GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**INDUSTRIAL AC MACHINES**
COURSE CODE	**EE41205**
PREREQUISITE COURSE CODE & TITLE	**EE31202 ELECTRICAL CIRCUIT & NETWORK**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE41205	**INDUSTRIAL AC MACHINES**	DSC	**4**	**--**	**2**	**2**	**8**	**4**	**3 Hr**	**30**	**70**	**100**	**40**	**--**	**--**	**25#**	**10**	**25**	**10**	**150**

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

AC machines are widely used in various industries and generating stations, while three phase induction motors are work horse of the industries, alternators are used for generating electrical power. This course is designed to enable the diploma students to acquire the knowledge and skills related to operation and maintenance of these AC machines to enhance the employability in the field

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1 – Understand the fundamental of three phase induction motor.

CO2- Evaluate the performance of three phase induction motor.

CO3 - Control the speed of three phase induction motor using appropriate technique(s).

CO4 – Select the appropriate single phase induction motor for specific task.

CO5 - Evaluate the performance of three phase alternator & synchronous motor.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION - I			
	UNIT - I THREE PHASE INDUCTION MOTORS (HRS - 10, Marks -15)			
1	TLO 1.1 Classify three phase AC machines. TLO 1.2 Explain constructional details and working principle of the given induction motor. TLO 1.3 Explain the production of a rotating magnetic field with two and three phases. TLO 1.4 Define synchronous speed. TLO 1.5 Mention the general specifications and ratings of three phase induction motor. TLO 1.6 Analyze the behavior of the rotor under the given conditions. TLO 1.7 Calculate the given parameter related to the induction motor. TLO 1.8 Describe the given method(s) for slip measurement of the given induction motor. TLO 1.9 Interpret the torque-slip characteristics of the given induction motor an	1.1 Three phase AC machines: classification. 1.2 Squirrel cage induction motor and slip ring induction motor: constructional details & working principle and comparison. Between Slip ring & Squirrel cage Induction motor. 1.3 Concept of rotating magnetic field: production of rotating magnetic field (with two and three phases), synchronous speed. 1.4 Squirrel cage induction motor and slip ring induction motor: working principle, comparison. 1.5 Rotor behavior and relations: standstill and running conditions, speed, slip, frequency of induced emf/currents, power factor. 1.6 Slip measurement methods: tachometer, stroboscope, and galvanometer methods. 1.7 Torques: starting, full load and maximum torque & their ratios. 1.8 Torque-slip (T-S) characteristics.	Lecture Using Chalk-Board, Presentations, Video Demonstrations,	CO1
	UNIT- II PERFORMANCE OF THREE PHASE INDUCTION MOTOR (HRS – 06, MARKS - 10)			
2	TLO2.1. State the losses in I.M. and determine the efficiency. TLO 2.2. Explain the power flow diagram of three-phase induction motor. TLO2.3. Explain the equivalent circuit of three phase induction motor. TLO 2.4. Draw circle diagram by performing O.C&S.C test on 3-phase I.M.	2.1 Various losses in induction motor and efficiency. 2.2 Power flow diagram of induction motor. 2.3 Phasor diagram of induction motor 2.4 Equivalent circuit of three phases induction motor (No numerical) 2.5 Graphical method to find performance of Three phase I.M. by performing open	Lecture Using Chalk-Board, Presentations, Video Demonstrations,,	CO2

		circuit test & Short circuit test. Construct the circle diagram and plot mark points: a)Full load b) Maximum output c) Maximum torque. 2.6 Numerical on circle diagram		
UNIT – III STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTORS (HRS -06, MARKS - 10)				
3	TLO 3.1 Justify the need of starter for three phase induction motor. TLO 3.2 Describe constructional details of the given type of starter for the induction motor. TLO 3.3 Explain working of the given starter for three phase induction motors. TLO 3.4 List all the components used in the given soft starter. TLO 3.5 Explain the working of the given soft starter. TLO 3.6 Explain the given method(s) of speed control for the induction motor	3.1 Necessity of starter for three phase induction motors. 3.2 Stator resistance starter, DOL starter, auto transformer starter, star delta starter, rotor resistance starter: constructional details and working. 3.3 Soft starters: component details and working. 3.4 Speed control methods: stator voltage control, pole changing method, variable rotor resistance, variable frequency drives (VFD)	Lecture Using Chalk-Board, Presentations, Video Demonstrations,,	CO3
SECTION –II				
UNIT – IV SINGLE PHASE INDUCTION MOTORS (HRS - 08, MARKS - 12)				
4	TLO 4.1 Explain the double field revolving theory and its significance in single-phase induction motors. TLO 4.2 Describe the given self-starting technique(s) for the single phase induction motors. TLO 4.3 Describe the constructional details of the given single-phase induction motor. TLO 4.4 Explain the working principles of the given single phase induction motor. TLO 4.5 Interpret the torque-slip characteristics of the given single phase induction motor and state its applications.	4.1Construction and types of single-phase induction motor 4.2 Double field revolving theory and working Principle of single-Phase Induction motor. 4.3 Starting of single phase I.M. 4.4 Types of single-phase I. M.: - Split phasing principle • Resistance start I. M. • Capacitor start-run I.M. • Shaded pole motor. 4.5 Torque- slip characteristics of above single-phase induction motors. 4.5 Applications of different types of single-phase induction motors.	Lecture Using Chalk-Board, Presentations, Video Demonstrations,,	CO4

	UNIT – V THREE PHASE ALTERNATOR (HRS -10, MARKS -13)			
5	TLO 5.1 Describe the constructional details of three phase alternators. TLO 5.2 Explain the working principle of alternator. TLO 5.3 State the advantages of rotating field in turbo alternators. TLO 5.4 Calculate the speed and frequency for the given three phase alternator. TLO 5.5 Calculate the pitch factor, distribution factor and EMF for the given three phase alternator. TLO 5.6 Explain the given type of excitation system used in three phase alternator.	5.1 Three phase alternators: constructional details, working principle. Types of alternators and their comparison: turbo alternator and hydro alternator. 5.2 Turbo alternators: advantages of rotating field. 5.3 Winding: advantages of short, pitched winding and Distribution winding, & relations for pitch factor and distribution factor. 5.4 Excitation systems of Alternator. 5.5 E.M.F. equation of alternator. 5.6 Synchronous reactance. 5.7 Armature reaction at various power factors. 5.8 Determination of Voltage regulation: direct loading method and synchronous impedance method.	Lecture Using Chalk-Board, Presentations, Video Demonstrations,, Industry Visit	CO5
	UNIT – VI THREE PHASE SYNCHRONOUS MOTOR (HRS –05, MARKS - 10)			
6	TLO 6.1 Explain the working principle of three phase synchronous motor and its use for power factor improvement. TLO 6.2 Explain the necessity of sunchronization and describe the conditions for it. TLO 6.3 Explain the methods of starting of synchronous motor	6.1 principle of working/operation, significance of load angle. 6.2 Torques: starting torque, running torque, pull out torque, pull in torque 6.3 synchronous motor on load with constant excitation (numerical),effect of excitation at constant load(numerical) 6.4 V curve and inverted V curve 6.5 hunting and phase swinging. 6.6 methods of starting of synchronous motor 6.7 losses in synchronous motor and efficiency(no numerical) 6.8 Application areas.	Lecture Using Chalk-Board, Presentations, Video Demonstrations,, Industry Visit	CO5

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Identify the different parts of a three phase squirrel cage and slip ring induction motor.	Identification of different parts of a three phase squirrel cage and slip ring induction motor, interpretation of the nameplate of three phase induction motor and reversal of the direction of rotation	2	CO1

2	LLO 2.1 Measure slip of a three phase induction motor using tachometer/galvanometer. stroboscope.	Measurement of slip of a three-phase induction motor by : a) Tachometer b) galvanometer c stroboscope methods.	2	CO1
3	LLO 3.1 Perform brake test on a three-phase induction motor	Brake test on three-phase induction motor.	2	CO2
4	LLO 4.1 Calculate the equivalent circuit parameter of a three-phase induction motor.	No load and Block rotor test on given three phase squirrel cage induction motor to determine the equivalent circuit parameter.	2	CO2
5	LLO 5.1 Start a three phase induction motor using a given starter.	Starting of a three-phase induction motor using (a) auto transformer (b) DOL starter (c) star delta starter	2	CO3
6	LLO 6.1 Control the speed of a three phase slip ring induction motor by varying rotor resistance	Speed control of a three-phase slip ring induction motor by varying rotor resistance	2	CO3
7	LLO 7.1 To perform O.C. & S.C. test on 3-phase IM to draw circle diagram	To perform O.C. & S.C. test on 3-phase IM to draw circle diagram	2	CO2
8	LLO 8.1 Identify different parts of a single phase induction motor. And Reverse the direction of rotation of a single phase induction motor.	Identification of different parts of a single phase induction motor and reversing the direction of rotation of a ceiling fan/ single phase induction motor	2	CO4
9	LLO 9.1 To perform No load test on 1-phase I.M.	To perform no load test on 1-phase I.M.	2	CO4
10	LLO 10.1 Perform a direct loading test on a three phase alternator to determine voltage regulation under various loads.	Direct loading test of a three-phase alternator for determining voltage regulation with resistive, inductive, and capacitive loads	2	CO5
11	LLO 11.1 Perform open circuit (OC) and short circuit (SC) test on three-phase alternator and Calculate the efficiency and regulation of a three-phase alternator	Open circuit (OC) and short circuit (SC) test on three phase alternator for determining its efficiency and voltage regulation	2	CO5
12	LLO 12.1 Start 3 phase synchronous motor and run the synchronous motor in forward and reverse direction.	Start 3 phase synchronous motor and run the synchronous motor in forward and reverse direction.	2	CO5

Perform any 10 practicals. All COs should be covered in the performed practical.

VI. SUGGESTED MICRO PROJECT/ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING)

Assignment

- Calculate starting torque, full load torque and maximum torque for a given 3 phase induction motor connected to a rated power supply.
- Calculate rotor current frequency, synchronous speed and rotor speed for a given slip, number of poles and power supply of 3 phase induction motor.
- Calculate the external resistance to be inserted in rotor circuit to get the maximum torque at the starting conditions for a given slip ring induction motor connected to a rated power supply.
- Calculate the external resistance to be inserted in rotor circuit to get the maximum torque at a given running conditions for a given slip ring induction motor connected to a rated power supply.
- Solve numerical to calculate voltage regulation of alternator. Solve numerical to calculate emf of alternator.

Micro project:

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned Faculty:

- Collect information in brochures or other means for setting up VVVF drives.
- Collect information/product brochures on different types of alternators.
- Gather information and product brochures on both AC and DC servomotors commonly employed in robotics, CNC machining, conveyor systems, and other motion control applications.
- Collect information and product brochures, for single-phase induction motors and BLDC motor used in ceiling
- Obtain information and product brochures on stepper motors utilized in precision positioning systems, 3D printers, CNC machines, and other motion control applications.
- Visit an industry and collect information/product brochures on three phase induction motors used for lifts, cranes and hoists and prepare reports covering interpretation of technical specification, name of manufacturer, frame size and applications. Visit an industry and collect information/product brochures on three phase induction motors used for floor mills, agricultural solar pumps and prepare reports covering interpretation of technical specification, name of manufacturer, frame size and applications.
- Design a model of a three-phase/single-phase induction motor using software such as CAD, CATIA, or SOLIDWORKS to visualize and understand its constructional details

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Three Phase Induction Motor 3 hp / 5 hp, 415 V, 50 Hz, 1440 RPM Squirrel Cage type with Brake and Pulley arrangement.	1,2,3,4,5,6,7
2	Three Phase Induction Motor 3 hp / 5 hp, 415 V, 50 Hz, 1440 RPM Slip Ring type.	1,2,4,5,6,7
3	Stroboscope or relative Mobile app (e.g. Strobolight/RPM meter).	2
4	Galvanometer (30-0-30)	2
5	Auto Transformer: 3-Phase, 5kVA, 0 to 470V	2,3,4,5,6,7,8,9,10,11
6	Ammeters MI Type: AC/DC 0-5-10A, 0-10-20A.	2,3,4,5,6,7,8,9,10,11,12
7	Voltmeters MI Type: AC/DC, 0-150/300V, 0-250/500V	2,3,4,5,6,7,8,9,10,11,12
8	Clip on Meter Digital/Analog.	2,3,4,5,6,7,8,9,10,11,12

9	Digital Multimeter with standard makes for measurements	2,3,4,5,6,7,8,9,10,11,12
10	Tachometers: Contact and Non-contact types: 100 to 10000 RPM	2,3,4,5,6,7,8,9,10,11,12
11	Three Phase Induction Motor 3 hp / 5 hp, 415 V, 50 Hz, 1440 RPM Squirrel Cage type coupled with suitable DC Shunt Machine.	6
12	Wattmeters: Single Phase, Single Element, 2.5/5A, 200/400V	6,7
13	Wattmeters: Three Phase Double Element, 5/10A, 250/500V	6,7
14	Low Power Factor Wattmeter: Single Phase, 2.5/5A, 250/500V	6,7
15	Single Phase Induction Motor, Permanent Capacitor (single value), 1 hp, 230 V, 50 Hz, 1440 RPM.	8,9
16	Star- Delta Starter (Auto/Manual), DOL Starter, VFD for 3 to 5 hp Motors.	8,9
17	Load Bank: Resistive, 3-Phase, 5kW, 415V	9,10
18	Load Bank: Inductive, 3-Phase, 20A, 415V	10,11
19	Load Bank: Capacitive, 3-Phase, 20A, 415V	10,11
20	Three Phase Alternator: 5kVA, 415V, 50 Hz, 4 Pole, 1500 RPM coupled with appropriate DC Shunt Motor.	10,11

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION - I								
1	**I**	**THREE PHASE INDUCTION MOTORS**	**CO1**	**10**	**04**	**07**	**04**	**15**
2	**II**	**PERFORMANCE OF THREE PHASE INDUCTION MOTOR**	**CO2**	**06**	**02**	**04**	**04**	**10**
3	**III**	**STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTORS**	**CO3**	**06**	**02**	**04**	**04**	**10**
SECTION – II								
4	**IV**	**SINGLE PHASE INDUCTION MOTORS**	**CO4**	**08**	**02**	**06**	**04**	**12**
5	**V**	**THREE PHASE ALTERNATOR**	**CO5**	**10**	**02**	**08**	**03**	**13**
6	**VI**	**THREE PHASE SYNCHRONOUS MOTOR**	**CO5**	**05**	**02**	**06**	**02**	**10**
Grand Total				**45**	**14**	**35**	**21**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two-unit tests of 30 marks will be conducted and an average of marks obtained in these two-unit tests will be considered.	End semester assessment of 70 marks through offline mode of examination. End sem practical exam will be conducted for 25 marks.

X. SUGGESTED COS- POS MATRIX FORM

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	PSO-3	PSO-4
CO1	2	1	2	1	2	1	1	2	1		2
CO2	1	1	1	3	1	1	1	3	1	2	2
CO3	3		1	1	1		1	3	2	1	2
CO4	2		2	2	1		2	1	2	2	2
CO5	3	1	2	3	1	1	1	3	2	1	2

Legends:- High:03, Medium:02, Low:01, No Mapping: --
***PSOs are to be formulated at the institute level**

XI. SUGGESTED LEARNING MATERIALS/BOOKS

Sr. No	Author	Title	Publisher
1	Theraja B. L., Theraja A. K.	A Textbook of Electrical Technology Vol II	S. Chand and Co. New Delhi ISBN10: 8121924375
2	Ashfaq Husain	Electric Machine	Dhanpat Rai & co. ISBN13: 978-8177001662
3	Kothari D. P. and Nagrath I. J.	Electrical Machines	McGraw Hill, New Delhi ISBN13: 978 9352606405
4	Bhattacharya S. K.	Electrical Machines	Tata McGraw Hill, New Delhi ISBN13: 978 9332902855
5	Mittle V. N., Arvind Mittle	Design of Electrical Machines	McGraw Hill, New Delhi, ISBN: 9788180141263, 978818014126
6	Dr. P. S. Bimbhra	Electrical Machinery	Khanna Publication ISBN13:978-9389139105
7	Samarjit Ghosh	Electrical Machines	Pearson Education India, 2012; 9788131776025

XII. LEARNING WEBSITES & PORTALS

Sr No	Link / Portal	Description
1	https://ems-iitr.vlabs.ac.in/exp/speed-control-slip-ring/	Speed Control of Slip Ring Induction Motor (VLAB)
2	https://archive.nptel.ac.in/courses/108/106/108106072/	Operation of Induction Machine and Synchronous Machine
3	https://archive.nptel.ac.in/courses/108/105/108105131/	Construction of Three Phase Induction Motor
4	https://archive.nptel.ac.in/courses/108/102/108102146/	Electromechanical Energy Conversion and Synchronisation of Alternators
5	https://ems-iitr.vlabs.ac.in/exp/lab-equipment-familiarizati	Familiarization of the electrical machine laboratory apparatus (VLAB)

Name & Signature: **Mr. J.G.Momin** Lecturer in Electrical Engineering (Course Experts)	**Smt. Nilambari Vasant Devarkar** Lecturer in Electrical Engineering
Name & Signature: **Mr.R.U.Shelke** **Dr.S.V.Bhangale** (Programme Head)	Name & Signature: **Shri.S.B.Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**SWITCHGEAR AND PROTECTION**
COURSE CODE	**EE41210**
PREREQUISITE COURSE CODE & TITLE	**EE31204 ELECTRICAL POWER GENERATION AND TRANSMISSION**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE41210	Switchgear and Protection	DSC	4	0	2	2	8	4	3 Hr	30	70	100	40			25#	10	25	10	150

Total IKS Hrs for Term: 00 Hrs

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Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Switchgear and protection ensures reliability and stability of the power system. To ensure the continuity and maintain the power supply system, student must be aware of operational principles, selection and testing aspects of switchgear and protection system.

