output offset voltage. LSO15.2 Calculate CMRR.	15.	Measure input offset voltage, output offset voltage, and common mode rejection ratio (CMRR) of op-amp IC-741.	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO16.1 Measure the output voltage for various input voltages of inverting amplifier and non-inverting amplifier circuit. LSO16.2 Determine the gain of the inverting amplifier and non-inverting amplifier.	16.	Measure the output voltage of Inverting and non inverting OP-Amp for the given Input.	CO4
LSO17.1 Construct the adder/Subtractor circuit using IC-741. LSO17.2 Measure the output voltage of the adder/Subtractor circuit and compare it with theoretical calculation.	17.	Test adder/subtractor circuit consist of IC-741.	CO4
LSO18.1 Measure the output voltage of integrator/differentiator circuits for different input waveforms.	18.	Test Integrator/ Differentiator circuit consists of IC-741.	CO4
LSO19.1 Build Binary to Gray code Converter circuit using logic gate IC. LSO19.2 Verify the output for different binary input.	19.	Test Binary to Gray Code converter.	CO5
LSO20.1 Build Gray Code to Binary Converter circuit using logic gate IC. LSO20.2 Verify the output for different Gray code input.	20.	Test Gray Code to Binary converter.	CO5
LSO21.1 Build the circuit of Decade counter on breadboard.	21.	Decade Counter (0-9) using IC 7490.	CO5
LSO22.1 Build the TTL NAND logic family. LSO22.2 Analyze logic operation of TTL logic family.	22.	Test the characteristics of TTL NAND logic family.	CO5
LSO23.1 Build the CMOS NAND logic family. LSO23.2 Analyze logic operation of CMOS logic family.	23.	Test the characteristics of CMOS NAND logic family.	CO5

L) Suggested Term Work and Self-Learning: S2439305 Some sample suggested assignments, micro-projects and otheractivities are mentioned here for reference.

a. Assignments:

1. Calculate the circuit's performance of a common emitter amplifier in terms of its gain, input, output impedance, and frequency response.
2. Calculate the effect of feedback on the amplifier's performance in terms of its gain, stability, and distortion.
3. As per the given transistor's specifications, students have to calculate the values of resistors needed for biasing the BJT in a common emitter amplifier.

b. Micro Projects:

1. Build an Audio amplifier.
2. Construct a doorbell using a Transistor.
3. Build a Simple Class A Amplifier for radio application.
4. Electronics water level controller device.
5. Develop a temperature control DC fan using IC 741

c. Other Activities:

1. Seminar Topics:
   - Renewable energy using a photovoltaic cell.
   - Li-Fi and its application
   - Usage of ICs in consumer and industrial electronics appliances.
   - Commercially available Op-amp ICs.

2. Visits: Visit nearby electronic shops/industries having sufficient electronic equipment.
3. Self-learning topics:
   - h-Parameter.
   - MOSFET as a capacitor and resistor
   - Read the datasheet of various linear ICs.
   - Test electronics equipment and components through a multimeter.

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

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

Legend:

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

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

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1. Diode and Transistor Biasing	08	CO1	14	4	4	6
Unit-2. Amplifiers	10	CO2	14	4	4	6
Unit-3. Oscillators and Multivibrator	10	CO3	14	4	4	6

Unit-4. Op-Amp and its application	10	CO4	14	4	4	6
Unit-5. Overview of Combinational , Sequential Circuits and Logic family	10	CO5	14	4	4	6
Total	**48**	**-**	**70**	**20**	**20**	**30**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	To study and verify the functionality of a Point contact diode.	CO1	30	60	10
2.	Plot the V-I characteristic of Photo diode/LED.	CO1	40	50	10
3.	To study and verify the functionality of PN junction diode as series and shunt clippers.	CO1	30	60	10
4.	To study and verify the functionality of PN junction diode as clamper.	CO1	30	60	10
5.	Build the CE amplifier circuit and verify theInput and output characteristics.	CO2	30	60	10
6.	Build the CC amplifier circuit and verify theInput and output characteristics.	CO2	30	60	10
7.	Build the CB amplifier circuit and verify theInput and output characteristics.	CO2	30	60	10
8.	Build the CE amplifier circuit and measurethe voltage gain & current gain of the CE amplifier.	CO2	40	50	10
9.	Construct the CC amplifier circuit and measure the voltage & current gain of the CCamplifier.	CO2	40	50	10
10.	Construct the CB amplifier circuit and measure the voltage & current gain of the CEamplifier.	CO2	40	50	10
11.	Build the RC-coupled CE amplifier circuit andmeasure the operating frequency of the RC-coupled CE amplifier.	CO2	40	50	10
12.	Build the CD amplifier circuit and test theperformance of the Input and output characteristics of the CD amplifier.	CO2	40	50	10
13.	Build the Wien-bridge oscillator circuit on abreadboard/ trainer kit.	CO3	40	50	10
14.	Build the RC phase shift oscillator circuit on a breadboard/ trainer kit.	CO3	40	50	10
15.	Build an Astable multivibrator circuit using transistor.	CO3	40	50	10
16.	Measure input offset voltage, output offset voltage, and common mode rejection ratio (CMRR) of op-amp IC-741.	CO4	40	50	10
17.	Measure the output voltage of Inverting and non inverting OP-Amp for the given Input.	CO4	40	50	10
18.	Test adder/subtractor circuit consist of IC-741.	CO4	40	50	10

