

GOVERNMENT POLYTECHNIC MUMBAI
(Academically Autonomous Institute, Government of Maharashtra)
Teaching and Examination Scheme (P23) With effect from AY 2023-24

Programme: Diploma in Electrical Engineering (Sandwich Pattern) Term / Semester - IV

SN	Course Title	Course Type	Course Code	Total IKS Hrs for Sem	Learning scheme				Credits	Assessment Scheme															Total Marks
					Actual Contact Hrs/Week			Self Learning / Week		Notional Learning Hrs / Week	Paper Duration (Hrs)	Theory						Based on LL & TL				Based on Self Learning			
																		Practical				SLA			
												FA TH		SA TH		Total		FA-PR		SA-PR		SLA			
					T1	T2								Max											
					Max	Max	Max	Min		Max	Min	Max	Min	PR	OR	Min	Max	Min							
1	Utilization of Electrical Energy	DSC	EE23108	1	4		2		6	3	2.30	20	20	60	10	100	40	25	10		25#	10			150
2	AC Machines	DSC	EE23109	2	4		2	2	8	4	2.30	20	20	60	10	100	40	25	10	25#		10	25	10	175
3	Fundamentals of Power Electronics	DSC	EE23110	1	4		2	2	8	4	2.30	20	20	60	10	100	40	25	10	25#	-	10	25	10	175
4	Electrical Estimation & Costing	DSC	EE23111	1	4	-	2	2	8	4	2.30	20	20	60	10	100	-	-	-	-	25#	10	25	10	150
5	Entrepreneurship and Start Up	VEC	EE23502	1	-		2	2	4	2							25	10	-	25#	10	25	10	75	
6	Internet of Things (IoT)(Optional)	IDE	EE23701	1	4		2	-	6	3	2.30	20	20	60	10	100	40	25	10	-	25#	10	-	-	150
	Advanced Renewable Energy Sources (Optional)	DSE	EE23201	1	4		2	-	6		2.30	20	20	60	10	100	40	25	10	-	25#	10	-	-	150
	Total			8	20		12	8	40	20		100	100	300		500		125		50	100	-	100		875

Abbreviations : CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessment , SA -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends : @ Internal Assessment, # External Assessment, *# On Line Examination , @\$ Internal Online Examination

Note :1. FA-TH represents two class tests of 20 marks each conducted during the semester.

2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.

3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.

4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 16 Weeks

5. 1 credit is equivalent to 30 Notional hrs.

6. * Self learning hours shall not be reflected in the Time Table.

7. Students must secure a **minimum of 40 marks out of 100** for passing the course, It shall be **mandatory to obtain a minimum of 10 marks out of 60** in the End Term Theory Examination separately.

Course Category: Discipline Specific Course Core (DSC) : 1, Discipline Specific Elective (DSE) : 2, Value Education Course (VEC) : 3, Intern./Apprentice./Project./Community (INP) : 4, Ability Enhancement Course (AEC) : 5, Skill Enhancement Course (SEC) : 6, Generic Elective (GE) / [Inter Disciplinary Elective (IDE): 7

Department coordinator
Curriculum Development, Dept. of Electrical Engg

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Principal
Govt. Polytechnic, Mumbai

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CDC Co-ordinator
G. P. Mumbai

Programme : Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 108						Course Title: Utilization of Electrical Energy							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	--	6	3	20	20	60	25	--	25#	--	150

Total IKS Hrs. for course:

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

The electrical supervisors / technicians are expected to possess knowledge of utilization of electrical energy especially in the industry. Their main job functions are to supervise the operation & control of various electrical drives, electrical furnaces, etc. Railway is one of the major employers of Electrical Diploma holders therefore Diploma holder should also study the Electric Traction system. This course deals with utilization of electrical energy in various industries.

II. Industry / Employer Expected Outcome: Operate various electrical utilities used for industrial and commercial applications.

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

CO1	Identify suitable methods of Electric Heating for specific applications.
CO2	Operate the different electric welding system.
CO3	Select suitable electric drive for specific application
CO4	Identify the types of electric supply system for Electric Traction
CO5	Understand basic concept & types of Elevator & Escalators.