III. COURSE-LEVELLEARNING OUT COMES(CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify the different types of faults occurring in power system.
CO2: Select the suitable switchgears for different applications.
CO3 : Test the performance of different protective relays.
CO4 : Use suitable protection schemes for alternators and transformers.
CO5: Apply suitable protection schemes for motors, busbars and transmission lines
CO6 : Select suitable protection schemes for the power system against overvoltages

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes(TLO'S) alignedtoCO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		SECTION - I		
		UNIT-I Basics of protection (CL Hrs-08, Marks-07)		
1.	TLO 1.1 Describe the functions of the given elements of the protective system. TLO 1.2. Explain with sketches the given types of faults and abnormalities in a power system. TLO 1.3 Describe with sketches the concept of the Backup protection for the given protection zone. TLO 1.4 Determine the short circuit currents of symmetrical faults for the given generators. TLO 1.5 Select suitable current limiting reactors for the given situation with justification.	1.1 Protective system: Necessity, functions and components. 1.2 Normal and abnormal conditions. 1.3 Types of faults and their causes. 1.4 Protection zones and backup protection 1.5 Short circuit fault calculations for symmetrical fault on busbars fed through generators (Simple numericals) 1.6 Current Limiting Reactors: Need, types, arrangements, advantages and disadvantages	Lecture Using Chalk-Board , Video Demonstrations,Flipped Classroom, Case Study, Collaborative learning, Presentations	CO1
		UNIT-II Circuit Interruption Devices (CL Hrs-10, Marks-14)		
2	TLO 2.1. Explain the operation with sketches of the given isolators TLO 2.2 Explain with sketches the given terms related to the specified fuse (s). TLO 2.3 Explain the terms related to arc interruption process of the fuse. TLO 2.4 Explain with sketches arc formation, high resistance and zero current interruption in the given type of circuit breaker. TLO 2.5 Calculate the terms related to circuit interruption based on the given data of the circuit. TLO 2.6 Explain the operation with sketches of the given circuit breaker(s).	2.1 Isolators- Vertical break, Horizontal break and Pantograph types with its advantages and disadvantages 2.2 HRC fuses – Construction, types, working, Inverse time current characteristics , characteristics of fuse element, Fuse current rating, Minimum fusing current, Fusing factor, Prospective current, Cut off Current. 2.3 Terms related to Arc interruption process of fuse – pre-arcing time, cut off value, arcing time, total operating time, peak of prospective current and applications. 2.4 Arc formation process, methods of arc extinction (High resistance and Low resistance). 2.5 Arc voltage, Recovery voltage, Re-striking voltage, Rate of rise of restriking voltage (RRRV). 2.6 Effects of circuit interruption: Resistance switching, current Chopping, capacitive current breaking.	Lecture Using Chalk-Board , Video Demonstrations ,Flipped Classroom, Case Study, Collaborative learning, Presentations	**CO2**

	TLO 2.7 Compare the given circuit interrupting devices on the specified parameters. TLO 2.8 Select the relevant switchgear for the given application with justification. TLO 2.9 Describe the general arrangement of Gas insulated switchgear TLO 2.10 Explain the Insulation coordination for the given installation/machine. TLO 2.11 Classify the Ring main unit switchgear parameters based on given criteria.	2.7 HT circuit breakers: Vacuum circuit breaker , (Sulphur-hexa Fluoride (SF_6) - Working, construction, specifications and applications. 2.8 L.T. circuit breaker: Miniature circuit breakers (MCB), Moulded case circuit breakers (MCCB), Motor Protection Circuit Breaker (MPCB) , Residual Current Circuit Breaker (RCCB) and Earth leakage circuit breaker(ELCB), Air circuit breakers (ACB)- Construction, Working and applications 2.9 Selection of LT and HT circuit breakers. 2.10 Isolator, fuses and circuit breaker: Comparison 2.11 Gas insulated switchgear. 2.12 Insulation Coordination : Type 1 & Type 2 coordination 2.12 Ring Main Unit Switchgear: Introduction, classification based on: type of insulation (gas, oil, air), installation (outdoor, indoor).		
UNIT-III Protective Relays (CL Hrs-12 , Marks-14)				
3	TLO3.1 Explain the given terms related to protective relays. TLO 3.2 Calculate the relay time based on the given data in the power system. TLO 3.3 Explain with sketches the working of the given protective relay. TLO 3.4 Select relevant protective relay for required application with justification.	3.1 Protective Relay: Fundamental quality requirements (Selectivity, Speed, Sensitivity, Reliability, Simplicity, Economy) 3.2 Basic relay terminology- Protective relay, Relay time, Pick up, Reset current, current setting, Plug setting multiplier, Time setting multiplier. 3.3 Electromagnetic disc relay, Thermal relay, over voltage relay, Over current, Earth fault relay: Operation and its characteristics. 3.4 Static, Digital Relay (Microprocessor based): Block diagram, working, advantages and limitations. Numerical relay: Introduction 3.5 Voltage Monitoring relay (Under voltage and Over voltage) 3.6 Distance relaying- Principle 3.7 Directional relay: Need and operation with block diagram. 3.8 Current and Voltage differential relay: Operation	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO3

SECTION - II				
UNIT-IV Protection of Alternator and Transformer (CL Hrs-10, Marks-12)				
4	TLO 4.1 Explain the causes and remedies of the given faults in the specified machine. TLO 4.2 Explain with sketches the given protection schemes of the specified machine. TLO 4.3 Determine percentage of winding protected for the specified alternator TLO 4.4 Determine CT ratio of the specified transformer protection scheme.	**Alternator Protection** 4.1 Abnormalities and Faults occurring in alternator 4.2 Differential, Overcurrent , Earth fault Protection: Schemes **Transformer Protection** 4.3 Abnormalities and Faults occurring in transformer 4.4 Differential, over current, earth fault, over heating protection. 4.5 Buchholz relay: Construction, operation.	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO4
UNIT-V Protection of Motors, Bus-bar And Transmission Lines (CL Hrs-10, Marks-12)				
5	TLO 5.1 Explain the causes and remedies of the given faults in the specified machine. TLO 5.2 Explain with sketches the given protection schemes of the specified machine. TLO 5.3 Describe the causes and remedies of the given faults in the busbar TLO 5.4 Describe the causes and remedies of the given fault in transmission line	**Motor** 5.1 Abnormalities and Faults occurring in Motor 5.2 Short circuit protection, Overload protection, Single phase preventer. **Bus bar** **5.3** Abnormalities and Faults occurring in Bus bar 5.4 Bus bar protection: Differential and Fault bus protection. **Transmission line** 5.5 Abnormalities and Faults occurring in Transmission Line 5.6 Distance and Pilot wire protection	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO5
UNIT-VI Lightning Protection and Neutral earthing (CL Hrs – 10, Marks-11)				
6	TLO 6.1 Explain the formation of lightning phenomena & its effect on the transmission line TLO 6.2 Describe the procedure of protecting transmission line and substation using the given type of protection methods. TLO 6.3. Describe the constructional details of given types of lightning arrestors, its working & types TLO 6.4 Describe the protection scheme to protect transmission line from travelling waves TLO 6.5 Describe the procedure of given types of neutral earthing	6.1 Lighting phenomena and overvoltage due to lightning 6.2 Protection of transmission line and substation from direct stroke: Earthing screen, overhead earth wire, Lightning arrestor 6.3 Lightning arrestor Types: Expulsion type and Valve type 6.4 Protection against travelling waves. 6.5 Neutral Earthing: Introduction, importance and its types (Solid, Resistance, reactance) 6.6 Earthing transformer: Construction, working and application 6.7 Difference between equipment earthing and Neutral earthing	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO6

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory LearningOutcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Test protection system for the earth fault or short circuit fault.	*Simulation of Earth Fault/ Short Circuit fault for relay testing	02	CO1
2	LLO 2.1 Test the performance of HRC fuse. LLO 2.2 Validate the performance of HRC fuse by drawing the inverse time current characteristics.	*Testing of HRC Fuse.	02	CO2
3	LLO 3.1 Test the performance of MCB. LLO 3.2 Validate the performance of MCB by drawing the inverse time current characteristics.	*Testing of Miniature Circuit Breaker	02	CO2
4	LLO 4.1 Carry out plug and time setting (with PSM, TSM) of induction type electromagnetic relay.	*Plug Setting and Time setting Multiplier of Induction type relay.	02	CO3
5	LLO 5.1 Test Induction type over-current relay by performing load test.	*Characteristics of Induction type over-current relay.	02	CO3
6	LLO 6.1 Use Differential protection for protecting the Alternator.	*Demonstrate/ Simulate differential protection scheme for different types of faults on Alternator.	02	CO4
7	LLO 7.1 Use Differential protection for protecting the Transformer.	*Demonstrate/ Simulate differential protection scheme for different types of faults on Transformer.	02	CO4
8	LLO 8.1 Use Single Phase Preventer for protection of three-phase Induction Motor.	*Testing of single phase preventer for protecting three phase induction motor.	02	CO5
9	LLO 9.1 Use Overvoltage and Undervoltage conditions to operate microcontroller / Numerical relay	Testing the Overvoltage and Undervoltage conditions with the help of a microcontroller / Numerical relay	02	CO6
10	LLO 10.1 Use Overcurrent and Undercurrent conditions to operate microcontroller / Numerical relay	Testing the Overcurrent and Undercurrent conditions with the help of a microcontroller / Numerical relay	02	CO6
11	LLO 11.1 Select relevant protection Scheme for the given transmission line	*Demonstrate/Simulate transmission line protection by using the impedance/over current relay for various faults.	02	CO5

Sr. No	Practical/Tutorial/Laboratory LearningOutcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
12	LLO 12.1 Identify different parts of the Lightning Arrestor.	*Demonstration of Thyrite type lightning arrester using video /Dismantling the same.	02	CO6
13	LLO 13.1 Describe the step by step procedure to carry out Neutral Earthing.	Demonstrate process of carrying out neutral earthing at different substations / locations or with suitable media.	02	CO6
14	LLO 14.1 Test the Equipment earthing of the given equipment LLO 14.2 Test the Neutral earthing of the given circuit	Video shows on / performs practical on equipment earthing and Neutral earthing.	02	CO6

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed. Judicial mix of LLOs are to be performed to achieve desired outcomes.

VI SUGGESTED MICROPROJECT/ ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING ASSIGNMENT/)

Microproject: Teacher should give the topic on theory/lab contents

- Installation and commissioning of MCB / ELCB: Calculate load current and finalize the specifications of protection schemes for Electrical Engineering laboratory.
- Alternator/Transformer/Motor/Busbar and Transmission Line protection Relays: Prepare power point presentation on digital and multifunction protection relays used to protect feeder, motor , generator, busbar and Transmission line.
- IEC 61850 communication protocol : Prepare a power point presentation on communication protocol used to provide communication between different equipment located in a substation, such as protection, control, and measurement equipment, as well as (IEDs) intelligent electronic devices.
- Case study of past major grid power failure: Prepare a report after studying the previous power failure in India or abroad

VII. LABORATORYEQUIPMENT/INSTRUMENTS/TOOLS/SOFTWAREREQUIRED

Sr.No	EquipmentNamewithBroadSpecifications	Relevant LLO No
1	Fuses (5A), MCB(5A) , Connecting wires.	1
2	Earth tester 500 V, hand-driven or digital type.	13, 14
3	HRC Fuses:5A	2
4	MCB : 5A	3
5	Induction Overcurrent Relay : 10A or above	4
6	Alternator Differential Protection Scheme Simulation Kit	6
7	Transformer Differential Protection Scheme Simulation Kit.	7
8	Three phase induction motor with Single phase preventer: 3HP or above.	8
9	Transmission line protection simulation kit using impedance/over current relay.	10, 11
10	Thyrite type/ Metal oxide Type Lightning arrester.	9,12

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (SpecificationTable)

Sr.No	Unit	Unit Title	AlignedCOs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION - I								
1	I	Basics of protection	CO1	08	2	2	3	07
2	II	Circuit Interruption Devices	CO2	10	2	6	6	14
3	III	Protective Relays	CO3	12	2	6	6	14
SECTION - II								
4	IV	Protection of Alternator and Transformer	CO4	10	2	6	4	12
5	V	Protection of Motors, Bus-bar And Transmission Lines	CO5	10	2	6	4	12
6	VI	Lightning Protection and Neutral Earthing	CO6	10	2	5	4	11
Grand Total				**60**	**12**	**31**	**27**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessmentfor Learning)	Summative Assessment (Assessmentof Learning)
Two-unit tests of 30 marks will be conducted and an average of marks obtained in these two-unit tests will be considered.	End semester assessment of 70 marks through offline mode of examination. End sem practical exam will be conducted for 25 marks.

X. SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programm 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	PSO-3	PSO-4
CO1	**3**	**3**	**1**	**2**	**2**	**2**	**3**	**2**	**1**	**1**	**1**
CO2	**3**	**3**	**2**	**2**	3	**2**	**3**	**2**	**2**	**2**	**2**
CO3	**3**	**3**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**	**2**
CO4	**3**	**3**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**	**2**
CO5	**3**	**3**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**	**2**
CO6	**3**	**3**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**	**2**

Legends:- High:03, Medium:02, Low:01, No Mapping: --
***PSOs are to be formulated at the institute level**

XI . SUGGESTEDLEARNINGMATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Principles of Power System	Mehta V. K ; Rohit Mehta .	S.Chand and Co., New Delhi., 2016 ISBN: 978-81-2192-496-2.
2	Switchgear and Protection	Rao.Sunil S.	Khanna Publishers, New Delhi, 2015 ISBN: 978-81-7409-232-3.
3	Switchgear and Power System Protection	Singh, R. P.	PHI Learning, New Delhi,2015 ISBN: 978-81-203-3660-5.
4	Switchgear and Protection	Gupta. J. B.	S. K. Kataria and Sons, New Delhi, 2015 ISBN: 978-93-5014-372-8.
5	Switchgear and Protection	Veerapan, N., Krishnamurty, S. R.	S .Chand and Co., New Delhi. 2014 ISBN: 978-81-2193-212-7.
6	Power System Protection and Switchgear	Ram, Badri Vishwakarma D. N.	McGraw-Hill, New Delhi. 2015 ISBN : 978-07-107774-X

XII. LEARNINGWEBSITES& PORTALS

Sr.No	Link/Portal	Description
1	www.cgglobal.com	Different types of Switchgears
2	https://nptel.ac.in/courses/108101039	NPTEL course on Power System Protection (Fundamentals of Power System Protection, Fault Analysis, Overcurrent Protection, Directional Overcurrent Protection, Distance Protection, Numerical Relay Fundamentals, Differential Protection of Busbar, Transformer and Generator)
3	https://www.elecspare.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgear
4	www.abb.co.in/ProductGuide/	Different types of Switchgears, Ring Main Unit (RMU) Switchgears, Relays.
Note: Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before used by the students		

Name &Signature:	
Shri. R B Chautmal Lecturer in Electrical Engineering (Course Expert)	**Smt.T.J.Bhangale** Lecturer in Electrical Engineering (Course Expert)
Name & Signature: **Mr.R.U.Shelke** **Dr.S.V.Bhangale** (Programme Head)	Name & Signature: **Shri.S.B.Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120-NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**TESTING AND MAINTENANCE OF ELECTRICAL EQUIPMENT**
COURSE CODE	**EE41206**
PREREQUISITE COURSE CODE AND TITLE	**EE31205-DC MACHINES AND TRANSFORMERS**
CLASS DECLARTION COURSE	**YES**

I. LEARNING AND ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE41206	TESING AND MAINTENANCE OF ELECTRICAL EQUIPMENT	DSC	04	00	02	02	08	04	03Hr	30	70	100	40	--	--	25#	10	25	10	150

Total IKS Hrs for Term: 0 Hrs
Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**-Self Learning Assessment
Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination
Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.

6.* Self-learning includes micro-projects/assignments/other activities.

II.RATIONALE:

Application of knowledge is an ultimate aim of education. In industry the technicians are required to install, commission, maintain and test different types of electrical equipment and perform all this by following all the industrial safety precautions. After studying this course, a student will be able to inspect/test/trouble shoot electrical machines. Also carry out routine/preventive & breakdown maintenance.

III.COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1: Test stationary and rotating electrical machines as per IS code.
CO2: Use various tools to install electrical equipment as per IS code.
CO3: Schedule & carryout the (routine & preventive) maintenance of electrical equipment.
CO4: Measure and maintain insulation resistance using various methods.
CO5: Locate the fault and identify the cause of trouble in electrical machines.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mappedwith TLO's	Suggested Learning Pedagogies	Relevant COs
	SECTION - I			
	UNIT - I TESTING OF TRANSFORMERS (CL Hrs - 12, Marks –15)			
1	TLO 1.1 State the objectives of testing. TLO1.2 Explain the significance of Indian Standards and role of BIS in testing of electrical equipment. TLO 1.3 State and explain the types and methods of testing TLO 1.4 Define tolerance for electrical equipment. State the permissible limits of tolerance for various quantities during testing of equipment as per IS TLO 1.5 List out various tests performed on transformer as per Indian Standards Explain specific test in detail (with neat diagram) TLO 1.6 Numerical on above topics	1.1 Objectives of testing 1.2 Significance of Indian Standards Rules of Bureau of Indian Standards (BIS) in testing of electrical equipment. 1.3 Types of tests: Routine test ,Type test , Supplementary test & Special tests. **Methods of testing:** a) Direct b) Indirect c) Regenerative 1.4 Define Tolerance. Limits of Tolerance for following quantities w. r. t. rotating machines and transformers for: a) Voltage b) Current c) Frequency d) Noise as per Indian Standards. 1.5 Testing of transformer as per IS 2026 (Part-I)-2011 **A. Routine tests**: a) Measurement of winding resistance b) Voltage ratio test c) Polarity test d) Phasing out test (only for 3-phase transformer) e) Measurement of no load loss& current f) Measurement of impedance voltage, s.c impedance & load losses g) Measurement of Insulation resistance h) Dielectric test/High voltage test **B. Type tests** : All above (a to h and also) i) Temperature rise test j) Impulse voltage withstand test **C. Special tests:** a) Dielectric test b) Measurement of zero sequence (3 phase transformer) c)Measurement of harmonics of no load current d)Measurement of acoustic noise level **D. Supplementary tests**: a) back to back test b) Load test or efficiency test 1.6 Numerical on Testing of Transformer for a) O.C. test and S.C. test b) Back to back test c) Winding resistance	Presentation Chalk and board lectures Tutorial Assignment Demonstration	**CO1**

UNIT - II TESTING OF ROTATING ELECTRICAL MACHINES (CL Hrs - 08, Marks –10)				
2	TLO 2.1 State and explain in detail various tests carried out on three phase Induction motor as per Indian Standards Explain specific test in detail (with neat diagram) TLO 2.2 State and explain in detail various tests carried out on single-phase Induction motor as per Indian Standards TLO 2.3 Tests before installation of electrical equipment TLO 2.4 Numerical on above topics.	2.1 Testing of three-phase Induction motor as per IS 4029 : – 2010 and IS 325 – 1996 A. **A. Routine tests**: a) Measurement of DC resistance b) Measurement of Insulation resistance c) Dielectric test / H.V. test d) Reduced voltage running up test e)Open circuit voltage ratio test (only for slip ring I.M.) f) No load test or O.C. test g)Blocked rotor test or S.C. test h) Measurement of slip **B. Type tests**: All above (a to h and also) i) Temperature rise test j) Momentary overload test **C. Special tests:** Load test on 3-phase I.M. by i) Using calibrated generator ii) Brake test (using spring pulley arrangement) 2.2 Testing of single-phase induction motor as per IS 7572- 2009. **A. Routine tests**: a) Measurement of DC resistance b) Measurement of Insulation resistance c) High voltage test d) Quiet running test e) No load test f) Blocked rotor test **B. Type tests :** a) Load test b) Temperature rise test c) Momentary overload test d) Moisture proofness test e) Pullout torque test f) Leakage current test 2.3 Mechanical & Electrical tests before installation of electrical equipment. (For Transformer & Rotating machines) 2.4 Numerical on Testing of 3-phase I. M. for a) Measurement of winding resistance b) Brake test c) Load test with calibrated generator.	Presentation Chalk and board lectures Tutorial Assignment Demonstration	**CO1**
UNIT - III INSTALLATION OF ELECTRICAL EQUIPMENT (CL Hrs – 10, Marks- 10)				
2	TLO 3.1 Describe the stepwise procedure for Installation of static and rotating electrical machines. TLO 3.2. Use the devices and tools for handling of electrical	3.1 Standard procedure for installation of various electrical machines a) Inspection of equipment/machine on arrival at site and before installation. b) Preparation of technical report for above situation. 3.2 Tools / equipment required for installation during		**CO 2**

	equipment TLO 3.3 State various safety precautions to be followed while handling the equipment. TLO 3.4 Specify the requirements of foundation for different electrical machines. **E**nlist various factors to be taken into consideration while doing foundation. TLO 3.5 Describe the stepwise procedure of Leveling & Alignment for installation of electrical equipment. TLO 3.6 Specify the requirements for installation of transformer, rotating electrical machines, overhead transmission lines and underground cables as per IS. TLO 3.7 Describe the importance of safety precaution while installation.	a) loading b)unloading c)lifting and d)carrying heavy electrical equipment/ machines. 3.3 Precautions to be taken while handling equipment/ machines. 3.4(a) Requirements of dimensions of foundation for static & rotating machines. 3.4(b) Factors to be taken in to account while designing machine foundations. 3.5(a) Procedure of leveling & aligning. 3.5(b) Alignment of direct coupled drive and belt & gear drives 3.6 (a) Installation of transformer (as per IS) for : a) indoor substation b) pole mounted substation. 3.6 (b) Installation of rotating electrical machines as per IS . 3.6(c) Installation of overhead transmission lines and underground cables. 3.7 Safety precautions & their importance while working on electrical installations.	Lectures using Chalk-Board Presentations Case Study Site/Industry Visit	
SECTION-II				
UNIT - IV MAINTENANCE OF ELECTRICAL MACHINES (CL Hrs-08, Marks-10)				
4	TLO 4.1 Explain the need of maintenance, types of maintenance, importance of routine and preventive maintenance. TLO 4.2 Stepwise procedure to develop preventive maintenance schedule. TLO 4.3 Enlist the factors affecting preventive maintenance schedule. TLO 4.4 Steps to be followed during breakdown maintenance TLO 4.5 Describe the safety precautions to be followed while doing maintenance. TLO 4.6 Prepare the Maintenance schedules for electrical equipment as per IS	4.1 Need of maintenance. a) Types of maintenance:-Routine, Preventive & Breakdown maintenance. b) Causes of failure of electrical machines. c) Preventive maintenance:- Meaning, Importance and advantages of preventive maintenance. 4.2 Procedure for developing preventive maintenance schedules for electrical machines. 4.3 Factors affecting preventive maintenance schedule of an electrical equipment. 4.4 Breakdown maintenance and its record keeping. 4.5 Safety rules applicable for preventive maintenance and breakdown maintenance 4.6 Maintenance schedules of the following as per I.S. 1. Distribution transformer and Power	Lecture Using Chalk-Board Presentations Case Study Site/Industry Visit	**CO3**

		transformer as per IS 10028 (Part-III)-1981 2. Single phase & Three phase Induction motors as per IS 900-1992 . 3. 3-phase Synchronous generator or 3-phase alternator 4.7 Maintenance of outdoor unit		
UNIT -V TESTING AND MAINTENANCE OF INSULATION (CL Hrs-08, Marks-10)				
5	TLO 5.1 State the importance & qualities of insulating materials in electrical equipment. TLO 5.2 Classify insulating materials on basis of temperature withstanding limits. TLO 5.3 State & explain the factors affecting life of insulating materials. State various electrical & thermal properties of insulation oil. TLO 5.4 Describe the methods to measure insulation resistance & interpret the condition of insulation. TLO 5.5 Explain the methods of reconditioning of insulation TLO 5.6 State & explain various Properties of good insulating oil TLO 5.7 Describe the agents contaminating the insulating oil. TLO 5.8 Describe various methods used for testing of insulating oil as per IS TLO 5.9 Describe various methods used for purification of insulation oil.	5.1 Importance of insulation in electrical equipment & machines. 5.2 Classification of insulating materials as per I.S.8504 (part III) 1994. 5.3(a) Various Factors affecting life of insulating materials. 5.3(b) Electrical & thermal properties of insulating oil. 5.4(a) Measurement of insulation resistance by different methods : i) Polarization Index, ii) Dielectric absorption, iii) Megger 5.4(b)Interpretation of condition of insulation 5.4(c) Meaning of infinity and zero reading 5.5 Reconditioning of insulation by a. Cleaning of the insulation. b. Drying of electrical insulation. c. Re-varnishing & it's different methods. d. Construction & working of vacuum impregnation plant 5.6 Properties of good insulating oil (transformer oil) 5.7 Various agents which contaminate the insulating oil. 5.8 Testing of insulation oil as per IS 1866-2000 a) Acidity test b) Sludge test c) Crackle test d) Flash point test. e) Dielectric strength test. 5.9 Methods of purification and filtration of insulating oil a) Centrifugal purifier b) Stream line filter or vacuum type	Presentations Lecture Using Chalk-Board, Case Study Site/Industry Visit	**CO4**