19.	Test Integrator/ Differentiator circuit consists of IC-741.	CO4	40	50	10
20.	Test Binary to Gray Code converter.	CO5	40	50	10
21.	Test Gray Code to Binary converter.	CO5	40	50	10
22.	Decade Counter (0-9) using IC 7490.	CO5	40	50	10
23.	Test the characteristics of TTL NAND logic family.	CO5	40	50	10
24.	Test the characteristics of CMOS NAND logic family.	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools, and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	C.R.O.	Dual Channel 100MHz	ALL
2.	Function generator	20 MHz with sine , square and triangular output with variable frequency and amplitude	ALL
3.	Dual Power supply	Digital Dual Output DC Power Supply, Input Voltage: 230 V Ac, Output Voltage: 0 To 128 V	ALL
4.	Variable DC power supply	0-30V , 2A Dual Tracking power supply	ALL
5.	Bread Board	MB 102 Breadboard with Power Supply Module, Jumper Wires, Battery Clip,830 & 400 tie-Points	ALL
6.	Digital Multimeter	DM-86 Digital Multimeter AC Frequency Response: 40-400Hz Low Battery Display: Approx. < 7.5V	ALL
7.	IC 741C	Dual-In-Line or S.O. Package	ALL
8.	Connecting Wires	Single strained Teflon coating (0.6mm diameter)	ALL
9.	Resistors	82Ω, 1KΩ, 1.5KΩ, 3KΩ, 3.3KΩ, 10KΩ, 12KΩ, 15KΩ, 33KΩ, 39KΩ, 100KΩ	ALL
10.	Capacitors	0.01µF, 0.1µF, 1µF	ALL
11.	Function Generator	20 MHz with sine , square and triangular output with variable frequency and amplitude	ALL

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Analog Circuits	A.K. Maini	Khanna Publishing House Ed. 2018 (ISBN: 978-93-86173-584)
2.	Electronic Devices and Circuits	S. Salivahanan and N. Suresh Kumar	McGraw Hill Education; Fourth edition (1 July 2017) ISBN: 978-9339219505
3.	Electronics Devices and circuit theory	Boyestad & Nash-elsky	Pearson Education India; 11 edition (2015) ISBN: 978-9332542600
4.	Electronic Principles	Albert Malvino & David Bates	Tata McGraw Hill Publication 2010 ISBN: 978-0070634244
5.	Electronics Devices & Circuits	Jacob Millman	McGraw Hill Education; 4 edition (2015) ISBN: 978-9339219543
6.	Linear Integrated Circuits	Salivahanan S	McGra Hill, New delhi, 2008 ISBN: 9780070648180
7.	Fundamentals of Logic Design	Charles H. Roth, Larry L. Kinney	Jaco Publishing House; First edition ISBN: 978- 8172247744

(b) Online Educational Resources:

1. https://www.youtube.com/watch?v=HQ9pHFvq5do&list=PLm_MSClsnwm8EdADExAUnwdEM51R3Yhfc
2. https://www.youtube.com/watch?v=xhn188JafbM&list=PL350612601E2DBFDE
3. https://youtube.com/playlist?list=PLMksOeFI6x39hw7SMZp9xb_Np0ClVPzpA
4. https://youtu.be/lpXNCwsnxjM?si=5U9VyrPe_zFcKMnx

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

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A) Course Code : 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/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 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 respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	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:

Board of Study	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
- Calliberation 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

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