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Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1.1 Explain construction, working principle and classification of the specified electrical heating system. TLO 1.2 Recommend the relevant heating system for the given application with proper justification. TLO 1.3 Design the heating element of the given type of furnace from the specified data. TLO 1.4 Solve simple numerical on estimation of size of induction furnace TLO 1.5 Explain working principle, application of dielectric heating	1: Electric Heating 1.1 Advantages of Electric Heating. 1.2 Modes of Transfer of Heat 1.3 Classification of Electric Heating 1.4 Resistance Heating: Construction & Operation of Direct Resistance Heating - Salt Bath Furnace, Indirect Resistance Heating: Resistance Ovens, Requirements of Heating Element Material, Causes of Failure of Heating Elements, Methods of Temperature Control, Applications of Resistance Heating, Design of Heating Element. (Simple Numerical problems on heating elements) 1.5 Arc Heating: Electrical properties or characteristics of an electric arc, effects of arc length. Construction & Operation of Direct Arc Furnace, Indirect Arc Furnace. Applications of Arc Heating 1.6 Induction Heating - Construction & Operation of Core Type Induction Furnaces: Ajax Wyatt Furnace, Coreless Induction Furnace, Applications of Induction Heating, High frequency eddy current heating. Infrared heating, Estimation of Heat data. (Simple Numerical problems on rating of furnace.) 1.7 Dielectric Heating: Principle of Dielectric Heating, Advantages of Dielectric Heating 1.8 Limitations of Dielectric Heating, Applications of Dielectric Heating (Simple Numerical problems on Dielectric Heating) Course Outcome : CO1 Teaching Hours :14 hrs Marks: 14
2	TLO 2.1 Select the relevant welding system for the specified application with justification. TLO 2.2 Describe the working principle and construction of special type of transformer used in welding. TLO 2.3 Describe the working principle of Electric Welding and its types TLO 2.4 State the applications of modern welding techniques	2 : Electric Welding 2.1 Methods of Electric Welding – Electric arc welding, resistance welding. 2.2 Resistance Welding – Principles, types of resistance welding. Advantages, disadvantages of resistance welding 2.3 Electric Arc Welding- Principles, Types, advantages, disadvantages & applications of all types. 2.4 Comparison with resistance welding & Electric Arc Welding 2.5 Modern welding techniques like Ultrasonic, Laser, under water welding, IGBT controlled welding. Course Outcome: CO2 Teaching Hours : 8 Marks : 10

- 3** TLO3.1 Differentiate the salient features between the given types of electric drives.
TLO 3.2 Recommend the relevant motor for the given application with justification.
TLO 3.3 Select the relevant enclosure for the given atmospheric condition with justification.
TLO 3.4 Select the power transmission drive of the electric motor for the given application with justification.
TLO 3.5 Estimate the relevant size and rating of electric motor for the specified load cycles.

3 : Electric Drives

- 3.1 Definition and block diagram of Electric Drive
- 3.2 Advantages and Disadvantages of Electric Drive.
- 3.3 Factors Governing Selection of Electric Motors, Types of Electric Drive.
- 3.4 Nature of Load: Nature of the Mechanical Load, Matching of the Speed Torque Characteristics of the Motor with that of the Load
- 3.5 Braking Characteristics - Plugging, Rheostatic Braking and Regenerative Braking, as Applied to Three Phase Induction Motor.
- 3.6 Mechanical Features - Type of Enclosure as per IS, Type of Bearings, Type of Transmission for Drive, Noise Level.
- 3.7 Load Conditions - Continuous Loads, Short Time Loads, Intermittent Loads, and Continuous Operation with Intermittent Loads.
- 3.8 Factors affecting size of Motor (Simple numerical).
- 3.9 Load equalization meaning & means of obtaining it (no calculations).

Course Outcome: CO3

Teaching Hours : 12 Marks: 12

- 4** TLO 4.1 Recommend relevant traction system for the given application with justification.
TLO 4.2 Select the relevant track electrification system for the specified traction services with justification.
TLO 4.3 Differentiate the salient features between the given types of track electrification system.
TLO 4.4 Draw the speed -time curve for the specified electric traction application.
TLO 4.5 Differentiate between the given types of traction services based on the given criteria.
TLO 4.6 Determine average and schedule speed for the given traction service.