UNIT – VI FAULT FINDING AND TROUBLE SHOOTING (CL Hrs-14, Marks-15)				
6	TLO 6.1 State the conditions for normal working of electrical equipment. TLO 6.2 Describe the permissible limits electrical parameters for safe working of electrical machines. TLO 6.3 Describe the effect of variation of various parameters on working of specific equipment/machine. TLO 6.4 State the causes of faults. List different types of faults and Locate faults in electrical machines. TLO 6.5 Define and state the significance of trouble shooting. TLO 6.6 Describe the use of various tools during fault finding in electrical machines. TLO 6.7 Prepare the trouble shooting charts for rotating machines and transformers.	6.1 Normal working of electrical equipment. 6.2 Permissible limits for safe working of electrical machines w.r.t following parameters: a) voltage b) frequency c) current d) speed. 6.3 Effect of variations of above parameters on performance of a) 3-phase transformer b) 3-phase I.M. c) DC motor 6.4(a) Causes of faults and types of faults 6.4(b) Mechanical faults, Electrical faults & Magnetic faults in the electrical equipment 6.4(c) Detail procedure to find/locate the faults in electrical machines. 6.5. Trouble shooting: need & significance 6.6 Tools and equipment used during trouble shooting and repairs:- a) Bearing puller, b)Filler gauges, c)Dial test indicator, d) Spirit level, e)Megger, f)Earth tester, g) Growler. 6.7(a) Various common troubles in electrical equipment. 6.7(b) Trouble shooting charts for following electrical equipment and machines. 1) D.C. Motor 2) 1-phase & 3-phase I.M. 3) 1-phase & 3-phase Transformer 4) Underground cables.	Presentations Lectures Using Chalk-Board Case Study Site/Industry Visit	**CO5**

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIALEXPERIENCES.

Sr. No.	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/Practical Titles/Tutorial Titles	Number of Hrs.	Relevant COs
1	LLO 1 Test the insulation condition of single-phase induction motor	Measurement of winding resistance of a single-phase induction motor by D.C. V-I method before and after no load running.	02	CO1
2	LLO 2 Test the three phase induction motor before commissioning.	Reduced voltage running up test of three phase induction motor	02	CO1
3	LLO 3 Test the insulation condition of three phase induction motor.	Measurement of winding resistance (any one phase) of a three-phase induction motor by D.C. V-I method before and after conducting brake test.	02	CO1
4	LLO 4 Test the insulation condition of three phase induction motor.	Measurement of winding resistance (any one phase) of a three-phase induction motor by D.C. V-I method before and after no load running.	02	CO1
5	LLO 5 Identify primary and relevant secondary windings of transformer.	Phasing out test of the three-phase transformer.	02	CO1

6	LLO 6 Identify the polarity of transformer windings.	Polarity test of three phase transformer.	02	CO1
7*	LLO 7 Apply regenerative method of testing	Back-to-Back test on two identical single-phase transformers.	02	CO1
8*	LLO 8.1 Use tools/accessories applicable in the process. LLO 8.2 Identify the parts of a given motor.	Dismantle and reassemble the given electrical machine and identify the various parts.	02	CO2
9	LLO 9 Use testing instrument for testing electrical equipment.	Use of instruments for testing/maintenance of given electrical equipment.	02	CO3
10	LLO 10 Maintain the given induction motor.	Carryout maintenance activities suggested in IS: 900- 1992(Annex G) at 5.6,7 and 8 for maintenance of induction motors.	02	CO3
11*	LLO 11 Maintain the given transformers.	Carryout maintenance activities suggested in IS: 10028- part 3 at 1,2,3 and 4for maintenance of transformer.	02	CO3
12*	LLO 12 Test the dielectric strength of transformer oil	Dielectric strength test of transformer oil.	02	CO4
13	LLO 13 Test insulation resistance and dielectric strength of the windings of three-phase/ single – phase induction motor.	Insulation resistance and dielectric strength of the windings in a three-phase/ single phase induction motor by subjecting the motor to high-voltage conditions. ensuring that the motor can withstand operational voltage without insulation failure.	02	CO4
14	LLO 14 Measure insulation resistance of single-phase / three phase induction motor	Measurement of insulation resistance of single-phase / three phase induction motor.	02	CO4
15	LLO 15 Measure insulation resistance of single phase / three phase transformer.	Measurement of insulation resistance of single-phase / three phase transformer.	02	CO4
16*	LLO 16.1 Identify the parts of single-phase induction motor. LLO 16.2 Rectify the basic faults in given single phase induction motor	Ceiling fan available in the laboratory running slow. Diagnose the problem and rectify it.	02	CO5
17	LLO 17.1 Identify the parts of single-phase induction motor. LLO 17.2 Rectify the basic faults in given single phase induction motor.	Ceiling fan available in the laboratory running in reverse direction. Diagnose the problem and rectify it.	02	CO5

Note: Out of the above suggestive LLOs perform any 12.

- '*' Marked Practical (LLOs) Are mandatory.
- A minimum of 80% of the above list of lab experiments are to be performed. Judicial mix of LLOs is to be performed to achieve desired outcomes.
- A2 size drawing sheet should be used for drawing work.

VI. SUGGESTED MICRO-PROJECTS / ASSIGNMENTS/ ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF LEARNING)

Micro project:

- Arrange Demonstration of Fire extinguisher available in the institute.
- Arrange Demonstration of artificial respiration technique after electrocution
- Measurement of earth resistance of electrical laboratory equipment.
- Identify protective class of a given electric equipment.
- Visit BIS portal (bis.gov.in) and prepare a report on obtaining a license / ISI code.

Assignment:

1) Troubleshoot the electrical motors available in the institute / for given condition.
2) Numerical to calculate various parameters of given electrical equipment

Note : The above is just a suggestive list of microprojects and assignments; faculty must prepare their bank of microprojects, assignments, and activities similarly.

- The faculty must allocate a judicial mix of tasks, considering the weaknesses and/or strengths of the student in acquiring the desired skills.
- If a micro project is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- If the course does not have an associated SLA component, the above suggestive listings apply to Tutorials and may be considered for FA-PR evaluations.

VII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	400V/230V, 50 Hz, 3-phase transformer with all phase winding terminals brought out for connections (suitable output in range of 2 kVA to 4 kVA).	11
2	Ceiling fan	16,17
3	AC-DC Ammeter range (0-2.5-5-10A).	2,3,4
4	AC-DC Voltmeter Range (0-75/150/300V, 0-300V/600 V)	2,3,4
5	Single phase auto transformer 0-270 V, 15 A, input single phase, 230 V.	5,6,7
6	Three phase auto transformer 0-450 V, 15 A, input 3 phase, 400 V.	5,6,7
7	At least two identical 230 V/115 V or 400 V/ 230 V 50 Hz, 1 or 2 kVA single phase transformers.	6
8	Dielectric oil testing kit (with input at 230 V).	12
9	HV test kits for motors up-to 400 V.	13
10	230 V, 50 Hz, single phase capacitor start cage type induction motor (suitable available HP)	8,10
11	3-phase 5 HP, 400 V, 50 Hz, 1500 RPM squirrel cage induction motor with brake load arrangement as required.	8,10
12	Bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers	9
13	3-phase 400V, 50 Hz, 1500 RPM slip ring induction motor about 5 HP.	10
14	Tachometers 0-5000 RPM minimum.	10,13,16,17
15	A.C. Watt meters: 0-300/600 V, 5/10 A or 10/20 A as needed.	10,13,16,17
16	LPF Wattmeter, 0-300/600 V, 1A to 2A.	10,13,16,17

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION – I								
1	I	TESTING OF TRANSFORMERS	CO1	12	4	6	5	15
2	II	TESTING OF ROATING ELECTRICAL MACHINES	CO1	08	2	4	4	10
3	III	INSTALLATION OF ELECTRICAL EQUIPMENT	CO2	10	2	4	4	10
SECTION – II								
4	IV	MAINTENANCE OF ELECTRICAL MACHINES	CO3	08	2	4	4	10
5	V	TESTING AND MAINTENANCE OF INSULATION	CO4	08	2	4	4	10
6	VI	FAULT FINDING AND TROUBLE SHOOTING	CO5	14	4	6	5	15
TOTAL				60	16	28	26	70

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two-unit tests of 30 marks will be conducted and an average of marks obtained in these two-unit tests will be considered.	End semester assessment of 70 marks through offline mode of examination. End sem practical exam will be conducted for 25 marks.

X. SUGGESTED COS- POs –PSOs MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programm 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	PSO-3	PSO-4
CO1	3	3	3	3	3	2	3	3	-	2	3
CO2	3	2	3	3	3	2	3	3	-	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	2	2	2	2	3	3	-	2	3
CO5	3	3	3	3	2	2	3	3	3	3	3

Legends:- High:03, Medium:02, Low:01, No Mapping: --
***PSOs are to be formulated at the institute level**

XI. SUGGESTED LEARNING MATERIALS / BOOKS:

Sr. No.	AUTHOR	TITLE	PUBLISHER
1	Bhattacharya S.K.	Electrical machines	Publisher McGraw Hill Education, ISBN-10. 9332902852 · ISBN-13. 978-933290285
2	Thereja B.L	Electrical Technology (Volume II)	S. Chand Publication, ISBN 9789355018250
3	Madhavi Gupta	Installation Maintenance and Repair of Electrical Machines and Equipment	S.K. Kataria & Sons, ISBN 978-93-5014-546-3
4	S. Rao	Testing, Commissioning, Operation and Maintenance of Electrical Equipment	Khanna Publications ISBN: 978-81-7409-185-7
5	Bandopadhyay M.N.	Electrical Machine theory & Practices	PHI Learning Pvt. Ltd, New Delhi, ISBN : 9788120329973 Vi
6	Jean-Claude Trigeassous	Electrical Machine Diagnosis	John Wiley & Sons , Inc ISBN : 978-1-84821-263-3

XII. LEARNING WEBSITES & PORTALS

S.N.	Link/Portal	Description
1	https://www.youtube.com/watch?v=w4jHpHoYZhk	How to Use a Fire Extinguisher
2	https://www.youtube.com/watch?v=wrawEAaJrrY	Artificial respiration methods
3	https://www.youtube.com/watch?v=CvuDFgFFOa8	Fundamentals of Transformer Commissioning, Testing and Maintenance
4	https://www.youtube.com/watch?v=ntOc4h792UE	Motor Maintenance & Troubleshooting
5	https://www.youtube.com/watch?v=uMxK6djp_rI	Electric Motor Repair & Rebuild Instructions
6	https://youtu.be/JvsPnGbUH5M	power transformer oil filtration and treatment
7	https://nptel.ac.in/	Relevant information from NPTEL
8	https://www.wikipedia.com	Relevant information

** Note : Teacher must check the copyright policy before giving the link to students.

Name & Signature:

Smt. Sujala Parimal Phadnaik
Lecturer in Electrical Engineering

Shri. Ravi B. Chauthmal
Lecturer in Electrical Engineering

(Course Experts)

Name & Signature:

Mr. R.U. Shelke
(Programme Head)

Dr.S.V.Bhangale

Name & Signature:

Shri. S. B. Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**ENERGY CONSERVATION AND AUDIT**
COURSE CODE	**EE51203**
PREREQUISITE COURSE CODE & TITLE	**EE41203 DISTRIBUTION AND UTILIZATION OF ELECTRICAL ENERGY**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE51203	ENERGY CONSERVATION AND AUDIT	DSE	3	0	2	1	6	3	3 Hr	30	70	100	40	25	10	--	--	25	10	150

Total IKS Hrs for Term: 00 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment
Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination

Note:
FA-TH represents an average of two class tests of 30 marks each conducted during the semester.
1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:
The world is facing a significant challenge in meeting the increasing demand for electrical energy due to rapid industrialization, urbanization, and population growth. With the depletion of fossil fuels at an alarming rate, it has become essential to focus on energy conservation. One unit of saved electricity is equivalent to two units of generated electricity. Conserving energy is a responsibility that every citizen must take seriously.

III. COURSE-LEVEL LEARNING OUTCOMES(CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1 - Interpret energy conservation policies in India.
CO2 - Apply different energy conservation techniques in electrical machines.
CO3- Apply different energy conservation techniques in electrical installations.
CO4 – Utilize different energy conservation techniques in electrical Power Systems
CO5 - Use appropriate energy conservation equipment and relevant tariff for reducing losses in facilities.
CO6 - Perform energy audit for electrical installation system.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes(TLO'S) alignedtoCO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION I			
	UNIT -I BASICS OF ENERGY CONSERVATION AND MANAGEMENT (CL –6 HRS, MARKS-08)			
1.	TLO 1.1 Explain the current energy scenario of conventional and non-conventional energy sources in India. TLO 1.2 Differentiate between energy management, energy efficiency, energy conservation and energy audit. TLO 1.3 Describe the objectives and salient features of Energy conservation act 2001. TLO 1.4 Describe the role of BEE, MEDA and MNRE. TLO 1.5 Interpret the Star Labeling of the given electrical equipment. TLO 1.6 Explain the Concept of energy conservation and its benefits. TLO 1.7 Describe the key features of ECBC and green buildings.	1.1 Indian Energy Scenario General energy problem, Sector wise Energy consumption, demand supply gap. 1.2 Energy conservation: Objectives of energy Conservation, its benefits & strategies and scope for energy conservation 1.3 Energy conservation act 2001: Objectives and salient features. 1.4 Role of Bureau of Energy Eficiency (BEE), Maharashtrra Energy Development Agency (MEDA) and Ministry of new and Renewable Energy(MNRE) 1.5 Star labeling: Need, significance and benefits. 1.6 Concept of energy conservation and benefits. 1.7 Energy Conservation Building Codes (ECBC) with latest revision, concept of green buildings.	Lecture Using Chalk-Board , Video Demonstrations ,Flipped Classroom, Case Study, Collaborative learning, Presentations	CO1
	UNIT-II ENERGY CONSERVATION IN ELECTRICAL MACHINES (CL – 10 HRS MARKS- 18)			
2	TLO 2.1 Justify the need and significance of energy conservation in induction motor and transformer.	2.1 Need and significance of energy conservation in induction motor and transformer.		CO2

Sr. No	Theory Learning Outcomes(TLO'S) alignedtoCO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 2.2 Enlist the energy conservation techniques for a given three phase induction motor. TLO 2.3 Describe the energy conservation techniques for a given Transformer. TLO 2.4 Differentiate between energy efficient motor and standard motor TLO 2.5 Compare energy efficient transformer with standard transformer. TLO 2.6 Select the energy conservation techniques in compressors pumps, fans and blowers. TLO 2.7 Explain energy saving techniques in EVs and batteries.	2.2 Energy conservation techniques in induction motor by: Improving power quality, motor survey, matching motor with loading, minimizing the idle and redundant running of motor, operating in star mode, rewinding of motor, replacement by energy efficient motor, periodic maintenance by using sensor based motors. 2.3 Energy conservation techniques in transformer: Load sharing, parallel operation, isolating techniques, replacement by energy efficient transformers, use of static capacitors in transformers, periodic maintenance. 2.4 Energy efficient motor: Key features, merits, demerits, comparison with standard motor. 2.5 Energy efficient transformers: Amorphous transformers, epoxy resin-cast transformer and dry-type of transformer. 2.6 Methods and techniques of energy conservation in compressors pumps, fans and blowers. 2.7 Energy conservation techniques in electric vehicles and batteries.	Lecture Using Chalk-Board , Video Demonstrations , Flipped Classroom, Case Study, Collaborative learning, Presentations	
UNIT-III ENERGY CONSERVATION IN THERMAL UTILITY (CL – 04 HRS, MARKS- 09)				
	TLO 3.1 Explain the energy conservation techniques for specified thermal systems. TLO 3.2 Describe the energy conservation techniques for specified lighting systems	3.1 Energy Conservation in Thermal systems: Fuels and combustion, properties of Fuel Oil, coal and gas, storage and handling of fuels, principles of combustion, combustion of oil, coal, gas 3.2 Energy efficiency in Boilers, Steam systems, Furnaces, Insulation and Refractors. 3.3 Energy Conservation in Lighting systems: Replacing Lamp sources, using energy efficient luminaries, using light controlled gears,	Lecture Using Chalk-Board , Video Demonstrations , Flipped Classroom, Case Study, Collaborative learning, Presentations	CO3

Sr. No	Theory Learning Outcomes(TLO'S) alignedtoCO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		Installation of separate transformer /servo stabilizer for lighting, use of sensors-motion, occupancy, proximity, color, photo sensitive sensors,Periodic survey and adequate maintenance programs.		
		SECTION II		
UNIT-IV ENERGY CONSERVATION IN TRANSMISSION AND DISTRIBUTION SYSTEMS (CL – 10HRS MARKS- 11)				
4.	4.1 State the methods of energyconservation in the specified portion of generation system. 4.2 Explain the causes of the given type of losses in the transmission and distribution systems. 4.3 Explain the methods to reduce the specified technical & commercial losses in power system. 4.4 Calulate the losses in the given power system. 4.5 Explain the need for cogeneration in the given situation/type of utility. 4.6 Select the co-generation system for the given facility. 4.7. Enlist the advantages of the given type of co-generation system.	4.1 Scenario of transmission and distribution losses at state level, national level and at global level , Classification of Transmission & Distribution losses. 4.2 Causes of technical & commercial losses. 4.3 Methods of energy conservation in transmission & distribution system on the basis of following points- i) Reducing I^2R losses ii) Compensating reactive power. iii) Improving p.f. of utility & consumers. iv) Optimizing distribution voltage. v) Balancing phase currents. vi) Energy conservation techniques related to commercial losses 4.4 Co-generation and its types on on basis of sequence of energy use : Definition , Need of co-generation, topping cycle & bottoming cycle. 4.5 Types of cogeneration on the basis of technology:Steam turbine cogeneration, Gas turbine Cogeneration, reciprocating engine cogeneration. 4.6 Advantages of co-generation 4.7Performance improvement of existing power station by a).Optimization of load, b)Optimal distribution of load among different units. c)Periodical maintenance.	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO4

Sr. No	Theory Learning Outcomes(TLO'S) alignedtoCO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	4.8 Identify the objectives for the Supply side management for the given utility. 4.9 Explain the suitability of the Demand side management for the given situation.	d)Using renewable energy source e)Increasing the capacity by adopting technology f)Implementing supply-side management g)Adopting use of co-generation & DG set 4.8 Supply side management: Need and Objectives 4.9 Demand-side management: Defination, Objectives ,Advantages of demand side management to consumers, enterprises, utilities,society, globe & environment.		
UNIT-V ENERGY CONSERVATION EQUIPMENT AND TARIFF (CL –10 HRS, MARKS- 14)				
5.	TLO 5.1 Describe the key features and working of a given energy conservation equipment. TLO 5.2 Select the relevant energy conservation equipment for the given system with justification TLO 5.3 Select the appropriate analytical tools to assess the financial and economic viability of a proposed investment for the given energy conservation project. TLO 5.4 Select appropriate tarriff structure to reduce energy bill. TLO 5.5 Describe the suitable tariff system for reducing the electricity bill of a given facility. TLO 5.6 Compare two different tariff structure illustrating electrical energy conserved in a given facility. TLO 5.7 Describe the recent tariff structure given facility	5.1 Energy conservation equipment- key features and working of: Soft starters, Automatic star delta convertor, Variable Frequency Drives (VFD). 5.2Energy conservation equipment: Maximum Demand Controller, kVAR Controller, Capacitor bank, Automatic Power Factor controller (APFC), Intelligent Power Factor Controller (IPFC) and Active Harmonic Filters (AHF). 5.3 Energy Conservation Project: Definitions, formula ,selection criterion, simple numerical, advantages, limitations of analytical tools required. 5.4 Tariff: Concept from the point of view of energy conservation, Types of tariff structure: LT, HT,Special, Time-off-day, Peak-off-day, Availability Based Tariff (ABT), kVAh tariff, Concept of flexible tariff, Advanced tariff 5.5 Application of tariff system to reduce energy bill (Numerical). 5.6 Recent tariff structure of different utilities.	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO5