4: Electric Traction

- 4.1 Introduction to Traction System, Requirements of an Ideal Traction System, Non-electric Traction Systems, Electric Traction Systems, Advantages and Disadvantages of Electric Traction Systems.
- 4.2 Systems of Track Electrification
- 4.3 Block diagram of AC locomotives by using three phase Induction Motor with description of various equipment and accessories
- 4.4 Single and compound catenary construction in railways.
- 4.5 Traction Mechanics: Types of services, speed time curve, simplified speed time curve, Definition of Crest speed, Average speed scheduled speed and schedule time. Factors affecting schedule speed, analysis of trapezoidal and quadrilateral speed time curve (No derivation, simple numerical on it)
- 4.6 Tractive effort (No derivation only formula) Specific energy consumption, Factors affecting specific energy consumption, coefficient of adhesion, factors affecting on coefficient of adhesion.
- 4.7 Working principal, advantages and disadvantages of Mono Rail and Metro Railways
- 4.8 Introduction of Hyperloop train
- 4.9 Introduction of DMU and EMU

Course Outcome: CO4

Teaching Hours : 16 Marks: 14

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5	TLO5.1 Describe Components of Elevator TLO5.2 Explain Working of Elevator TLO5.3 Enlist Types of Electric Elevators TLO5.4 Describe Components of Escalator TLO5.5 Explain Working of Escalator TLO5.6 Enlist Types of Escalators TLO5.7 Compare Elevator and Escalator TLO5.8 Explain Maharashtra Lifts, Escalators and Moving Walks Act, 2017	5: Elevators & Escalators 5.1 Introduction 5.2 Components of Elevators 5.3 Working of Elevator 5.4 Types of Electric Elevators 5.5 Advantages and Dis-advantages of Elevators 5.6 Components of Escalator 5.7 Working of escalator 5.8 Types of escalator 5.9 Advantages and Dis-advantages of Escalators 5.10 The Maharashtra Lifts, Escalators and Moving Walks Act, 2017
	Course Outcome: CO5 Teaching Hours : 10 Marks: 10	

IV. List of Laboratory Experiment. (Minimum 10)

Sr No	Laboratory outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Identify component of electrical heating furnace	Prepare a report on electrical heating furnace after visiting industry / laboratory/internet survey	2	CO1
2	LLO 2.1 Identify component of welding transformer	Prepare a report on welding transformer after visiting industry / laboratory/internet survey	2	CO2
3	LLO 3.1 Solve the numerical on size or rating of motor	Numerical on size or rating of motor	4	CO3
4	LLO 4.1 Observe component used in traction sub-station LLO 4.2 Observe Control system used in traction sub-station	Prepare a report on your visit to nearby electric traction sub-station.	4	CO4
5	LLO 5.1 To observe different types of elevators	Prepare a report by observing different types of elevators at various sites / locations/ internet survey	4	CO5
6	LLO 6.1 To observe different types of escalators	Prepare a report by observing different types of escalators at various sites / locations/ internet survey	4	CO5
7	LLO7.1 Observe various equipment's and accessories used in AC Locomotives	Prepare a report on various equipment's and accessories used in AC Locomotives	4	CO4
8	LLO8. Describe dielectric heating oven.	Prepare report on dielectric heating oven.	2	CO1
9	LLO 9.1 Explain welding generator	Prepare report on welding generator	2	CO2
10	LLO10.1 Compare Metro and Mono Rail for public transport.	Prepare a report by comparing Metro and Mono Rail for public transport.	2	CO4
11	LLO11.1 Explain Ultrasonic, Laser & under water welding	Prepare a report on Ultrasonic, Laser & under water welding	2	CO2
12	LLO 12.1 Demonstrate of ARC welding and noting down the specifications of equipment used.	Demonstration of ARC welding and noting down the specifications of equipment used.	2	CO2

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I. List of Tutorial

NIL

II. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 5)

NA

III. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Electric Heating	2	4	8	14
2	Electric Welding	2	4	4	10
3	Electric Drives	--	4	8	12
4	Electric Traction	2	8	4	14
5	Elevators & Escalators	2	6	2	10
Total		08	26	26	60

IV. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce, Workshop performance (25 marks)

V. 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
CO1	3	2	3	3	2	2	3	2	2	2
CO2	3	2	2	1	2	2	3	2	1	2
CO3	3	1	-	1	1	-	2	-	1	1
CO4	3	2	1	2	2	2	3	3	2	2
CO5	3	1	-	1	2	1	3	2	-	2

Legends: - High:03, Medium:02, Low:01, No Mapping: --

VI. Suggested Learning Materials / Books

Sr.No	Author	Title	Publisher
1	H.Pratab	Art and Science of Utilization of Electrical Energy	Dhanpat Rai & Sons, New Delhi, ISBN 9788177001440
2	J.B. Gupta	Utilization of Electric Power and Electric Traction.	S.K. Kataria & Sons, New Delhi, ISBN 978- 9350142585
3	G. C. Garg	Utilization of Electric Power and Electric Traction.	Khanna Publishers, New Delhi, ISBN 8174091645
4	J. Upadhaya and S.N. Mahendra	Electric Traction	Allied Publisher Ltd., New Delhi, ISBN: 8177640054
5	G.K. Dubey	Fundamentals of Electric Drive	Narosa Publishing House, New Delhi, ISBN: 8173190410 , 9788173190414
6	V. K. Mehta	Principles of Power System	S. Chand, New Delhi, ISBN: 9788121924962
7	H.Pratab	Modern Electric Traction	Dhanpat Rai & Sons, New Delhi, ISBN: 1234567147206
8	S. Sivanagaraju & M. Balasubba Reddy & B. Srilatha	Generation and Utilization of Electrical Energy	Personal Education, New Delhi, ISBN: 9789332515673

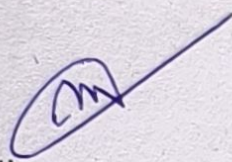
VII. Learning Websites & Portals

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=CoHVA7nr82A	Complete description of Arc Welding
2	https://www.youtube.com/watch?v=7GLiBwgVBLQ	Videos on Electric Traction
3	https://www.youtube.com/watch?v=fakGLu03jYg	Videos on Electric Traction
4	https://www.youtube.com/watch?v=BDMFsYnTdVI	Videos on Electric Locomotive with full description
5	https://www.youtube.com/watch?v=49rH3buD0bc	Video showing the working of Diesel Locomotive
6	https://www.youtube.com/watch?v=82EFMvYcbN4	Videos on Electric Multiple Unit
7	https://www.youtube.com/watch?v=AAyLKnz4UJY	Videos to describe Electric Heating system

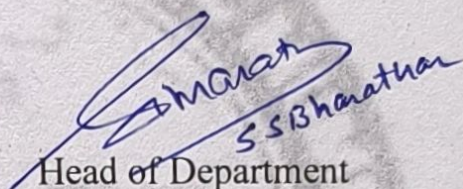
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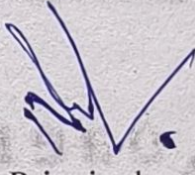
Academic Consultation Committee/Industry Consultation Committee:

Sl. No	Name	Designation	Institute/Organization
1	Mr. Rahul H Shewale	Assistant Engineer	Mumbai Inspection Division Industry Energy and Labour Dept. Govt of Maharashtra Mumbai Central
2	Mrs. D. R. Kirtane	Lecturer in Electrical Engineering	Government Polytechnic, Nashik
3	Miss A.V. Patil	Lecturer in Electrical Engineering	Government Polytechnic, Mumbai
4	Dr .P.N. Padghan	Lecturer in Electrical Engineering	Government Polytechnic, Mumbai

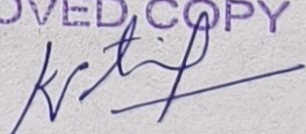

Coordinator,
Curriculum Development,
Department of Electrical Engineering


I/C, Curriculum Development Cell


Head of Department
Department of Electrical Engineering


Principal

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CDC Co-ordinator
G. P. Mumbai

Programme: Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 110						Course Title : Fundamentals of Power Electronics							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30Hrs.)	FA-PR	SA		SLA	Total
						T1	T2			PR	OR		
4	--	2	2	8	4	20	20	60	25	25#	--	25	175

Total IKS Hrs. for course: 1 Hr.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH- Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work
4. SA-PR represents the end term practical examination.

I. Rationale :

Power Electronics devices and circuits nowadays, in addition to its traditional roles in industrial automation and high-efficiency energy systems are also having important role in energy conservation, renewable energy systems, bulk utility energy storage, electric and hybrid vehicles. This course aims to impart the knowledge and skill sets of operating and testing different power electronic devices and their applications.