Sr. No	Theory Learning Outcomes(TLO'S) alignedtoCO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	UNIT-VI ENERGY AUDIT	**(CL – 05 HRS, MARKS-10)**		
6	TLO 6.1 Define energy audit and list the objectives. TLO 6.2 Describe the types of energy audit. TLO 6.3 Select relevant instrument (s) for the specified energy audit with justification. TLO 6.4 Design the questionnaire for energy audit of the given facility. TLO 6.5 Design the energy flow diagram of the given facility/ apparatus. TLO 6.6 Evaluate the Simple Pay Back period, IRR for the facility created. TLO 6.7 Describe energy audit procedure followed in industries TLO 6.8 Prepare the energy audit report for the given facility/ apparatus. TLO 6.9 Explain the roles and responsibilities of energy manager and auditor.	6.1Energy audit- Definition & objectives. 6.2 Types of energy audit: walk-through audit and Detailed audit-objectives & procedure. 6.3 Energy audit instruments & their use: Electrical measuring instruments, power analyzer, lux meter, smart energy meter, fuel efficiency monitor, combustion gas analyzer, thermometer, flow meter and tachometer 6.4 Questionnaire for energy audit projects 6.5 Energy flow diagram or Sankey diagram. 6.6 Simple payback period, Internal Rate of Return (IRR) (Numerical) 6.7 Roles & responsibilities of energy manager and energy auditor. 6.8 Numerical on calculation of Simple payback period, Internal Rate of Return (IRR) (Numerical). 6.9 Energy Audit Procedure and Enery Audit report format used in industries, power quality audit.	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO6

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL /TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome (LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number of hrs.	Relevant COs
1	LLO 1.1 Calculate the energy saving in ceiling fans using different regulators.	Calculate the energy saving in ceiling fan(using conventional regualtor and Electronic regulators) 1. Conventional fan 2. Star rating (BLDC) fans	02	CO1
2	LLO 2.1 Identify star labelled appliances and compare them for various star ratings. LLO 2.2 Compare the data sheet of various star rating appliances.	Collect star labelled electrical appliances/equipment and compare data sheets of various star labelled ratings.	02	CO1

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome (LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number of hrs.	Relevant COs
3	LLO 3.1 Perform an experiment on three phase induction motor both in star and delta mode. LLO 3.2 Measure the effect of voltage reduction in power consumption.	Determination of reduction in power consumption in star mode operation of 3 phase Induction motor compared to delta mode.	02	CO2
4	LLO 4.1 Perform load test on three phase induction motor for different loading conditions. LLO 4.2 Plot the graph of efficiency verses percentage loading of induction motor.	Performance of load test on three phase induction motor for different loading conditions and check the energy consumption.	02	CO2
5	LLO 5.1 Improve power factor of given load using APFC. LLO 5.2 Use APFC for improving power factor.	Improve Power factor in Induction Motor using APFC.	02	CO3 CO5
6	LLO 6.1 Improve power factor of given load using static capacitor. LLO 6.2 Calculate the value of capacitor to change from initial power factor to desired power factor.	Improve Power factor using static capacitor.	02	CO4 CO5
7	LLO 7.1 Compare power consumption of different types of Tube Light with choke, electronic ballast and LED lamps by direct measurement.	Comparison of power consumption of different types of Tube Light with choke, electronic ballast and LED lamps by direct measurement.	02	CO5
8	LLO 8.1 Determine the reduction in power consumption by replacement of different lamps in a classroom / laboratory by energy efficient lamps.	Comparison of reduction in power by replacement of lamps in a classroom / laboratory by energy efficient lamps.	02	CO5
9	LLO 9.1 Suggest suitable tariff for energy conservation and reduction of energy bill for an industrial customer. LLO 9.2 Interpreting electricity bill of an industrial consumer.	Tariff for industrial consumer for reducing the kVAh electricity bill.	02	CO5
10	LLO 10.1 Suggest suitable tariff for energy conservation and reduction of energy bill for a commercial customer. LLO 12.2 Interpreting electricity bill of a commercial customer.	Tariff for commercial consumer for reducing the electricity bill.	02	CO5
11	LLO 11.1 Suggest suitable tariff for energy conservation and reduction of energy bill for a residential customer. LLO 11.2 Interpreting electricity bill of a residential customer.	Tariff for residential consumer for reducing the electricity bill.	02	CO5
12	LLO 12.1 Prepare a sample energy audit questionnaire for a given facility.	Preparation of Energy audit questionnaire for the given facility.	02	CO6

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome (LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number of hrs.	Relevant COs
13	LLO 13.1 Prepare energy audit report of your electrical department.	Preparation of Energy audit report of electrical department.	02	CO6

VI. SUGGESTED MICRO PROJECT/ ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING ASSIGNMENT/)

- **Microproject:**

1.Energy efficient lamps:Prepare comparative charts with ratings, cost and manufacturer details.
2.Energy conservation campaign: Prepare charts/slogans to create energy conservation awareness in polytechnic
3.Energy efficient electrical machines: Prepare technical presentation on details of energy efficient transformers& motors
4.Energy conservation policies. Prepare report on energy conservation policies of Govt. Maharashtra 2017
5.Energy Manager and Energy Auditor: Identify from available resources their roles and responsibilities.

- **Assignment**

1.Visit a facility adopting cogeneration system and prepare a presentation.
2.Estimate the payback period, depreciation cost, for the given energy saving equipment in the transmission and distribution system.
3.Prepare a report on maintenance procedure followed for improving efficiency of a given lighting scheme. 4.Collect information about energy efficient luminaries and prepare a report on it.
5.Write report on performance of motor after rewinding.
6.Compile the energy saved in at least five star labeled various appliances and prepare a report. 7.Prepare a report on various star labeled equipment.
8.Compare the energy conserved by an energy efficient motor with a standard motor and prepare a report.

VII. LABORATORY EQUIPMENT / INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	EquipmentNamewithBroadSpecifications	Relevant LLONumber
1	Lux meter	12,13
2	Soft starter/ DOL starter/ star delta starter.	3,4,5
3	Energy audit software such as SafetyCulture (formally iAuditor), EnergyCAP or any other equivalent open-source software.	12,13
4	Star delta convertor.	3
5	Induction motor: Single phase/three phase.	3,4
6	Clamp on ammeter.	3,4,5,7
7	Ammeter: MI type, AC/ DC 0-5-10Amp.	3,4,5,7

8	Voltmeter: MI type, AC/DC, 0-150/300V, 0-250/500V.	3,4,5,7
9	Wattmeter: Single phase/three phase, single element/double element, 2.5/5Amp - 5/10 Amp, 200/400V -250/500V.	3,4,5,7,9,10,11
10	Multi-function meter.	3,4,5,7,9,10,11
11	Single/ three phase power factor meters: AC, 415V, 50 Hz, 5-10 Amp.	5,6
12	Automatic power factor controller.	5
13	Low power factor wattmeter: Single phase, 5/10Amp, 250/500V.	5,6
14	Load bank.	5,6
15	Electronic choke, electronics ballast.	7,9
16	LED lamp/ tube.	7
17	Tube light (Fluorescent Tube/ CFL)	7

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

(SpecificationTable)

Sr.No	Unit	Unit Title	AlignedCOs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Energy Conservation and Management	CO1	06	4	4	0	08
2	II	Energy conservation in Electrical Machines	CO2	10	2	8	8	18
3	III	Energy Conservation in Thermal Utility	CO3	04	2	4	3	09
4	IV	Energy Conservation in Electrical Power Systems	CO4	10	4	3	4	11
5	V	Energy Conservation Equipment & Tariff	CO5	10	2	8	4	14
6	VI	Energy Audit	CO6	05	02	04	04	10
			TOTAL	**45**	**16**	**31**	**23**	**70**

IX. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessmentfor Learning)	Summative Assessment (Assessmentof Learning)
Two unit tests of 30 marks each will be conducted and the average of the two unit tests will be considered. For the formative assessment of laboratory learning, a total of 25 marks will be allocated. Each practical will be assessed based on the appropriate percentage weightage given to the process and the product, following the specified assessment guidelines and instructions.	The end-semester assessment will consist of a 70-mark offline examination.

X. SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programm 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	PSO-3	PSO-4
CO1	3	1	1	-	2	-	3	1	1	1	3
CO2	3	2	2	1	2	1	3	2	2	3	3
CO3	3	2	2	1	2	1	3	2	2	3	3
CO4	3	3	3	2	2	1	3	3	3	2	3
CO5	3	3	3	2	2	1	3	3	3	3	3
CO6	3	3	3	3	2	3	3	2	2	3	3

Legends:- High:03, Medium:02, Low:01, No Mapping: --
***PSOs are to be formulated at the institute level**

XI . SUGGESTED LEARNING MATERIALS /BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bureau of Energy Efficiency (BEE)	Guidebooks no. 1 to 4 for National Certification Examination for Energy Managers and Energy Auditors	Bureau of Energy Efficiency (A Statutory body under Ministry of Power, Government of India) (Fourth Edition 2015)
2	Dr. Sanjeev Singh, Dr. Umesh Rathore	Energy Management	S K Kataria & Sons, New Delhi. ISBN- 13: 9789350141014
3	V.K.Mehta and Rohit Mehta	Principles of Power System	S. Chand & Co. New Delhi, 2022, ISBN: 9789355010773
4	Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher Gautam	Energy Management Conservation and Audits	CRC Press, 2020, ISBN: 9780429325458
5	Stephan A. Roosa, Steve Doty, Wayne C. Turner	Energy Management Handbook	Fairmount Press, New York 2020 ISBN: 9781003151364
6	Murphy W.R.	Energy Management	Butterworth-Heinemann Publication, ISBN: 9788131207383.
7	K.V. Sharma, P. Venkataseshaiah.	Energy Management and Conservation	I K International Publishing House Pvt. Ltd; 2011 ISBN 9789381141298
8	Yogendra V. Talware.	Art of reading Electricity bills.	Dnyatavya Prakashan

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1	https://mnre.gov.in/	Information about new and renewable energy.
2	https://powermin.gov.in/	Indian power scenario.
3	https://aipnpc.org/Guidebooks.aspx	BEE guidebooks 01 to 04.
4	https://akshayurja.gov.in/res/renw-all-india-cp	Akshay Urja Ministry of New and Renewable Energy (MNRE)
5	https://www.mahaurja.com/meda/en/energy_conservation/energy_ conservation_program	Energy Conservation Schemes in Maharashtra state (MEDA)
6	https://www.eia.gov/totalenergy/	U S Energy information administration.
7	https://beeindia.gov.in/sites/default/files/ECBC%20User%20Gu ide%20V-0.2%20(Public).pdf	Energy Conservation Building Code User Guide.
8	https://iiec.org/	International Institute for Energy Conservation (IIEC)
9	https://cea.nic.in/	Central Electricity Authority

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

Name & Signature:

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(Course Expert)

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Name & Signature:

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Name & Signature:

Shri.S.B.Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**SPECIAL ELECTRICAL MACHINES**
COURSE CODE	**EE51204**
PREREQUISITE COURSE CODE & TITLE	**EE31205 DC MACHINES AND TRANSFORMERS**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE51204	SPECIAL ELECTRICAL MACHINES	DSE	3	0	2	1	6	3	3 Hr	30	70	100	40	25	10	--	--	25	10	150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Due to research and development the specialized electrical machines have been developed for specialized applications. They play an important role in industries such as production, processing, fabrications and renewable energy applications, etc. Some special electrical machines have higher efficiency, small size and useful for specific applications. This course refers to such machines which have not been considered in the earlier semesters. The most significant development in recent years in the allied area of motor control also plays an important role. Essential efforts are made in this course to familiarize the students with advanced technology in such machines which is a necessary to maintain them.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1 - Use Switched Reluctance Motor for various applications.

CO2- Use different types of servo motors for various applications.

CO3 - Use different types of Permanent magnet for various applications.

CO4 - Analyze the different types of PMBLDC motors.

CO5 - Use of stepper motor for industrial applications.

CO6 – Use of linear induction motor for industrial applications.

IV. THEORY LEARNING OUTCOMES AND ALLIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		SECTION I		
		UNIT-I SWITCHED RELUCTANCE MOTORS (SRM) (CL HRS. -10 MARKS- 15)		
1	LLO1.1Describe the Constructional details of Switched Reluctance Motor LLO1.2. Analyze the performance characteristics of Switched Reluctance Motor LLO1.3. Summarize the Basic Control Techniques for Switched Reluctance Motor	1.1 Switched Reluctance Motor (SRM) 1.2 Constructional features, Principle of operation, 1.3 Torque equation 1.4 Characteristics of SRM, Power Converter Circuits of SRM 1.5 Basic Drive – Concept, Control of SRM 1.6 Advantages & Disadvantages 1.7 Applications	Lecture Using Chalk-Board, Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO1
	UNIT-II SERVO MOTORS (CL HRS. -06 MARKS -10)			
2	LLO2.1 Describe the Constructional details and torque production in Servo Motor. LLO2. 2. Analyze the performance Characteristics of Servo Motor LLO2.3 Summarize the control Strategies and areas of applications of Servo Motor LLO2.4 State the applications of DC and AC servomotors	2.1 DC Servo motor- 2.1.1 Construction 2.1.2 Working principle 2.1.3 Operation 2.1.4 Schematic diagram 2.1.5 Torque-Speed characteristics 2.1.6 Advantages and disadvantages 2.1.7 Applications 2.2 AC Servo motor- 2.2.1 Construction 2.2.2 Working principle 2.2.3 Operation 2.2.4 Schematic diagram 2.2.5 Torque-Speed characteristics 2.2.5 Advantages and disadvantages 2.2.6 Applications	Lecture Using Chalk-Board, Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO2
	UNIT-III PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM) (CL HRS.- 06 MARKS- 10)			
3	LLO3.1 Describe the various Permanent magnet Synchronous motors along with its performance LLO3.2. Analyze the Torque speed characteristics of PMSM LLO3.3 Compare conventional and PM synchronous motor.	3.1 Principle of operation permanent magnet synchronous motors. 3.2 EMF and torque equation, Torque speed characteristics. 3.3 Comparisons of conventional and PM synchronous motor. 3.4 Applications	Lecture Using Chalk-Board, Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO3

		SECTION II		
UNIT-IV- PERMANENT MAGNET BRUSHLESS DC (BLDC) MOTORS (CL HRS. -08 MARKS -12)				
4.	LLO4.1 Compare the mechanical and electronic commutators (BLDC) MOTORS LLO4.2. Analyze the different types of PMBLDC motors and Torque-speed characteristics	4.1 Constructional features, Principle of operation 4.2 Commutation in DC motors, 4.3Difference between mechanical and electronic commutators 4.4 Types of BLDC motors, 4.5 EMF and torque equation, Torque-speed characteristics, 4.6 Drives - concept and Control of BLDC motors. 4.7 Advantages & Disadvantages BLDC motors 4.8 Applications	Lecture Using Chalk-Board, Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO4
UNIT-V- STEPPER MOTORS (CL HRS.- 07 MARKS -12)				
5	LLO5.1 Describe the Constructional details of Stepper Motor LLO5.2. Explain different modes of excitation and torque production in stepper motor LLO 5.3 State the applications of stepper motor.	5.1 Constructional features, Principle of operation of stepper motor. 5.2 Modes of excitation, Torque production in Variable Reluctance (VR) stepping motor. 5.3 Dynamic characteristics 5.4 Drive system 5.5. Application 5.6 Advantages & Disadvantages of stepper motor.	Lecture Using Chalk-Board, Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO5
UNIT-VI- LINEAR INDUCTION MOTOR (CL HRS.- 8 MARKS -11)				
	LLO6.1 Analyze the performance characteristics of linear induction motor. LLO6.2 Classify the Linear Induction motor. LLO 6.3 State the applications of Linear Induction Motor	6.1. Construction of Linear Induction Motor 6.2 Operating Principle of Linear Induction Motor, Forces, Thrust, End effect, Levitation 6.3 Operating Principle of Linear Induction Motor 6.4 Classification of Linear Induction Motor A) Single-sided LIM i) Moving Primary and Fixed Secondary ii) Moving Secondary and Fixed Primary B) Double-sided LIM 6.5 Advantages of Linear Induction Motor 6.6 Disadvantages of Linear Induction Motor 6.7 Applications of Linear Induction Motor	Lecture Using Chalk-Board, Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO6

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant Cos
1	LLO 1.1 Identify the different parts of a Switched reluctance motor.	Dismantle the Switched reluctance motor	02	CO1
2	LLO 2.1 Draw a Torque speed characteristics of AC Servo Motor	Plot Torque-Speed characteristics of Switched reluctance motor	02	CO1
3	LLO 3.1 Draw a Torque speed characteristics of DC Servo Motor.	Plot Torque-Speed characteristics of DC Servo motor.	02	CO2
4	LLO 4.1 Draw a Torque speed characteristics of AC Servo Motor	Plot Torque-Speed characteristics of AC Servo motor.	02	CO2
5	LLO 5.1 Identify the different parts of a Permanent magnet synchronous motor	Dismantle a Permanent magnet synchronous motor	02	CO3
6	LLO 6.1 Identify the different components of a Stepper motor. LLO 6.2 Observe the operation of the Stepper motor.	Demonstrate the working principle of Stepper motor.	02	CO5
7	LLO 7.1 Identify the different components of a BLDC motors. LLO 7.2 Observe the operation of the BLDC motors.	Demonstrate the working principle of BLDC motors.	02	CO4
8	LLO 8.1 Observe the construction and working of Linear Induction motor.	Study the construction of Linear Induction motor.	02	CO5
9.	LLO 9.1 Identify the different components of a Linear Induction motor. LLO 9.2 Observe the operation of the Linear Induction motor.	Demonstrate the working principle of Linear Induction motor.	02	CO5

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VI. SUGGESTED MICRO PROJECT/ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING)

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course:
Students should conduct following activities in group and prepare reports of about 5 pages for each activity, This will also be useful for their placement interviews.

1. Visit to manufacturing industries of AC and DC Servo motor.
2. Visit to manufacturing industries of Linear induction Motor
3. Visit to manufacturing industries of Switched reluctance motor

Micro project:

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned Faculty:

a. Comparative study of all types of special motors with respect to –
i. Specification. ii. Type of supply iii. Name of manufacturer iv. Cost. V) Area of use
b. Collect information/product brochures on Switched reluctance motor
c. Collect information/product brochures on AC and DC Servo motor
d. Collect information/product brochures on Linear induction Motor

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Permanent magnet motor	5
2	Switched Reluctance motor	1,2
3	Stepper motors of different types	6
4	Brushless DC motors	7
5	Servomotors	3,4
6	Linear Induction Motor	8,9

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

(Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
Section -I								
1	**I**	Switched reluctance motor	**CO1**	**10**	**8**	**6**	**1**	**15**
2	**II**	Servomotors	**CO2**	**06**	**4**	**4**	**2**	**10**
3	**III**	Permanent Magnet synchronous motors	**CO3**	**06**	**4**	**4**	**2**	**10**
Section -II								
4	**IV**	Permanent Magnet Brushless DC (BLDC) Motors	**CO4**	**08**	**4**	**6**	**2**	**12**
5	**V**	Stepper motor	**CO5**	**07**	**4**	**6**	**2**	**12**
6	**VI**	Linear Induction motor	**CO6**	**08**	**3**	**8**	**0**	**11**
		TOTAL		**45**	**27**	**34**	**09**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two unit tests of 30 marks each will be conducted and the average of the two unit tests will be considered. For the formative assessment of laboratory learning, a total of 25 marks will be allocated. Each practical will be assessed based on the appropriate percentage weightage given to the process and the product, following the specified assessment guidelines and instructions.	End semester assessment of 70 marks through offline mode of examination.

X. SUGGESTED COS- POS MATRIX FORM

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 Lifel o n g Learning	PSO-1	PSO-2	PSO-3	PSO-4
CO1	2	2	1	1	2	1	1	3	2	1	3
CO2	2	2	1	2	2	1	2	3	2	1	3
CO3	2	2	1	2	2	1	2	3	2	1	3
CO4	2	2	1	2	1	1	2	3	2	1	3
CO5	2	2	1	2	2	1	2	3	3	1	3
CO6	2	2	1	2	2	1	2	3	3	1	3
Legends: - High:03, Medium:02, Low:01, No Mapping: -- *PSOs are to be formulated at the institute level											

XI. SUGGESTED LEARNING MATERIALS/BOOKS

Sr. No	Author	Title	Publisher
1	E.G. Janardanan	"Special Electrical Machines" PHI Learning Private Limited,	Delhi First Edition reprinted in 2014.
2	K. Venkataratnam	"Special Electrical Machines"	Universities Press (India) Private Limited, Hyderabad,
3	R.S.Krishnan	"Switched Reluctance Motor Drives: Modeling Simulation Analysis, Design and Application"	CRC press 2001.
4	R.S.Krishnan	"Permanent Magnet Synchronous Motor and Brushless DC Motor Drives"	Rc press First edition, 2002.
5	Kenjo, T	"Stepping Motor and their Microprocessor control",	Clarendon press Oxford, Second edition, 1989.

XII. LEARNING WEBSITES & PORTALS

Sr No	Link	DESCRIPTION
1	https://nptel.ac.in/courses/108102156	Special Electromechanical Systems
2	https://unacademy.com/course/special-electrical-machines/21AZBGE3	Special types of Electrical machines and there uses, operation and working.
3	https://books.google.co.in/books/about/SPECIAL_ELECTRICAL_MACHINES.html?id=Cttz	List of books for special Electrical machines.

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Smt Tejeshree Jagdish Bhangale
Lecturer in Electrical Engineering

(Course Experts)

Name & Signature:

Mr.R.U.Shelke
(Programme Head)

Dr.S.V.Bhangale

Name & Signature:

Shri.S.B.Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**ILLUMINATION ENGINEERING**
COURSE CODE	**EE51205**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**Yes**

I. LEARNING&ASSESSMENTSCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL Practical				Based on SL		Total Marks
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE51205	Illumination Engineering	DSE	3	0	2	1	6	3	3 Hr	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Term: 00 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment
Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination

Note:
FA-TH represents an average of two class tests of 30 marks each conducted during the semester.
1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Illumination Engineering is essential for careers in electrical engineering, architecture, interior design, and energy management. Polytechnics prepare students for technical roles, making this subject crucial for industries focusing on lighting design, energy efficiency, and smart lighting systems. This subject is included to teach the students various aspects of illumination and illumination schemes. Students will know various types of lamps, lighting accessories & control circuit and their applications. He/she will become aware of his/her role in designing and installing illumination equipment as per new illumination trends.

III. COURSE-LEVELLEARNING OUT COMES(CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Select the relevant illumination level for various applications

CO2: Investigate on various types of electric bulbs as well as can evaluate their performance in terms of their colour rendering and luminous efficacy.

CO3 : Design a control circuit for Illumination.

CO4 : Design various schemes for interior & Outdoor applications for lighting

CO5 : Select and apply an appropriate light fitting method for any specific application.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
SECTION - I				
UNIT-I Fundamentals of Illumination Engineering (CL Hrs-6, Marks-08)				
1	TLO 1.1 Describe the Fundamentals of Light and Vision TLO 1.2. Explain the illumination scheme and level of illumination TLO 1.3 Define various illumination terminology TLO 1.4 State the laws of Illumination TLO 1.5 Explain the feature of good illumination	1.1 Fundamentals of Light & Vision 1.2 Identify and measure the level of illumination 1.3 Design illumination schemes 1.4 Use IEI standards for illumination schemes 1.5 Fundamentals of Illumination 1.6 Illumination terminology: Illumination, Light intensity, Lumen, Lux 1.7 Laws of Illumination (Simple numerical) 1.8 Features of good Illumination scheme 1.9 Advantages of good Illumination scheme	Lecture Using Chalk-Board , Video Demonstrations ,Flipped Classroom, Case Study, Collaborative learning, Presentations	CO1
UNIT-II Types of Lamps (CL Hrs-10, Marks-18)				
2	TLO 2.1Interprete with sketch the given types of lamps TLO 2.2 Explain with working of given types of lamps TLO 2.3 Select the relevant mounting arrangement for the given light source. TLO 2.4 Compare the silent feature of the given types of lamps TLO 2.5 Describe the lighting scheme for the given area	2.1 Types of lamps: Construction, working principle, advantages, disadvantages and application of lamps a. ARC lamps – AC & DC arc lamp b. Fluorescent lamp (using Electronics chock) c. HPMV lamp, d. Mercury iodide lamp e. Neon lamp , f. Neon Sign Tubes g. Metal halides lamp h. LED lamps i.LASER lamp	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 2.6 Describes the various lighting calculations methods	2.2 Lighting schemes: selection of lamp, illumination efficiency , glare & power consumption a. Direct & Indirect b. Semi direct & semi indirect c. General lighting scheme 2.3 Lighting calculation methods a. Watt /m2 method b. Lumens or light flux method c. Point-to-point method (Simple numerals on the above methods)		
UNIT-III Illumination Control and Control Circuits (CL Hrs-08 , Marks-09)				
3	TLO3.1 Describe proper light source for given application TLO 3.2 Select the controlling method of brightness/colour of light of the source for a given requirement. TLO 3.3 Explain with a sketch the working of given types of dimmer TLO 3.4 Design control circuit for illumination TLO 3.5 Explain with a sketch the given types of control circuits for lamps	3.1 Purpose of lighting control 3.2 Working principle and operation of Dimmer - a. Resistance type dimmer b. Salt water dimmer Dimmer Transformer 1) Auto transformer dimmer 2) Two winding transformer dimmer 3.3 Electronic Dimmer : working principle and operation a. Thyrister operated dimmer b. Triac operated dimmer 3.4 Control of Enhance Lighting 3.5 Methods used for light control 3.6 Control circuits for lamps : a. single lamp controlled by single switch and b. Single Lamp control by two point method , c. three point method & four point method 3.7 Polar curve : its meaning and applications for designing the lamps	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO3

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION - II			
	UNIT-IV Illumination for Interior applications (CL Hrs-08, Marks-12)			
4	TLO 4.1 State the lux level required for given working plan as per applications TLO 4.2 Calculate the total lux level required for the given working plane TLO 4.3 Select the proper light source with a particular colour of light for the given situation TLO 4.4 Estimate the illumination scheme for the given types of residence	4.1 Standards for various situations in Interior Illumination 4.2 Methods for Designing illumination schemes 4.3 Design considerations for Interior location of Residential and Commercial, Industrial premises 4.4 Design Illumination scheme for different Interior locations of Residential places 4.5 Design Illumination scheme for different Interior locations of Commercial places 4.6 Design Illumination scheme for different Interior locations of Industrial Places	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO4
	UNIT-V Illumination for Outdoor & Special Applications (CL Hrs-10, Marks-18)			
5	TLO 5.1 Describe the general requirements for an outdoor lighting scheme TLO 5.2 Explain the specific requirement for the given outdoor lighting TLO 5.3 Describe the lighting scheme and applications for the given special lighting	5.1 General requirements for lighting schemes 5.2 Specific requirements for above schemes a) Factory Lighting b) Street Lighting, PV Solar street light c) Flood Lighting d) Railway platform Lighting e) Lighting for Advertisement/Hoardings f) Sports Lighting 5.3 Simple numerical based on the design of simple schemes 5.4 Lighting schemes and general requirements for : a) Agricultural & Horticultural applications b) Health Care Centers and Hospitals c) Decorative lighting d) Stage lighting e) Aquariums & Shipyards	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO4

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT-VI Lighting fittings and Special lighting (CL Hrs-03 Marks-05)				
6	TLO 6.1 Explain the requirement for good lightning TLO 6.2 Describe the types of Symmetrical fittings TLO 6.3 Describe the types of Asymmetrical fittings	6.1 Requirements of good lightning, 6.2 Symmetrical fittings: A type fitting; B type fitting; C type fitting; D type fitting; E type fitting, 6.3 Asymmetrical fittings, Factory lighting, Flood lighting, Street lighting 6.4 Diffusion principle; specular reflection principle 6.5 Smart home lighting 6.6 Traditional and festival lamps	Lecture Using Chalk-Board , Video Demonstrations, Flipped Classroom, Case Study, Collaborative learning, Presentations	CO5

V. LABORATORYL EARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Measure **luminous flux, power consumption, and lifespan** of LED, CFL, and incandescent bulbs.	*Measure and compare **luminous flux, power consumption, and lifespan** of LED, CFL, and incandescent bulbs.	02	CO1
2	LLO 2.1 Measure the lux level of the given workplace	*Conduct illumination level assignment in the workplace using lux meter	02	CO1
3	LLO 3.1 Check the continuity of wire used for street light	*Use a **multimeter and continuity tester** to diagnose open/short circuits in a street light setup.	02	CO4
4	LLO 4.1 Analysis of glare produced from the given LED	*Analyze glare from LED bulbs and **test diffusers/reflectors** to minimise it.	02	CO5
5	LLO 5.1 Prepare the polar curve of the given lamp	Interprete the polar curve of the given type of lamp and verify it using lux meter	02	CO3
6	LLO 6.1 Measurement of Lux level with and without reflectors	*Measure the illumination level with and without reflectors used in the various luminaries	02	CO5
7	LLO 7.1 Identify the given dimmer electrical / electronics	Prepare the light dimmer arrangement using the relevant dimmer type of transformer	02	CO3

Sr. No	Practical/Tutorial/LaboratoryLearningOutcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
8	LLO 8.1 Identify the given dimmer and their parts	*Identify the given types of dimmer transformer and their parts	02	CO3
9	LLO 9.1 Connect a circuit of single lamp control by single switch	Build a circuit of single lamp control by single switch	02	CO3
10	LLO 10.1 Connect a circuit of single lamp control by Two way switch	*Build a circuit of single lamp control by two way switch	02	CO3
11	LLO 11.1 Connect the circuit of single lamp control by three points methods	Build a single lamp control by three point method	02	CO3
12	LLO 12.1 Connect the circuit of single lamp control by four points methods	*Build a single lamp control by four point method	02	CO3
13	LLO 13.1 Collect the information of various types of lights used in commercial areas with their standard lux level	*Make a chart of various types of lights used in commercial areas with their standard lux level	02	CO2
14	LLO 14.1 Collect the information of various types of lights used Industrial areas with their standard lux level	*Make a chart of various types of lights used in the Industrial area with their standard lux level	02	CO2
15	LLO 15.1 Using any open source software for the design of the illumination level.	Design of Illumination Level using Open Source software	02	CO2

Note : Out of above suggestive LLOs -

'*' Marked Practicals (LLOs) Are mandatory.

- Minimum 80% of above list of lab experiment are to be performed. Judicial mix of LLOs are to be performed to achieve desired outcomes.

VI. SUGGESTED MICROPROJECT/ ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING ASSIGNMENT/)

Microproject: Teacher should give the topic on theory/lab contents

1. **Design and Analysis of an Energy-Efficient LED Lighting System**
Compare power consumption and illumination levels of LED vs. traditional bulbs.
2. **Study of Color Rendering Index (CRI) in Different Light Sources**
Measure and compare CRI values of LEDs, CFLs, and incandescent bulbs.
3. **Automatic Street Light Control Using LDR & PIR Sensor**
Design a circuit to switch street lights based on ambient light and motion detection.
4. **Solar-Powered LED Lighting System for Rural Areas**
Develop a small-scale solar-powered LED lamp and test its efficiency.
5. **Human-Centric Lighting: Impact of Light Temperature on Productivity**
Study how warm (3000K) vs. cool (6000K) light affects concentration.
6. **Flicker Measurement in LED Drivers**
Analyze flicker percentage in different LED drivers using a photodiode and oscilloscope.
7. **Smart Lighting System Using IoT (Wi-Fi/Bluetooth Control)**
Create a prototype of a smartphone-controlled dimmable LED light.
8. **Glare Analysis in Indoor Lighting Systems**
Measure and reduce glare in office/study lighting setups.
9. **UV Disinfection Lighting for Surface Sterilization**

Test the effectiveness of UV-C LEDs in killing bacteria on surfaces.

10. **Li-Fi (Light Fidelity) Data Transmission Using LEDs**

Demonstrate basic data transfer (text/audio) using modulated LED light.

Assignments:

1. Estimate and compare luminous efficiency of incandescent and compact fluorescent lamp.
2. Compare performance of magnetic and electronic ballast. Estimate the energy saving with electronic ballast.
3. Understand energy efficient illumination equipments.
4. Design illumination scheme for any one of the following. (A)Flat (B)Bunglow (C)Row House and similar
5. Design illumination scheme for any one of the following. (A) Mall (B) Cloth shop (C) Restaurant (D) Showroom.
6. Write a report on illumination scheme used in industry by visiting small or medium industry.
7. Conduct illumination assessment in workplace using luxmeter

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	LUX Meter	1,2,4,5,6
2	Auto transformer	7,8
3	Control circuits for luminaries	4,6
4	Stroboscope	4,5
5	Ammeter, Wattmeter, Voltmeter	9,10,11,12

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	AlignedCOs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION - I								
1	I	**Fundamentals of Illumination Engineering**	CO1	06	02	04	02	08
2	II	**Types of Lamps**	CO2	10	02	08	08	18
3	III	**Illumination Control and Control Circuits**	CO3	08	02	04	03	09
SECTION – II								
4	IV	**Illumination for Interior applications**	CO4	08	02	06	04	12
5	V	**Illumination for Outdoor & Special Applications**	CO4	10	02	10	06	18
6	VI	**Lighting fittings and Special lighting**	CO5	03	01	02	02	05
Grand Total				**45**	**11**	**34**	**25**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessmentfor Learning)	Summative Assessment (Assessmentof Learning)
Two unit tests of 30 marks each will be conducted and the average of the two unit tests will be considered. For the formative assessment of laboratory learning, a total of 25 marks will be allocated. Each practical will be assessed based on the appropriate percentage weightage given to the process and the product, following the specified assessment guidelines and instructions.	The end-semester assessment will consist of a 70-mark offline examination.

X. SUGGESTED COS- POSMATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programm 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	PSO-3	PSO-4
CO1	2	1	3	1	2	2	3	1	1	2	1
CO2	3	1	2	1	2	2	2	1	2	3	-
CO3	2	2	3	2	-	2	3	1	2	3	1
CO4	2	3	2	1	2	2	3	1	2	-	1
CO5	3	2	3	1	2	-	3	1	2	3	2
CO6	2	2	3	1	2	2	3	1	2	3	1

Legends:- High:03, Medium:02, Low:01, No Mapping: --
***PSOs are to be formulated at the institute level**

XI . SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	N. V. Suryanarayana	Utilisation of Electrical Power	Wiley Eastern Limited ISBN-13: 978-8122436815 ISBN-10: 8122436811
2	Jack l. Lindsey	Applied illumination engineering	The Fairmont Press Inc. ISBN-10. 0881730602 · ISBN-13. 978-0881730609
3	R.H. Simons& Robart Bean	Lighting Engineering & applied calculations	Architectural Press (ISBN0750650516)

XII. LEARNINGWEBSITES& PORTALS

Sr.No	Link/Portal	Description
1	www.opticalres.com/lt/illuminationfund.pdf	Provide the latest illumination information
2	www.Nptel.com	Illumination-related experts lecture
3	www.archlighting.com	Information about lighting reflectors
4	www.youtube.com/ illumination engineering	Illumination-related contains

Note:
Teachers are requested to check the Creative Commons license status/financial implications of the suggested online educational resources before use by the students

Name &Signature:

Shri. R.U. Shelke
HOD in Electrical Engineering
(Course Expert)

Shri. R.B. Chauthmal
Lecturer in Electrical Engineering
(Course Expert)

Name & Signature:

Shri. R. U. Shelke **Dr. S. V. Bhangale**
(Programme Head)

Name & Signature:

Shri. S.B.Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	02
COURSE TITLE	**INDUSTRIAL AUTOMATION**
COURSE CODE	**EE51206**
PREREQUISITE COURSE CODE & TITLE	**EE51201 - Digital Electronics and Microcontroller Appication**
CLASS DECLARTION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE51206	**Industrial Automation**	**DSE**	**3**	**0**	**2**	**1**	**6**	**3**	**3 Hr**	30	70	100	40	25	10	--	--	25	10	150

Total IKS Hrs for Term: Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the course.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that semester.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.

6.* Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Diploma holder, employed in the industry, needs to operate, test and maintain the industrial control circuits. It is very essential for him/her to know the PLC programming and logic of process control circuits. The aim of this course is to develop competencies in the technician, to carry out various responsibilities in the industry, related to industrial control and automation

III. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify control circuit components

CO2:Connect input/output devices to PLC and test it in different applications.

CO3:Develop ladder diagram for various logics.

CO4: Carry out installation, troubleshooting and maintenance of PLCs.

CO5:Understanding anatomy of Industrial robots and its capabilities.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION I			
	UNIT-I Introduction to Control Circuits and Its Components (CL Hrs-06 , Marks- 09)			
1.	TLO 1.1 Explain general idea industrial automation. TLO 1.2 State the Disadvantages of hard wired realy control system. TLO 1.3 Design Power and Control Circuit for Star-Delta Starter – Manual, Semi-automatic, Automatic,Forward – Reverse control of induction motor. TLO 1.4 Develop control circuit with interlocking. TLO 1.5 List& Explain types of switches. TLO 1.6 Explain working of Push button Foot switches, Selector switches ,Simple Limit switch. Proximity switches Pressure switches TLO 1.7 Explain construction and working of output devices TLO 1.8 Draw symbols of devices.	1.1 Introduction to industrial automation 1.2 Disadvantages of hard wired realy control system 1.3 Concept of Power circuit and Control circuit. Development of control circuits. Star-Delta Starter – Manual, Semi-automatic, Automatic. Forward-reverse control of Induction motor by DOL Starter using contactors. 1.4 Concept of interlocking of drives, 1.5 Input devices –working, applications and ratings. Push button Concept of NO, NC. Foot switches, Selector switches Simple Limit switch. Proximity switches- Inductive, Capacitive, Photoelectric, Ultrasonic. Pressure switches ,motion sensors. 1.6 Output devices – Their construction, working, applications and ratings Solenoid valve, Contactor coil,servo motor,stepper motor,VFD. 1.7 Symbols of control devices.	Chalk-Board, Demonstration video,presentations	CO1
	UNIT-II Fundamentals of PLC (CL Hrs-07 , Marks- 12)			
2	TLO 2.1. Define PLC. TLO 2.2. List PLC manufacturers. TLO 2.3. Compare PLC with other controller TLO 2.4. List types of PLCs. TLO 2.5. Describe architecture of PLC. Explain power supply for PLC systems. TLO 2.6. Explain sink/source concept.	2.1 PLC Definition. 2.2 PLC manufacturers 2.3 Advantages of PLC over other Controller 2.4 Type of PLCs. 2.5 PLC. – block diagram, Input image file, output image file, scan cycle and watchdog timer, Power supply. 2.6 Input, output modules – Types, sink/source concept.	Chalk-Board , Demonstration video, presentations	CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 2.7. Show connections of I/O devices to PLC. TLO 2.8. Compare communication protocol cables for PLC TLO 2.9. List Programming languages of PLC	2.7 Connection of I/O devices to PLC and downloading of PLC programme into target.sinking to sourcing converter. 2.8 Communication protocols – RS 232, RS385, Ethernet. Features, limitations, cables and terminations,comparision. 2.9 Programming languages of PLC as per IEC 61131-3.		
UNIT-III Programming of PLC			**(CL Hrs-10 , Marks-14)**	
3	TLO 3.1 Explain rules for ladder programming. TLO 3.2 Draw and explain simple ladder diagrams TLO 3.3 Draw and explain ladder diagrams for logic gates. TLO 3.4 Draw and explain ladder diagrams using Timers . TLO 3.5 Draw and explain ladder diagrams using Counters. TLO 3.6 Draw and explain ladder diagrams for Arithmetic functions. TLO 3.7 Draw and explain ladder diagrams for Comparison Functions. TLO 3.8 Develop ladder diagram for analog application.	3.1 Rules for proper construction of PLC Ladder Diagram. 3.2 Programming On-Off inputs to produce On-Off outputs. NO, NC, Latch, Unlatch, Memory. Addressing systems. Programming Logic gates. 3.3 Logic gates:Types 3.4 PLC Timer function block, Types of timers. 3.5 PLC Counter function block, Types of Counters. 3.6 PLC Arithmetic functions - Addition, Subtraction, Multiplication, Division. 3.7 PLC Number comparison functions - Equal to, Not equal, Greater than, Greater than equal to, Less than, Less than and equal to 3.8 String operation functions 3.9 PLC Analog Programming	Chalk-Board , Demonstration video, presentations	CO3