II. Industry / Employer Expected Outcome:

The aim of this course is to help the student to attain the following industry identified Use of power electronics based systems for various industrial applications through various teaching learning experiences:

- 1) To know the basic elements of power electronics
- 2) To have a understanding of power electronics circuits, Test the Performance of Power Electronic Devices and Circuits, including the ability to design, analyze, and implement circuits involving components such as SCRs, MOSFETs, IGBTs, and diodes in real-world applications like motor control, power conversion, and lighting systems.

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IX. 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
CO1	3	3	-	3	1	-	-	2	2	2
CO2	3	3	-	3	-	-	-	3	2	1
CO3	3	3	1	3	-	3	3	3	2	1
CO4	3	3	1	3	-	3	3	3	2	1
CO5	3	3	1	3	-	3	3	3	2	1

Legends: - High:03, Medium:02, Low:01, No Mapping: --

X. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year of Publication	ISBN
1	Power Electronics	Dr. P. S. Bimbhra, Khanna Publisher, 2012	978-81-7409-279-3
2	Power Electronics	M.D. Singh, K.B. Khanchandani, McGraw Hill, 2014	978-0-07-058389-4
3	Power electronics: devices, circuits, and applications	M.H.Rashid, Pearson Education Limited, 2014	978-0-273-76908-8
4	Power Electronics Devices Circuits and Industrial Applications	V.R. Moorthi, Oxford University Press, 2005	978-1-62-870877-6

XI. Learning Websites & Portals

Sr. No	Link / Portal	Description
1	www.youtube.com/	Laboratory course on Power Electronics
2	https://www.elprocus.com/category/projects/eee-projects	Steps to Building a Project on Breadboard Circuit
3	https://nptel.ac.in/course.html	Binary numbers, diodes, filters, Logic gates, Transistors
4	https://nptel.ac.in/courses/108101038	Course on Power Electronics by IIT Bombay
5	Power Electronics, Prof. Sabyasachi Sengupta, Prof.N.K.De, Prof.D.Prasad, Dr.D. Kastha IIT Kharagpur	

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	TLO2.3: Gain knowledge about natural and forced commutation methods and their role in turning off SCRs. TLO 2.4 Explain the need of the given protection for SCR	• R-C triggering • UJT triggering. 2.2 Thyristor Turn off methods. a) Natural Commutation b) Forced Commutation: • Class A- Self commutation by resonating load • Class B- Self commutation by LC circuit • Class C - Complementary commutation • Class D -Auxiliary commutation • Class E – external pulse commutation 2.3 di/dt and dv/dt protection of SCR Course Outcome: CO 2 Teaching Hours: 8 Hrs Marks: 10 (R-02,U-06,A-02)
3	TLO3.1: Develop a thorough understanding of control techniques used in rectifier circuits and their effect on output performance. TLO3.2: Gain the ability to design and analyze single-phase rectifier circuits for various load conditions. TLO 3.3: Evaluate the role of freewheeling diodes in improving rectifier performance and reducing losses.	3: Phase Controlled Rectifier 3.1. Difference between uncontrolled rectification and controlled rectification. 3.2. Phase control: firing angle, conduction angle 3.3. Circuit diagram, working, input output waveforms and equation for average output voltage of following (no derivation) 3.4. Single Phase Fully Controlled Half Wave Converter - With Resistive Load, With RL Load and Freewheeling Diode, with RLE load. 3.5. Single Phase Fully Controlled Full Wave Mid point Converter - With RL Load. Single Phase Fully Controlled Bridge Converter – With RL Load ,with RLE load Single phase semi converter: symmetrical and asymmetrical configuration with RL load 3.6. Circuit diagram, working and input output waveforms of Three Phase Fully Controlled Bridge Converter-With RL Load. 3.7. Comparison of 1 phase and 3 Phase Converters. 3.8. Application: DC drives, Speed control of DC series motor with single phase half and full controlled converter. Course Outcome: CO3 Teaching Hours:12Hrs. Marks:12 (R-02,U-08,A-02)
4	TLO 4.1: Understand the fundamental principles and classification of inverters based on different operational characteristics. TLO 4.2: Analyze the working principles and waveforms of	4: Inverters 4.1 Introduction. Classification of inverters according to nature of input source, method of commutation, connection of thyristor & commutating component. 4.2 Working principle & operation of Basic and modified Series inverter ,