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION II			
	UNIT- IV Ladder Diagram for Process Control, PLC Installation, Troubleshooting and Maintenance (CL Hrs-06 , Marks-11)			
4	TLO 4.1 Develop ladder diagram for Sequential operation of motors. TLO 4.2 Develop ladder diagram for Automatic control of water level. TLO 4.3. Develop ladder diagram for Skip hoist control TLO 4.4. Develop ladder diagram forConveyor system TLO 4.5. Develop ladder diagram for Pneumatic System TLO 4.6. Develop ladder diagram for Traffic control signaling system TLO 4.7 Develop ladder diagram for Stepper motor TLO 4.8. Describe operating environment for PLC. List and discuss the procedure for checking the parts of PLC as received from the manufacturer. TLO 4.9. Describe the procedure for assembling and interconnecting the PLC system. TLO 4.10 List the reasons for grounding. TLO 4.11. List and describe PLC troubleshooting procedures. TLO 4.12. List and describe general and preventive maintenance procedure for PLCs. TLO 4.13. List factors to be considered for selection of PLC.	4.1 Sequential operation of motors. 4.2 Automatic control of water level. 4.3 Skip hoist control 4.4 Conveyor system 4.5. Pneumatic System 4.6 Traffic control signaling system 4.7 Stepper motor 4.8 Consideration of the operating environment.Receiving and checking of PLC. 4.9 Testing and assembly: Electrical connections. 4.10 Importance of PLC Grounding. 4.11 Troubleshooting PLC malfunctions. 4.12 PLC maintenance. 4.13 Factors to be considered in selecting PLC.	Chalk-Board , Demonstration video,presentations	CO3
	UNIT –V Introduction To Industrial Robots and Safety (CL Hrs-06 , Marks-08)			
5	TLO 5.1 Explain the need of industrial robot. TLO 5.2 Identify type of given automation TLO 5.3 Follow the safety practices while using robot	5.1Introduction, Definition, need, brief history of Industrial Robots 5.2 Automation: Type of automation, Need for Automation 5.3 Application of Robots in Industries	Chalk-Board , Demonstration video, presentations	CO4

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		5.4 Types of Robots 5.6 Safe Practices while Handling the Robot, Safety Symbols, Safety Gear. Applicable Safety Standards, General Safety Information, Safety Symbols on the Robotic Arm, Robot Controller, and Teach Pendant. 5.7 Risk Assessment, Workspace, and Safety Zones, Personal Safety Equipment, moving the Robot without Power, Residual Risks.		
UNIT –VI Anatomy of Industrial Robots (CL Hrs-10 , Marks-16)				
6	TLO 6.1 Compare different actuators for robotic system TLO 6.2Explain the different drive system of industrial robot	6.1 Robot specification: Degree of Freedom, Work envelope, Load carrying capacity, Speed of movement, Accuracy, Repeatability, Control Resolution, Spatial resolution, 6.2 Basic Robot motions: - Vertical motions, Radial motions, Rotational motions, Pitch motions, Roll motions, Yaw motions. 6.3 Types of mechanical joints used in Robotics system: - Linear Joint, Orthogonal joint, Rotational Joint, Twisting Joint, Revolving Joint (Symbol, Notations) 6.4 Robots End Effectors: Types of End Effectors- Gripper and Tools, Grippers- Mechanical, Pneumatic, Magnetic, Vacuum, adhesive, Considerations in gripper selection 6.5Actuators and types: Pneumatic, Hydraulic and Electric, 6.6 Need of Pneumatic System, Basic Components of Pneumatic Compressor, Valves, Actuators 6.7 Different Electric Rotary Actuators. Recent Advances in Actuators 6.8 Drive and drive system: Pneumatic, Hydraulic and Electric Drive Systems.	Chalk-Board , Demonstration video, presentations	CO5

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1 Identify symbols in control diagrams.	To Identify symbols used in industrial control diagrams.	02	CO1
2	LLO 2 Develop control circuit for DOL Starter	To develop control circuit for DOL Starter	02	CO1
3	LLO 3 Develop control circuit induction motor	To develop control circuit for Forward-Reverse control of 3-phase induction motor.	02	CO1
4	LLO 4 Develop control circuit for Semi-Automatic Star-Delta Starter	To develop control circuit for Semi-Automatic Star-Delta Starter	02	CO1
5	LLO 5 Develop control circuit for Fully Automatic Star-Delta starter	To develop control circuit for Fully Automatic Star-Delta starter.	02	CO1
6	LLO 6 Develop ladder diagram for logic gates	To develop ladder diagram for all logic gates	02	CO3
7	LLO 7 Develop ladder diagram for DOL Starter	To develop ladder diagram for DOL Starter	02	CO3
8	LLO 8 Develop ladder program for starter.	To develop ladder diagram for i) Semi-Automatic and ii) Fully Automatic Star-Delta starter	02	CO3
9	LLO 9 Develop ladder program for induction motor.	To develop ladder diagram for Forward-Stop-Reverse control of 3-phase induction motor.	02	CO3
10	LLO 10 Develop ladder program for Counters	To develop ladder diagrams using PLC (Software) Counters	02	CO3
11	LLO 11 Develop ladder program for stepper motor	To develop ladder program for running a stepper motor in clockwise/ anticlockwise direction	02	CO2 CO3
12	LLO 12 Develop ladder program for traffic light	To develop ladder program for simulating traffic light control	02	CO3 CO4
13	LLO 13 Develop ladder program for temperature control	To develop ladder program for ON/OFF temperature control	02	CO3 CO4
14	LLO 14 Develop ladder program for control of water pump	To develop ladder program for Automatic control of water pump	02	CO4
15	LLO 15 Identify different basic robotic components and working for given system.	Introduction to industrial robotics lab and safety	02	CO5
16	LLO 16 to observe linear movement of robotic arm	Demonstartion on operation of robotic arm for linear movement	02	CO5

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
17	LLO 17 To observe five axis movement of robotic arm	Demonstartion on operation of robot for 5 axis robotic arm movement	02	CO5
18	LLO 18 To identify basic robotic arm motions.	To study various robotic arm configurations	02	CO5
19	LLO 19 To make use of pneumatic system for industrial robot system	Demonstation on pneumatic system with single acting and double acting pneumatic cylinders.	02	CO5

Any 8 practicals from 1 to 14 and any 4 practicals from 15 to 19

VI. SUGGESTED MICRO PROJECT/ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING)

Micro projects:

- PLC based colour mixing plant.
- PLC based bottle filling plant.
- PLC based water supply system.
- PLC based induction motor control.
- PLC based soft starting of induction motor.
- PLC based series parallel control of traction motors.
- Demonstration of five axes rotation of robotic arm

Assignments: -

- Enlist the name of PLC international manufacturer
- Write report on use of PLC in automation System
- Write report on PLC based speed control of electric vehicle
- Give the selection criteria of I/O modules in automation system
- Preapre report on latest technology of industrial robot
- Prepare report on robot manufacturing industries
- Prepare report on types of industrial robots

Note

Suggestive list of microprojects and assignments are given here. Similar/suitable/related microprojects and assignments could be added by the concernd faculty.

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Control components: Push buttons (6 Nos.),Indicating Lamps(6Nos.),Limit Switches (2 Nos.),Proximity Switches (inductive proximity switches,2 Nos. and capacitive proximity switches ,2 Nos.)	2-14
2	Stepper Motor Drive model	11
3	3-Ø A.C. Contactors (3Nos.)	3, 5, 6, 7, 8
4	Traffic Light Simulation Model	13

5	3-Ø Induction Motor of small rating (<1HP)	3, 5, 6, 7, 8
6	PLC with minimum 8 I/Os and HMI and its programming software	1, 4, 6, 9- 15
7	Temperature measurement and control system	12
8	Mobile robot with sensors capable of atleat 5 axes movement	16,17
9	With and with out Onboard PC with high speed wireless communication for use on robot	15-19
10	Electo-pneumatic training system	19

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

(Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION - I								
1	**I**	**Introduction to Control Circuits and Its Components**	CO1	06	04	03	02	09
2	**II**	**Fundamentals of PLC**	CO2	07	06	04	02	12
3	**III**	**Programming of PLC**	CO3	10	04	06	04	14
SECTION - II								
4	**IV**	**Ladder Diagram for Process Control , PLC Installation, Troubleshooting and Maintenance**	CO3	06	03	04	04	11
5	**V**	**Introduction To Industrail robots and safety**	CO5	06	04	02	02	08
6	**VI**	**Anatomy of Industrial Robots**	CO5	10	04	04	08	16
Grand Total				**45**	**25**	**23**	**22**	**70**

IX.ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two unit tests of 30 marks will be conducted and an average of two unit tests considered. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering the appropriate % weightage to process and product and other instructions of assessment.	End semester assessment of 70 marks through offline mode of examination

X. SUGGESTED COS- POS MATRIX FORM

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	PSO3	PSO-4
CO1	2	3	3	1	1	-	1	3	3	1	3
CO2	2	3	2	3	1	2	1	3	3	2	3
CO3	3	2	2	2	1	1	1	2	3	2	3
CO4	3	2	2	3	3	1	1	3	3	1	2
CO5	3	3	2	2	2	3	2	3	3	3	3

Legends:- High:03, **Medium:**02, **Low:**01, **NoMapping:** -
*PSOs are to be formulated at the institute level

XI.SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	S. K. Bhattacharya and Brijinder Singh	Control of Machines	New Age International Publication ISBN81-224-0363-8
2	John W. Webb and Ronald A. Reis	Programmable Logic Controllers-Principles and Applications	Prentice-Hall of India Private Limited, New Delhi,2003 ISBN: 9780130416728
3	U. S. Eswar	Handbook of Electrical Motor Control Systems	Tata McGraw-Hill Publishing Company Limited, New Delhi,2013 ISBN: 9780074604380
4	Hackworth. J.R.; Hackworth. F;	Programmable Logic Controllers	Pearson Education, New Delhi,2015 ISBN: 9788177587715
5	Bolton,W.	Programmable Logic Controllers	Elsevier India Pvt. Ltd. New Delhi,2016 ISBN: 9780128029299
6	Petruzella. F.D.	Programmable Logic Controllers	McGraw Hill Education (India) Edition,New York,2016 ISBN: 9780073510880
7	Dunning. G.	Introduction to PLC	Cengage India (2009), ISBN: 9788131503027
8	Introduction to Industrial Robotics	Ramchandran Nagrajan	Pearson Education India, New Delhi,2006,ISBN:978-93-325-4480-2
9	Robotics and Industrial Automation	R.K.Rajput	S.Chand Limited,2008 ISBN-9788121929974
10	Robotics and Control	R.K.Mittal & I.J.Nagrath	TATA McGraw Hill education India Pvt.Ltd.,New Delhi,2009 ISBN:0-07-048293-4

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	https://ifr.org/	International Federation of Robotics
2.	https://www.exeter.ac.uk/	In collaboration with COROT Project
3.	https://www.gre.ac.uk/	In collaboration with COROT Project
4.	https://www.learnrobotics.org	Learn Robotics Online
5.	https://nptel.ac.in/courses/112105249	NPTEL Course-Robotics

Name & Signature:

Mr.J.G.Momin
Lecturer in Electrical Engineering

Smt. A.A.Patole
Lecturer in Electrical Engineering

(Course Experts)

Name & Signature:

Mr.R.U.Shelke
(Programme Head)

Dr.S.V.Bhangale

Name & Signature:

Shri.S.B.Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**ELECTRIC TRACTION**
COURSE CODE	**EE51207**
PREREQUISITE COURSE CODE & TITLE	**EE41203 DISTRIBUTION AND UTILIZATION OF ELECTRICAL ENERGY**
CLASS DECLARTION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE51207	ELECTRIC TRACTION	DSE	03	00	02	01	06	03	03 Hr.	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.

6.* Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Electric traction- One of the practical applications of electricity in service of mass transport – the electric propulsions of vehicles – electric trains and in the latest developments such as metro, monorails and wheel-less traction systems. Indian Railways (IR) is the largest organization with very large job potential and opportunities for electrical engineering diploma holders which requires recent technological developments in this area of electric traction.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify the different electric locomotives and know the function of the components in it.
CO2: Apply the various track and supervisory control systems.
CO3: Protect the electric locomotive for the safe operation of it.
CO4: Maintain the electric locomotive by proper maintenance procedure.
CO5: Get updated with modern trends in electric traction.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		SECTION I		
	UNIT-I ELECTRIC LOCOMOTIVE		**(CL Hrs- 09, Marks- 13)**	
1.	TLO 1.1. Know types of Electric Locomotives By Nomenclature. TLO 1.2. Know the fundamentals of three phase Locomotive. TLO 1.3. State the function and purpose of different types of relays and contactors. TLO 1.4. State the various Equipments in Auxiliary Circuit and their functions. TLO 1.5. State and explain different methods of train lighting.	1.1 Nomenclature of Electric Locomotives 1.2 Power circuit of three phase locomotive, PWM control of Induction motor. 1.3 List and function of different type of Relays, List and Purpose of different type of Contactors 1.4 Equipment in auxiliary circuit and their functions- Head Light, Flasher Light, Horn, Marker Light, Batteries, Arno Converter, Blowers, Exhausters, Compressors, Selsyn Transformer 1.5 Train Lighting – Systems of train lighting, Special Requirements of Train Lighting, Method of btaining Unidirectional Polarity, Method of obtaining Constant Output, Single Battery System, Double Battery Parallel Block System, Failure of under frame generating equipments, End on Generation	Chalk-Board, lectures Tutorial Assignment, Demonstrations, Power point presentation, Industry Visit	CO1
	UNIT-II SIGNALLING AND SUPERVISORY CONTROL		**(CL Hrs- 07, Marks- 12)**	
2	TLO 2.1 Appreciate the importance of signalling. State different types of signals and their meanings. TLO 2.2 Know the functions, construction and working of track circuits. TLO 2.3 Understand Systems of Remote Control.	2.1 Signalling- Requirements of Signalling System, Types of signals according to function, location and operation, Cab signalling, Signalling at level crossings 2.2 Track Circuits- DC Track Circuit and AC Track Circuit 2.3 Supervisory control- Advantages of Remote Control, Systems of Remote Control, DC versus Voice Frequency (VF) Signalling, Remote Control System Equipment and Network, Mimic Diagram, Control Desk for TPC, Remote control switching equipments, F.M.V.F.T., Power supply, Controlled station equipment.	Chalk-Board, lectures Tutorial Assignment, Demonstrations, Power point presentation, Industry Visit	CO2
	UNIT-III PROTECTION OF ELECTRIC LOCOMOTIVE		**(CL Hrs- 06, Marks- 10)**	
3	TLO 3.1 Appreciate the importance of protection of Electric Locomotive and explain various types of protections provided to Electric Locomotive	3.1 Protection of Electric Locomotive- Broad Strategy For Protection i. Surge Protection: Direct Lightening Strokes, Switching Surges: External and Internal ii. Overload Protection of Main Power	Chalk-Board, lectures Tutorial Assignment, Demonstrations, Power point	CO3

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
		Circuit iii. Earth Fault Protection of Power and Auxiliary Circuit iv. Protection from Over Voltage and Under Voltage v. Differential Current Protection of Traction Circuits. vi. Protection against High and Low Air Pressure in the Air Circuit vii. Temperature Monitoring viii. Protection against Accidental Contact with H.T. Equipment ix. Protection against Fires	presentation, Industry Visit	
		SECTION II		
UNIT- IV MAINTENANCE OF ELECTRIC LOCOMOTIVE (CL Hrs- 12 , Marks- 15)				
4	TLO 4.1 Appreciate the importance of maintenance of Electric Locomotive. TLO 4.2 Describe the maintenance policies of Electric Locomotives. TLO 4.3 Understand the necessity of keeping Maintenance Record and importance of Efficient Maintenance. TLO 4.4 Know the causes of Electrical Faults that may occure during maintenance work and steps taken to detect the fault. TLO 4.5 Understand the necessity of testing.	4.1 Maintenance of Locomotive -Need of Maintenance and Policy of Obsolescence, Defects, Ideal Maintenance 4.2 Means to Improve the Reliability of Locomotive, Means to Improve Availability of Locomotive, Means to Reduce Maintenance Cost 4.3 Maintenance Record, Characteristics of Efficient Maintenance 4.4 Electrical Faults and Their Causes, Fault Localization 4.5 Necessity of Testing- Testing Procedure, Individual Equipment Tests fortransformer, motor.	Chalk-Board, lectures Tutorial Assignment, Demonstrations, Power point presentation	CO4
UNIT –V LEM PROPELLED TRACTION (CL Hrs- 06, Marks- 10)				
5	TLO 5.1 . Know the working of Linear Electric Motor (LEM) and understand the new developments in the Area of Electric Traction and Traction System. TLO 5.2 Know the strengths and	5.1 LEM Propelled Traction- Linear Electric Motor (LEM), Linear Induction based traction systems- - Moving Primary Fixed Secondary Single Sided LIM - Moving Secondary Fixed Primary Single Sided LIM - Moving Primary Fixed Secondary Double Sided LIM	Chalk-Board, lectures Tutorial Assignment, Demonstrations, Power point presentation	CO5

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	weaknesses of LIM propelled traction systems and the changes required to modify the existing traction system with LIM system.	5.2 Strengths and Weaknesses of LIM Propelled Railway Traction, Practical Possibilities of LIM Propelled Transportation, Inputs/Modifications for adoption of LIM- Propulsion in the existing system related with track modification, Vehicle modification. Voltage and Speed Control		
UNIT –VI MODERN TRENDS IN ELECTRIC TRACTION (CL Hrs- 05, Marks- 10)				
	TLO 6.1 Describe important features of Metro system and Bullet train. TLO 6.2 Enlist the various factors influencing for the adaptation of underground Metrorail. TLO 6.3 Know the features of Suspended Monorail and Straddle Monorail systems. TLO 6.4 Compare Long run train, Metro system and Monorail system on the basis of technical features. TLO 6.5 Know the concept of Wheel-less Traction. TLO 6.6 State the Levitation Schemes used in Traction System.	6.1 Introductory features of Metro system related with, selection of traction voltage, substations, traction system, SCADA system, safety systems 6.2 Factors Influencing Adoption of LIM for Underground Metro Rail 6.3 Suspended Monorail and Straddle Monorail systems 6.4 Comparison between Long run (normal electric) train, Metro system and Monorail system. 6.5 Wheel-less Traction 6.6 Levitation Schemes 6.7 Introductory features of Bullet train	Chalk-Board, lectures Tutorial Assignment, Demonstrations, Power point presentation	CO5

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1	LLO 1.1 Drawing of the Sheet (Half Imperial Size) containg Power circuit and Auxiliary circuit of A.C. Locomotive.	Draw the Sheet (Half Imperial Size) containg Power circuit and Auxiliary circuit of A.C. Locomotive and write a report of it.	02	CO1
2	LLO 1.2 Drawing of the Sheet (Half Imperial Size) containg train lighting systems.	Draw the Sheet (Half Imperial Size) containg train lighting systems and write a report of it.	02	CO1
3	LLO 1.3 Observe the train lighting employed in the the general and A/C coaches used in Indian Railways.	Visit the train lighting section and study the general and A/C coach lighting diagram.	04	CO1
4	LLO 2.1 Drawing of the Sheet (Half Imperial Size) containg various signalling systems.	Draw the Sheet (Half Imperial Size) containing the various signalling systems and write a report of it.	02	CO2

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
5	LLO 2.2 Observe the various signals, telecommunication systems and identify the locations, significance of these signals and identify.	Visit to signal and telecommunication section of Indian railway and study signalling system in railway.	04	CO2
6	LLO 3.1 Drawing of the Sheet (Half Imperial Size) containg various protection systems employed in the power circuit of an electric locomotive	Draw the Sheet (Half Imperial Size) containg various protection systems employed in the power circuit of an electric locomotive and write a report of it.	02	CO3
7	LLO 3.2 Observe the various protection systems employed in the power circuit of an electric locomotive.	Visit a railway electric loco shed to study the various protection systems employed in the power circuit of an electric locomotive.	04	CO3
8	LLO 4.1 Prepare the general maintenance schedule of an electric locomotive.	Prepare the general preventative maintenance schedule of an electric locomotive.	02	CO4
9	LLO 4.2 Prepare the chart giving the details of individual equipment tests that are required to be carried out for the equipment in an electric locomotive.	Prepare the chart giving the details of individual equipment tests that are required to be carried out for the equipment in an electric locomotive.	02	CO4
10	LLO 5.1 Drawing of the Sheet (Half Imperial Size) containg Linear Induction Based Traction Systems	Draw the Sheet (Half Imperial Size) containg Linear Induction Based Traction Systems and write a report of it.	02	CO5
11	LLO 5.1 Identify different types of switchgear used in Traction substation.	Visit the substation for power supply arrangement of Metro rail system, draw the single line diagram and prepare a report.	04	CO5

All COs should be covered in the practical.

VI. SUGGESTED MICRO PROJECT/ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING)

Micro project:

- Develop the models related to train lighting systems of electric locomotive.
- Prepare the model illustrating the signalling systems used for electric locomotive.
- Build a model for over voltage and under voltage protection system used for electric locomotive.
- Prepare monthly and yearly maintenance chart of electric locomotive.
- Prepare a chart showing SCADA system used for Metro system.

Assignment: -

- Prepare a report regarding the different types of relays and contactors used in electric locomotive.
- Prepare a report on comparative study of track circuits.
- Prepare a chart showing various protection systems used in electric locomotive.
- Prepare a report on equipment testing procedure carried out for electric locomotive.
- Prepare a report on comparative study of long run trains, metro and mono rail systems.

VII. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED: NA

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

(Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	**ELECTRIC LOCOMOTIVE**	CO1	09	04	05	04	13
2	II	**SIGNALING AND SUPERVISORY CONTROL**	CO2	07	04	04	04	12
3	III	**PROTECTION OF ELECTRIC LOCOMOTIVE**	CO3	06	02	04	04	10
4	IV	**MAINTENANCE OF ELECTRIC LOCOMOTIVE**	CO4	12	05	05	05	15
5	V	**LEM PROPELLED TRACTION**	CO5	06	03	04	03	10
6	VI	**MODERN TRENDS IN ELECTRIC TRACTION**	CO5	05	03	04	03	10
Grand Total				**45**	**21**	**28**	**21**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)	Summative Assessment (Assessment of Learning)
Two unit tests of 30 marks will be conducted and an average of two unit tests considered. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering the appropriate % weightage to process and product and other instructions of assessment.	End semester assessment of 70 marks through offline mode of examination.

X. SUGGESTED COS- POS MATRIX FORM

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	PSO-3	PSO-4
CO1	**3**	**1**	**2**	**2**	**3**	**3**	**2**	1	1	2	1
CO2	**3**	**2**	**2**	**3**	**3**	**3**	**2**	1	1	2	1
CO3	**3**	**3**	**2**	**3**	**3**	**2**	**2**	2	2	3	2
CO4	**3**	**2**	**2**	**3**	**3**	**2**	**2**	1	1	2	2
CO5	**3**	**1**	**1**	**2**	**3**	**3**	**2**	1	1	2	1
Legends:- High:03, **Medium:**02, **Low:**01, **NoMapping:** - *PSOs are to be formulated at the institute level											

XI. SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	H. Partab	Modern Electric Traction	Dhanpat Rai & Sons, New Delhi, ISBN:1234567147206
2	J. Upadhyay, S. N. Mahendra	Electric Traction	Allied Publishers Pvt. Ltd. ISBN-10. 8177640054
3	J.B. Gupta	Utilization of Electric Power and Electric Traction	S.K. Kataria & Sons, New Delhi, ISBN:978-9350142585

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	http://www.railway-technical.com/	Railway Technnical Website
2.	http://www.irfca.org/faq/faq-elec.html	Electric Traction
3.	http://en.wikipedia.org/wiki/Railway_electrification_system	Railway Electrification
4.	http://en.wikipedia.org/wiki/Traction_substation	Traction Substation

Name & Signature:

Shri. Sunil Padmakar Date
Lecturer in Electrical Engineering

Mrs. Madhuri Hemant Bilgi
Lecturer in Electrical Engineering

(Course Experts)

Name & Signature:

Mr.R.U.Shelke
(Programme Head)

Dr.S.V.Bhangale

Name & Signature:

Shri.S.B.Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN ELECTRICAL ENGINEERING**
PROGRAMME CODE	**02**
COURSE TITLE	**RENEWABLE ENERGY TECHNOLOGY**
COURSE CODE	**EE51208**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARTION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL &TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE51208	RENEWABLE ENERGY TECHNOLOGY	DSE	03	00	02	01	06	03	03 Hr.	30	70	100	40	25	10	--	--	25	10	150

Total IKS Hrs for Term: Hrs
Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**-Self Learning Assessment
Legends: @-Internal Assessment, **#** - External Assessment,***#** - Online Examination,**@$** - Internal Online Examination
Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Renewable energy technology has a huge potential in mitigating climate change as well as the gap between power supply and demand and also creating job opportunities. Therefore, Government of India is focusing on the generation of electrical energy through renewable energy sources. This course is designed for diploma students to acquire skills in operating and maintaining the renewable energy technologies for its proper utilization.

III. COURSE LEVEL LEARNING OUTCOMES (COs)

Students will be able to achieve & demonstrate the following COs on completion of course based learning:

- **CO1** – Test the performance of the solar panels.
- **CO2** –Evaluate and maintain wind turbine systems
- **CO3** – Utilize small-capacity hydrogen systems for various applications with safety practices
- **CO4** – Maintain and evaluate biomass and biogas systems considering sustainability and energy output.
- **CO5** – Identify major components of the geothermal, ocean and small hydro power plants.
- **CO6--** Utilize fuel cell systems for various applications with safety practices .

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION I			
	UNIT-I Solar Power Technology (CL Hrs- 10, Marks-15)			
1.	**TLO 1.1** Define the given terminology related to solar radiation. **TLO 1.2** Calculate the given parameter related to solar radiation geometry. **TLO 1.3** Describe working principle of the given instrument used for solar radiation measurement. **TLO 1.4** Illustrate the working principle of solar cell using equivalent circuit. **TLO 1.5** Describe the concept of maximum power point using current intensity versus output voltage graph. **TLO 1.6** Calculate the electrical parameters of the given solar array arrangement. **TLO 1.7** Describe basic photovoltaic system using block diagram. **TLO 1.8** Describe working principle of given solar collector.	**Unit – 1 Solar Power Technology** **1.1** Solar radiation: Beam radiation or direct radiation, diffused radiation, insolation, absorption. **1.2** Solar radiation Geometry: Declination, hour angle, altitude angle, incident angle, zenith angle, solar azimuth angle, surface azimuth angle, day length, local solar time. **1.3** Instruments for measuring solar radiation: Pyrheliometer, Pyranometer, Sunshine recorder; Working principle, types. **1.4** Principle of conversion of solar radiation into electricity and heat **1.5** Solar Cell: Working Principle, Equivalent Circuit, Current intensity versus output voltage graph **1.6** Solar Cell modules and arrays: Solar cell connecting arrangements **1.7** Basic Photovoltaic system for power generation: Concept and Block Diagram **1.8** Flat plate collectors: Typical liquid collector, Solar Air Heaters; Construction, Working Principle and applications and advantages. **1.9** Solar concentrating collectors: Focusing Type, Non-Focusing Type; Working Principle and applications **1.10** Safety & maintenance practices for rooftop installations.	Chalk-Board, Demonstrations, Power point presentation, Industry Visit	CO1
	Unit II Wind Power Technology (CL Hrs- 08, Marks-12)			
2	**TLO 2.1** Define the given terms related to wind power. **TLO 2.2** Describe the principles applicable in the wind turbine rotation. **TLO 2.3** Derive expression for governing wind power. **TLO 2.4** State the criteria for site selection of wind energy conversion system.	**2.1** Basic terminologies: Cut-in, cut-out and survival wind speeds, Threshold wind speeds, Power in wind, Power coefficient, Maximum power and Betz Limit **2.2** Wind Turbine Rotation Principles: Forces on the blades, lift and drag, thrust and torque on wind turbine rotor **2.3** Mathematical Expression Governing Wind Power **2.4** Site selection consideration	Chalk-Board, Demonstrations, Power point presentation, Industry Visit	CO2

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	TLO 2.5 Describe wind energy conversion system using block diagram. **TLO 2.6** Describe the given type of wind mill system. **TLO 2.7** Describe wind electric conversion system block diagram. **TLO 2.8** Describe working principle of variable speed and constant frequency scheme**.** **TLO 2.9** Describe pitch control and yaw control. **TLO 2.10** Describe Wind Farm layout design concept,offshore wind turbines, direct drive systems	**2.5** Wind energy conversion system (WECS): Concept, Block diagram, Working principle **2.6** Wind mill: Horizontal axial, Vertical axial, small and large wind turbine **2.7** Wind power generators: Permanent Magnet DC Generator, Synchronous Generator, Squirrel-Cage rotor Induction Generator (SCIG), Doubly-Fed Induction Generator (DFIG); working principle **2.8** Gearbox arrangement **2.9** Variable speed and constant frequency scheme – Concept and working principle **2.10** Pitch system: Pitch Control and Yaw control **2.11** Wind Farm layout design concept,offshore wind turbines, direct drive systems		
UNIT-III Hydrogen Energy and Fuel cell (CL Hrs- 04, Marks-08)				
3	**TLO 3.1** Describe the given hydrogen production method. **TLO 3.2** Describe the hydrogen storage and transportation method. **TLO 3.3** Compare hydrogen with the other given fuel source(s). **TLO 3.4** Describe the hazards and its preventive measures related to hydrogen storage and transportation.	**3.1** Hydrogen Production: Electrolyser, Thermochemical Method, Coal Gasification, Photo-electrolysis; Working principle **3.2** Hydrogen Storage and transportation: Need, methods, limitations **3.3** Hydrogen as an alternative fuel for motor vehicle **3.4** Comparison of hydrogen over other fuels **3.5** Handling of Hydrogen: Hazard and its Preventive measures	Chalk-Board, Demonstrations, Power point presentation, Industry Visit	CO3
SECTION II				
Unit IV Biomass Energy (CL Hrs- 08, Marks-12)				
4	**TLO 4.1** Describe the given biomass conversion process. **TLO 4.2** State the materials used for biomass generation. **TLO 4.3** Describe the factors affecting the biomass generation. **TLO 4.4** Describe the given biogas plant using schematic diagram. **TLO 4.5** State the criteria for selection of site for the biogas plant. **TLO 4.6**Introduction waste-to-energy concepts and urban biogas plants	**4.1** Biomass conversion Process: Anaerobic digestion, Ethanol Fermentation, Pyrolysis, Digestion, Gasification, Hydrolysis **4.2** Materials used for Biogas generation **4.3** Factors affecting Biomass generation **4.4** Classification of Biogas Plant: Continuous and Batch type; Dome and Drum type **4.5** Biogas Plants: KVIC digester; Schematic diagram, construction; Chinese Digester; Concept; Pragati Biogas plant; Schematic diagram, working Principle **4.6** Selection of site for Biogas plant **4.7** waste-to-energy concepts and urban biogas plants	Chalk-Board, Demonstrations, Power point presentation	CO4

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
Unit V Other Renewable Sources of Energy (CL Hrs- 10, M arks-15)				
5	**TLO 5.1** Describe the general arrangement of the given type of geothermal power plant., its working **TLO 5.2** State the types of ocean energy power plant. **TLO 5.3** Describe the general arrangement of the given type of ocean energy power plant, its working **TLO 5.4**. Describe the general arrangement of the given type of small hybride power plant , its working principle **TLO 5.5** State the site selection criteria for the small hydroelectric power plant.	**5.1** Geothermal power plant: General arrangements, types (Dry type, Wet Type and Binary type), working principle, advantages and limitations **5.2** Ocean Energy: Ocean Thermal Electric Conversion, Tidal energy, wave energy, marine current; General arrangement and working principle, Prospects in India,Introduction to modern technologies in ocean energy like oscillating water columns **5.3** Hybrid systems (e.g., solar + wind + hydro) for off-grid power **5.4** Site selection for the Small Hydroelectric Power Plant	Chalk-Board, Demonstrations, Power point presentation	CO5
Unit VI Fuel cell (CL Hrs- 05, Marks-08)				
6	**TLO 6.1** Define the given terminology related to fuel cell. **TLO 6.2** Describe the fuel cell system. **TLO 6.3** Describe the resistance polarization in fuel cell. **TLO 6.4** List latest applications in automotive and industrial sectors	**6.1** Fuel cell: Terminology, working principle, types, main components of fuel cell system, advantages, disadvantages and applications **6.2** Polarization in fuel cell: Concept, Resistance polarization **6.3** latest applications in automotive and industrial sectors		CO6

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /TutorialTitles	Number of hrs.	Relevant COs
1.	**LLO 1.1** Measure current, voltage and power output of the solar cell/panel. **LLO 1.2** Measure current, voltage and power output of the solar panel for shadow effect	Measurement of electrical parameters of the solar cells/panel.	02	CO1
2.	**LLO 2.1** Measure the current, voltage and power output of the solar panel connected to variable resistive/inductive load. **LLO 2.2** Locate the maximum power generation point by analysing the graph of I-V Curve/Resistive load.	Effect of load and inclination angle on solar panel output	02	CO1

	LLO 2.3 Measure power output of the solar panel at different inclination angles. **LLO 2.4** Locate the maximum power generation point by analysing the graph versus inclination angle. **LLO 2.5** Perform case study on India's solar mission or local solar projects.	A case study on India's solar mission or local solar projects.		
3.	**LLO 3.1** Connect solar panels in series and parallel combination. **LLO 3.2** Measure voltage and current of the solar panels by connecting solar panels in series and parallel.	Series parallel connection of solar panels.	02	CO1
4.	**LLO 4.1** Design solar panel for the residential load. **LLO 4.2** Prepare layout for the installation of solar system. **LLO 4.3** Demonstrate hazard handling simulations and safety protocol training	Sizing of Solar panels required for a residential house having 500 W electrical load. Introduction to hazard handling simulations and safety protocol training	02	CO1
5.	**LLO 5.1** Measure wind speed at different meters at different heights and locations. **LLO 5.2** Perform a case study on Indian wind parks	Measurement of windspeed at different heights and locations. A Case study on Indian wind parks	02 04	CO2 CO2
6.	**LO 6.1** Identify different wind turbine. **LLO 6.2** Different models of small wind turbine.	Components of small wind turbine (Horizontal axis / Vertical axis).	02	CO2
7.	**LO 7.1** Measure output voltage and power for reverse type of induction generator for different wind speeds.	Performance of Induction Generator.	02	CO2
8.	**LLO 8.**1 Identify different components of fuel cell by dismantling experiment in lab. **LLO 8.2** Assemble the fuel cell kit and measure electrical parameters. **LLO 8.**3 Identify different components of hydrogen energy plant	Demonstration of hydrogen fuel cell	04	CO3/ CO6
9.	**LLO 9.1** Observe the output of biogas plant (Video /Demonstration/Actual Plant Visit).	Demonstration of biogas operated plant. OR Visit to biogas operated Plant.	02	CO4
10.	**LLO 10.1** Identify different components of geothermal power plant.	Demonstration of geothermal power plant using video/animation.	02	CO5
11.	**LLO 11.1** Prepare a report on tidal and wave power plant.	Demonstration of tidal and wave power plant using video / animation.	02	CO5
12.	**LLO 12.1** Prepare a report on marine current energy conversion.	Demonstration of marine current energy conversion / OTEC plant using video / animation.	02	CO5

13.	**LLO 13.1** Identify different components in small hybride power OR Prepare a report on small hybride power plant.	Demonstration of small/mini hybride power plant using video / animation. OR Visit to small hybride power plant.	02	CO5
14.	**LLO14.1** Visit to Hydrogen Energy system /Fuel Cell	Visit to Hydrogen Energy /Fuel Cell	04	CO3/ CO6

VI. SUGGESTED MICRO PROJECT / ASSIGNMENT / ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING) :

Suggested Activities

- Numerical based on governing of wind power.
- Prepare a report on potential of hydrogen as a fuel for vehicles.
- Prepare a report on effect of shadow on output parameters of solar panel.
- Numerical based on parameter related to solar radiation geometry.
- Design the solar system for a small residential premises.
- Prepare a report on cleaning and maintenance of solar panel system installed on a small residential premises.

VII. LABORATORY EQUIPMENT /INSTRUMENTS / TOOLS / SOFTWAREREQUIRED: NA

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION - I								
1	**I**	Solar Power Technology	CO1	10	05	05	05	15
2	**II**	Wind Power Technology	CO2	08	04	04	04	12
3	**III**	Hydrogen Energy	CO3	04	02	04	02	08
SECTION - II								
4	**IV**	Biomass Energy	CO4	08	04	04	04	12
5	**V**	Other Renewable Sources of Energy	CO5	10	05	05	05	15
6	**VI**	Fuel Cell	CO6	05	02	04	02	08
Grand Total				**45**	**22**	**26**	**22**	**70**

IX.. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessmentfor Learning)	Summative Assessment (Assessmentof Learning)
Two unit tests of 30 marks will be conducted and the average of two unit tests considered. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering the appropriate % weightage to process and product and other instructions of assessment.	End semester assessment of 70 marks through offline mode of examination.

X. SUGGESTED COS- POS MATRIX FORM

CourseOutcomes (COs)	ProgrammeOutcomes (POs)							ProgrammeSpecificOutcomes* (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	PSO-3	PSO-4
CO1	3	1	2	3	3	2	3	3		2	2
CO2	3	1	2	3	3	2	3	2		1	2
CO3	3	1	2	3	3	2	3	1	1	1	2
CO4	3	1	3	3	3	2	3	2		1	2
CO5	3	1	3	3	3	2	3	2		2	2
CO6	3	1	2	3	3	2	3	1	1	1	2

Legends:-High:03, **Medium:**02, **Low:**01, **NoMapping:**-
*PSOsaretobeformulatedatthe institutelevel

XI . SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Chetan Singh Solanki	Renewable Energy Technologies - A Practical guide for beginners	PHI Learning Pvt. Ltd. ISBN: 9788120334342
2	S.P. Sukhatme, Nayak J. K	Solar Energy: Principles of Thermal Collection and Storage	McGraw-Hill Education (India) ISBN: 978-0074519462
3	Chetan Singh Solanki	Solar Photovoltaic: Fundamentals, Technologies and Application	PHI Learning Pvt. Ltd. ISBN: 9788120351110, eBook ISBN: 9789390544448
4	Joshua Earnest, Tore Wizelius	Wind Power Plants and Project Development	PHI Learning Pvt. Ltd. ISBN: 978-81-203-5127-1
5	D.P. Kothari, K.C. Singal, Rakesh Ranjan	Renewable Energy Sources and Emerging Technologies	PHI Learning Pvt. Ltd. ISBN: 978-81-203-4470-9
6	Chetan Singh Solanki	Solar Photovoltaic Technology and System: A Manual for Technicians, Trainers and Engineers	PHI Learning Pvt. Ltd. ISBN: 978-81-203-4711-3
7	G.D. Rai	Non Conventional Energy Sources	Khanna Publishers, ISBN: 978-8174090737

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	https://www.youtube.com/watch?v=jswDvFzGoO4	50 MW Solar Power Plant for NTPC at Rajgarh, Madhya Pradesh
2.	https://archive.nptel.ac.in/courses/108/108/108108078/	Non-Conventional Energy Systems by Prof. L. Umanand (IISc Bangalore)
3.	https://archive.nptel.ac.in/courses/103/103/103103206/	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems by Prof. R. Anandalakshmi and Prof. Vaibhav Vasant Goud (IIT Guwahati)
4.	https://archive.nptel.ac.in/courses/103/107/103107157/	Technologies For Clean And Renewable Energy Production by Prof. P. Mondal (IIT Roorkee)
5	https://archive.nptel.ac.in/courses/121/106/121106014/	Non-Conventional Energy Resources by Dr. Prathap Haridoss (IIT Madras)
6	https://www.lccc.edu/science-in-motion/labs-equipment/renewable-energy-lab-experiments	Renewable Energy Lab Experiments

Name & Signature:

Shri. Sunil Padmakar Date
Lecturer in Electrical Engineering

Smt. Vaishali Prasad Karhad
Lecturer in Electrical Engineering

(Course Experts)

Name & Signature:

Mr.R.U.Shelke **Dr.S.V.Bhangale**
(Programme Head)

Name & Signature:

Shri.S.B.Kulkarni
(CDC In-charge)

GOVERNMENTPOLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN EE**
PROGRAMME CODE	**02**
COURSE TITLE	**CAPSTONE PROJECT**
COURSE CODE	**EE41207**
PREREQUISITE COURSE CODE & TITLE	**ACQUIRED MINIMUM OF 60 CREDITS**
CLASS DECLARATION COURSE	YES

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
EE41207	**CAPSTONE PROJECT**	**INP**	**--**	**--**	**--**	**4**	**--**	**2**	**--**	**--**	**--**	**--**	**--**	**--**	**50**	**20**	**50#**	**20**	**--**	**100**

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative Assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, # - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing the minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that Course.
2. If a candidate does not secure the minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit the SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Project work at the institute level serves as a vital bridge between theoretical learning and practical application. It offers students a valuable platform to apply the concepts, knowledge, and technical skills acquired in classrooms and laboratories to address real-world problems—ranging from well-defined tasks to complex, open-ended challenges. This experiential learning approach fosters a deeper understanding of engineering and technological principles by encouraging students to design, develop, and implement solutions in realistic contexts.

The course is strategically designed to integrate interdisciplinary knowledge gained throughout the diploma program, thereby enhancing students' ability to approach problems holistically. Furthermore, it plays a crucial role in nurturing essential professional competencies such as critical thinking, problem-solving, creativity, teamwork, project planning, and innovation.

In alignment with industry and societal expectations, students are encouraged to undertake projects that go beyond conventional solutions and aim to provide impactful, sustainable outcomes. By engaging in such projects, students not only reinforce their technical capabilities but also improve their employability by developing a mindset geared towards innovation, collaboration, and continuous improvement.

III. INDUSTRY EXPECTED OUTCOME

This course is designed to enable students to develop the industry-relevant competency of:

Effectively executing innovative solutions to real-world problems through collaborative teamwork, adhering to defined timelines, and delivering a well-documented project report.

IV. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify real-world field problems relevant to the project work conducted at the institute.
CO2: Analyse the feasibility and viability of the project by conducting data collection and experiments, as well as evaluating required resources, costs, and support.
CO3: Apply technical knowledge and engineering skills to develop effective solutions for real-life or industrial problems.
CO4: Evaluate the proposed project work's ethical considerations and societal impacts.
CO5: Create a comprehensive project report and present the methodology and results within the institute.
CO6: Demonstrate the project outcomes, findings, and achievements effectively through presentations and exhibits.

V. GENERAL GUIDELINES FOR PROJECT WORK

a) Project Selection and Scope

- The project must align with the field of engineering or technology. Interdisciplinary projects are permitted if expected to deliver outcomes aligned with industry relevance or societal needs.

Indicative Project Focus Areas:

i) Electrical Power Systems (Generation/ Transmission / Distribution)

- Designing and implementing renewable energy systems (solar, wind).
- Developing micro grids and exploring power generation from waste heat.
- Investigating smart grid technologies
- Improving power quality and developing fault detection and protection systems
- Solar wireless Electric vehicle charging system
- Solar Charger
- Underground cable fault distance locator

ii) Power Electronics

- Designing and analysing power converters, inverters and other electronic devices used in power systems

iii) Automation , Robotics Design and Control

- Designing and implementing robotic systems for various applications including industrial automation, exploration and heath care.
- Smart Home Automation system
- Smart Dustbin with Ultrasonic Sensor
- Developing and integrating sensors into robotic systems for sensing and data acquisition
- Electric vehicle charging systems
- Designing and implementing IoT devices for various applications such as environmental monitoring and smart agriculture
- Advance Wireless Power transfer system
- Smart Energy meter with load control over GSM

- Automatic smoke Detection and alarm system

- Students should select projects that match their skills, knowledge and interests. Faculty should support students in identifying suitable topics.
- Study-based (theoretical-only) projects are **not encouraged**. Projects should involve practical implementation.

i) Team Structure and Mentorship

- Each project must be executed by a group of 3–4 students under the guidance of an assigned faculty mentor.
- Faculty may organize teams based on:

  - Students' individual strengths and interests
  - Industry-relevant functional roles
  - Project requirements and scope
  - Balanced skill distribution among team members
  - Academic performance and specialization

ii) Nature and Type of Projects

Projects may involve:

- Hardware development
- Software development
- Combination of both

All projects must demonstrate logic building, problem-solving, and application of technologies learned during the diploma program.

Acceptable project formats include:

- Prototype design (design, build, test, and evaluate)
- Application/software development

iii) Project Execution and Documentation

- Students must develop a working model/prototype/software and simultaneously prepare a comprehensive project report.
- Submissions must include:
- One hard copy and one soft copy of the project report
- A soft copy of the source code or a demonstration video/file of the working model
- The project report should include (as applicable):
- Problem Definition
- Platform/Hardware Specifications
- Feasibility Study (Cost & Time Estimates)
- Design Diagrams (UML, Use Case, Activity, DFD, CFD, ERD, etc.)
- Key Code Snippets
- Testing Methodology and Results
- Limitations and Future Scope
- References (Books, Journals, Websites)

iv) Project Diary and Supervision

A project diary must be maintained by each group to log:

- Weekly progress and milestones
- Design decisions and challenges
- Faculty feedback and updates
- Faculty mentors should review the diary weekly and provide constructive feedback. The diary should be concise (5–10 pages) and follow the format outlined in Annexure IV.

v) Learning Outcomes Expected (As Applicable)

- Faculty should ensure students gain the following competencies through project execution:
- Identify and define real-world problems within their domain
- Investigate root causes and possible solutions
- Evaluate solution feasibility, including financial implications
- Gather and analyze data from reliable sources (e.g., books, web, experts, market)
- Develop required designs and execution plans
- Prepare and deliver effective seminar presentations.

vi) Industry-Sponsored Projects

- For industry-guided projects, implementation steps may vary per industry standards.
- However, students must still meet institutional submission criteria:
- Project report format
- Project diary
- Final demonstration
- Assessment based on institutional RUBRICs

b) National Relevance

Projects should ideally address national thrust areas such as:

- Environmental Sustainability
- Digitization
- Automation
- Renewable Energy
- Other relevant socio-technical development domains.

VI. COURSE IMPLEMENTATION STAGES

1. Orientation Session

A Project Orientation Session shall be conducted during the last week of the fourth term by the Portfolio In-charge faculty. This session will brief students on:

- Project objectives.
- Scope and expected deliverables
- Guidelines for execution and assessment
- Faculty and institutional support

2. Mapping of Students and Faculty Mentors

Students will be organized into teams and assigned faculty mentors based on the following criteria:

- Alignment of student interests
- Faculty expertise
- Team size and project scope.

3. Problem Identification and Finalisation

Students are required to:

- Conduct a field survey or exploratory study under faculty supervision
- Identify a real-world, relevant, and feasible problem
- present the idea to a group of faculty members for approval
- This activity should commence in the final week of the 4th semester and be completed by the first week of the 5th semester.

4. Requirement Gathering

A dedicated week is allotted for collecting detailed project requirements, including:

- Estimation of human resources
- Identification of technical (hardware/software) needs
- Feasibility study and cost analysis

Outcome: Students must present their findings to the faculty mentor for approval.

5. Project Planning

Students must prepare a comprehensive project plan covering:

- Task allocation and resource planning
- Time frame and cost estimation
- Team member responsibilities
- Selection of an appropriate development model (e.g., Waterfall, Agile, Spiral)

Deliverables: A clear roadmap including timelines, milestones, and expected outcomes.

6. Project Proposal Submission

The finalized project proposal must be submitted in **soft copy format** and should include:

- Project title and objectives
- Detailed requirement analysis
- Project plan and execution strategy
- Expected deliverables and outcomes
- Development model and tools to be used

7. Project Development, Testing & Report Preparation

Under the continuous guidance of faculty mentors, students shall:

- Develop the project according to the approved plan
- Maintain project documentation throughout the development lifecycle
- Prepare a detailed final report that includes:
  - System design and architecture
  - Implementation details
  - Testing procedures and results
  - Challenges encountered and solutions adopted
  - Final outcomes and evaluation metrics.

8. Project Demonstration

Students must present their project in two stages:

- **Preliminary Demonstration:** A progress review shown to the faculty guide during the development phase.
- **Final Demonstration:** A complete presentation of the working model or application during the End Semester Examination (ESE).

VII. DETAILED WEEKWISE TIMELINE FOR THE COURSE IMPLEMENTATION STAGES:

Week	Activity	Responsibilities
Week 1	**Orientation Session** (Last week of 4th Term)	Portfolio In-charge Faculty: Brief students on project objectives, scope, deliverables, guidelines, execution, and assessment.
Week 2	**Mapping of Students and Faculty Mentors**	Portfolio In-charge Faculty: Organize students into teams based on interests, faculty expertise, team size, and project scope.
Week 3-4	**Problem Identification and Finalisation**	Students: Carry out a field survey or exploratory study under faculty supervision, identify a relevant real-world problem, finalise the issue, and submit a synopsis for faculty approval.
Week 5	**Requirement Gathering**	Students: Collect detailed project requirements (human resources, technical needs, feasibility study, and cost analysis).
Week 6	**Requirements Gathering Presentation**	Students: Present findings to the faculty mentor for approval.
Week 7	**Project Planning**	Students: Prepare a project plan including task allocation, resource planning, timeline, budget, development model, and deliverables. Faculty Mentor: Review plan.
Week 8	**Project Proposal Submission**	Students: Submit final project proposal (title, objectives, requirements, plan, tools, outcomes). Faculty Mentor: Review and approve.

Week	Activity	Responsibilities
Week 9-12	**Project Development, Testing & Report Preparation**	Students: Begin project development according to the plan. Maintain documentation. Test and iterate. Prepare final report (design, implementation, testing results).
Week 13	**Preliminary Demonstration**	Students: Present a progress review to the faculty mentor.
Week 14	**Project Finalisation & Report Completion**	Students: Finalise development. Prepare a detailed project report with system design, testing results, challenges, and outcomes.
According to the Examination Schedule	**Final Demonstration (End Semester Examination)**	Students: Conduct final demonstration of the working model/application during the ESE. Faculty: Evaluate the project based on the demonstration and report.

VIII. CRITERIA FOR ASSESSMENT/EVALUATION OF PROJECT WORK

A. Formative Assessment (FA) Criteria

The evaluation of students during the fifth semester for Progressive Assessment (PA), totalling **50 marks**, will be carried out based on the following criteria:

Category	Week(s)	Assessment Criteria	Max Marks	Performance Description (Rubric Scale: 1 to 5)	Group Enrollment Nos.	Group Marks
i) Team Assessment (30 Marks)	Week 3-4	Project Selection & Problem Definition	5	2 – Lacks clarity and relevance 3 – Relevant and defined 4 - Clearly defined and suitable 5 – Innovative and impactful		
	Week 5	Literature Review & Data Collection	5	1 – Insufficient or irrelevant sources 2 – Limited data with unclear relevance 3 – Adequate review with relevant data 4 – Structured, relevant data 5 – Comprehensive and critically evaluated sources		

	Week 6	Project Design / Concept & Execution	10	1–2 Design is poorly structured; minimal or no execution 3–4 Weak concept, unclear goals, and limited execution 5–6 Basic concept with moderate execution; design may lack innovation or clarity 7–8 Solid, functional design with good planning and consistent execution 9–10 Creative, technically sound design with excellent planning and thorough execution		
	Week 7	Progress as per Action Plan / Milestones	5	1 – No measurable progress 2 – Progress is significantly behind schedule 3 – Moderate progress; some tasks completed 4 – Mostly on schedule with minor delays 5 – Fully on schedule and meeting milestones		
	Week 8	Quality & Presentation of Project Report	5	1 – Poorly organized and unclear 2 – Disorganized with formatting issues 3 – Fair structure and readability 4 – Well-organized and readable 5 – Professionally formatted and well-written report		

Category	Week(s)	Assessment Criteria	Max Marks	Performance Description (Rubric Scale: 1 to 5)	Individual Enrollment Nos.	Individual Marks
ii) Individual Assessment (20 Marks)	Week 2–13 (Ongoing)	Individual Contribution to the Team	10	1 -2 Rarely involved or shows minimal effort 3 -4 Occasionally contributes with limited involvement 4 –5 Participates adequately 6 – 7 Active and dependable team member 8 –10 Consistently proactive, often leads initiatives		
	Week 2–13 (Ongoing)	Subject Knowledge & Understanding	10	1–2 Very limited understanding of subject concepts; unable to answer questions 3–4 Basic awareness but with significant gaps in understanding 5–6 Fair knowledge of concepts; can answer general questions correctly 7–8 Good understanding of a subject; explains concepts clearly and applies them logically 9–10 Excellent grasp; demonstrates deep insight, applies concepts to real-world/project scenarios		
Total			**50**			

i) **Total Formative Assessment (FA) Marks**

Sr. No.	Assessment Criteria	Marks
1	Team Assessment	30
2	Individual Assessment	20
Total		**50**

Note: The Total **Formative Assessment (FA) Marks** for the individual student.

B. Summative Assessment Criteria

*The summative assessment for students in the Fifth Semester **SA-PR** will carry a total of **50 marks** and shall be conducted by the faculty. Appropriate rubrics may be developed by the faculty for evaluation.*

Course Name :		**Course Code :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Sr. No.	Week	Assessment Criteria	Max Marks	Performance Description (Score Range)	Marks
1	According to the Examination Schedule	**Knowledge and Skill Set Developed**	10	**1–2**: Minimal knowledge gained	
				3–4: Basic understanding with limited skills	
				5–6: Moderate knowledge and practical exposure	
				7–8: Sound knowledge and good skill application	
				9–10: Excellent grasp and skill mastery with advanced application	
2	According to the Examination Schedule	**Quality and Potential of the Project**	10	**1–2**: Poor quality, unclear purpose	
				3–4: Basic functionality with low impact	
				5–6: Adequate quality with moderate potential	
				7–8: High-quality, practical utility	
				9–10: Exceptional quality and strong potential for real-world implementation	

3	According to the Examination Schedule	**Creativity, Innovation, and Teamwork**	10	**1–2**: Lacks originality, poor collaboration	
				3–4: Limited creativity and uneven teamwork	
				5–6: Shows creativity and fair teamwork	
				7–8: Innovative and well-coordinated efforts	
				9–10: Highly original ideas with exemplary team synergy	
4	According to the Examination Schedule	**Project Design, Development, Execution**	10	**1–2**: Poor design and implementation	
				3–4: Basic structure with several gaps	
				5–6: Functional design and moderate execution	
				7–8: Well-planned and executed efficiently	
				9–10: Robust, optimized design with flawless execution	
5	According to the Examination Schedule	**Project Presentation**	10	**1–2**: Disorganized and unclear	
				3–4: Lacks confidence and structure	
				5–6: Acceptable delivery with room for improvement	
				7–8: Clear, engaging, and well-structured	
				9–10: Highly professional, confident, and impactful presentation	

Note: The above rubric will be used as the summative assessment framework for evaluating individual student performance.

IX. SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes (PSOs)	
	PO1 -Basic and Discipline-Specific Knowledge	PO2-Problem analysis	PO3-Design/ Development of Solutions	PO-4 Engineering Tools, Experimentation and Testing	PO-5 Engineering Practices for Society, Sustainability, and Environment	PO-6 Project Management	PO-7 Lifelong Learning	PSO-1	PSO-2
CO1	2	2	--	--	2	2	2	--	--
CO2	2	3	2	2	--	3	2	2	2
CO3	3	3	3	3	2	2	2	3	3
CO4	--	--	--	--	3	2	2	--	--
CO5	2	2	2	2	--	3	2	--	--
CO6	2	2	2	2	2	3	3	--	--

X. TYPOGRAPHICAL GUIDELINES FOR PROJECT REPORT WRITING:

After the completion of the project work, each student is required to submit a project report. The report should adhere to the following structure and formatting guidelines:

A. STRUCTURE OF THE REPORT

The project report must include the following sections in the given order:

1. **Cover Page** – As per *Annexure I*.
2. **Title Page** – As per *Annexure I*.
3. **Certificate** – As per *Annexure II*.
4. **Acknowledgment** – A brief section in which the student may express gratitude to individuals and organizations who supported the project. As per *Annexure III*.
5. **Abstract** – A one-page summary outlining the objective of the project and the methodology adopted. As per *Annexure IV*.
6. **Table of Contents** – Prepared as per general guidelines. As per *Annexure V*.
7. **List of Figures-**The **purpose of the List of Figures** in a project report is to provide a clear and organized index of all visual representations used throughout the document. As per *Annexure VI*
8. **List of Tables -**The **purpose of the List of Tables** in a project report is to provide a structured overview of all tabular data included in the document. As per *Annexure VI*
9. **Project Description** –
   - Divided into chapters or sections.
   - Each chapter should comprehensively describe a specific phase or component of the project.
   - Include properly labelled diagrams, tables, and flowcharts wherever applicable.
10. **Conclusion** – Summarizes findings and outcomes of the project work.
11. **References** –
    - Begin two spaces below the heading "**REFERENCES**", aligned to the left.
    - Use **single spacing** within entries and list in **alphabetical order**.

- References must be cited in the text using **square brackets [ ]**, numbered according to their first appearance.
- Include author name(s), publication year, and other relevant details.

B. REPORT SPECIFICATIONS

1. **Binding**: Hard-bound only
2. **Cover Color**: Black with gold-embossed text (as per *Annexure 1*)
3. **Number of Copies**: Five – One per student and one departmental copy

Paper Size: A4 (portrait orientation)

4. **Margins**:
   - Top: 1 inch
   - Bottom: 1 inch
   - Right: 1 inch
   - Left: 1.5 inches
5. **Font Style**: Times New Roman
6. **Font Sizes**:
   - **Chapter Titles:** 16-point**, Bold, Uppercase**
   - **Headings:** 14-point, **Bold**
   - **Body Text:** 12-point, **Regular**
7. **Line Spacing**: 1.5 throughout the report
8. **Page Numbering**: Bottom center in the format "Page X of N"

Annexure-I

GOVERNMENT POLYTECHNIC, PUNE

(An Autonomous Institute of the Government of Maharashtra)

DEPARTMENT OF ELECTRICAL ENGINEERING

PROJECT REPORT

ON

"[TITLE OF THE PROJECT IN CAPITAL LETTERS]"

Submitted By

Student name 1 (enrollment no.)
Student name 2 (enrollment no.)
Student name 3 (enrollment no.)
Student name 4 (enrollment no.)

UNDER THE GUIDANCE OF
[Guide's Full Name]
(Designation, e.g., Lecturer, Department of Electrical Engineering)

Submitted in Partial Fulfilment

of

The Requirements for the Award of the Diploma in

ELECTRICAL ENGINEERING

ACADEMIC YEAR: 20__–20__

GOVERNMENT POLYTECHNIC, PUNE, Ganeshkhind Road, Shivajinagar, Pune – 411016

Annexure-II

GOVERNMENT POLYTECHNIC, PUNE

(An Autonomous Institute of the Government of Maharashtra)

DEPARTMENT OF ELECTRICAL ENGINEERING

CERTIFICATE

This is to certify that

1)Name of Student	Enrollment Number
2)Name of Student	Enrollment Number
3)Name of Student	Enrollment Number
4)Name of Student	Enrollment Number

has completed the necessary project work and prepared the bonafide report on

"PROJECT TITLE"

in a satisfactory manner as a partial fulfillment of the requirements for the

DIPLOMA IN

ELECTRICAL ENGINEERING

FOR THE ACADEMIC YEAR

20__- 20__

(Internal Guide) **(External Examiner)**

(H.O.D) **(Principal)**

Annexure-III

Acknowledgment

(Sample Format)

We would like to express our sincere gratitude to all those who supported and guided us throughout the successful completion of this project.

We are especially thankful to **[Guide's Name]**, our project guide, for their constant encouragement, valuable suggestions, and constructive feedback during the entire duration of this project work.

We would also like to thank **[Head of Department's Name]**, Head of the Department of **[Branch Name]**, Government Polytechnic, Pune, for providing us with the necessary infrastructure and support.

We are deeply grateful to **[Principal's Name]**, Principal, Government Polytechnic, Pune, for providing us with this valuable opportunity and for fostering an academic environment conducive to learning and innovation.

Our heartfelt thanks go to all the faculty members and technical staff of the **[Department Name]** for their help in various ways during this project.

We also wish to acknowledge the support of our classmates, friends, and family members who encouraged and motivated us throughout the journey.

Lastly, we are thankful to the **Government Polytechnic, Pune**, for allowing us to work on this project as a part of our academic curriculum.

Student name 1 (enrollment no.)
Student name 2 (enrollment no.)
Student name 3 (enrollment no.)
Student name 4 (enrollment no.)

Annexure-IV

Abstract

The abstract serves as a one-page comprehensive summary that encapsulates the core aspects of the project. It begins by clearly stating the primary objective or goal of the work, providing the reader with an understanding of the problem being addressed or the purpose behind the study. Following this, the abstract outlines the methodology employed, detailing the approach, techniques, tools, and processes used to achieve the project's objectives. This section may also briefly touch on the scope of the work, key findings, and any conclusions or implications derived from the results. The abstract offers a concise yet informative overview, enabling readers to quickly grasp the essence and significance of the project without delving into the full report.

Annexure-V

Table of Contents

Annexure-VI

List of Figures

List of Tables

Annexure-VII
PROJECT DAIRY

Course code :		**Course Name :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Date	Enrollment Numbers of Present Students	Work Assigned/Corrections Suggested	Faculty Remarks	Faculty Signature

Signature of Faculty **Signature of HOD**

Name & Signature:		
Smt. Tejeshree J Bhangale Lecturer in Electrical Engineering	**Shri. S.B. Kulkarni** Lecturer in Mechanical Engineering (Course Expert)	**Dr. N. G. Kulkarni** HoD in Mechanical Engineering
Name & Signature:		Name & Signature:
Shri. R. U. Shelke (Programme Head)	**Dr. S V Bhangale**	**Shri. S.B. Kulkarni** (CDC In-charge)