	rectifier for RL load. LLO9.3 Connect CRO to the experimental trainer kit.			
10	LLO 10.1 Measure output voltage of single phase half wave bridge inverter by using CRO. LLO 10.2 Use various controls of the CRO	Operation of single phase half wave bridge inverter with resistive load.	2	CO4
11	LLO11.1 Plot Torque Vs Speed characteristics	Control of speed of Induction motor using v/f method	2	CO5
12	LLO12.1: Learn step-down chopper operation using SCR. LLO12.2 Learn to observe and analyze waveforms at different points in the circuit, such as the input, output, across the load, and the SCR terminals.	Test waveforms at various points of step up chopper using SCR	2	CO5
13	LLO13.1 Understanding the working principle of a parallel inverter, LLO13.2 Recognize and understand the function of major components in the circuit, such as SCRs, Diodes Commutating Capacitors, Inductors.	Trace the parallel inverter circuit and list the major components of the circuit, sketch the observed waveforms and measure Voltage levels.	2	CO4
14	LLO14.1 Understand the role of various protection circuits in safeguarding SCRs from damage	Case study on protection circuit of SCR	2	CO6
15	LLO 15.1 Control the speed of fan using TRIAC.	Speed control of fan using TRIAC.	2	CO6

Note: Minimum 10 experiments should be performed in a term for completion of TW

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 05 Assignments)

Micro project : to be submitted in group of 5 to 6 students

Micro project

- Build a power electronic circuit to produce variable voltage for a given application using following steps.
 - 1) Identify voltage range for a given application.
 - 2) Select circuit components suitable for the identified voltage range.
 - 3) Connect circuit components to build power electronic circuit controlling voltage.
 - 4) Test the circuit for the production of variable voltage.
 - 5) Prepare a report on the circuit built and submit the same.
- Prepare a report on commercial or industrial applications of power electronics devices by performing following activities.
 - 1) Identify 3 to 5 relevant applications.
 - 2) Visit site and understand role of power electronic devices in identified applications.
 - 3) Write the specifications of major components in the applications.
 - 4) Prepare block diagram or process flow diagram of the applications.
- Prepare a report on the ratings/specifications and applications of various power electronic devices.
 - 1) Select any 3 to 5 power electronic devices.
 - 2) Visit manufacturers' site or official websites of power electronic devices manufacturers and note the specifications or ratings of the selected power electronic devices.
 - 3) Compare selected power electronics devices based on collected information along with their applications.

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences. (Any 10)

Sr. No.	Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	No. of hrs.	Relevant COs
1	LLO 1.1 Assemble and test simple power electronic circuit. LLO 1.2 Test the performance of SCR LLO 1.3 Plot the V-I characteristic of SCR, plot the graph for forward blocking mode, forward conducting mode and reverse blocking mode	Construct circuit & verify the V-I characteristic of SCR.	2	CO1
2	LLO 2.1 Understand the significance and operation of TRIAC characteristics. LLO 2.2 Plot the V-I characteristic of TRIAC, plot the graph for mode I and IV.	Construct circuit & verify the V-I characteristic of TRIAC.	2	CO1
3	LLO 3.1 Test the proper functioning of the power MOSFET. LLO 3.2 Plot the V-I characteristic of power MOSFET, plot the graph for transfer and drain characteristic	Construct circuit & verify the V-I characteristics of power MOSFET.	2	CO1
4	LLO 4.1 Test the proper functioning of the IGBT. LLO 4.2 Plot the V-I characteristic of power IGBT	Construct circuit & verify the V-I characteristics of power IGBT	2	CO1
5	LLO5.1 Learn how a TRIAC is used in light dimmer circuits to control the intensity of light	Construct the circuit of light dimmer and observe the intensity of light	2	CO1
6	LLO6.1 Understand how SCRs are triggered using an R circuit. LLO6.2 Learn how the R value influences the firing angle by varying resistance LLO6.3 Measure the firing angle of the SCR and interpret its effects on circuit performance.	Construct circuit & observe firing angle (α) control of SCR using R triggering	2	CO2
7	LLO7.1 Understand how SCRs are triggered using an RC circuit. LLO7.2 Learn how the RC network influences the firing angle by varying resistance and capacitance values LLO7.3 Measure the firing angle of the SCR and interpret its effects on circuit performance.	Construct circuit & Observe firing angle control of SCR using RC triggering method.	2	CO2
8	LLO8.1 The effect of change in firing angle on the output LLO8.2 Compare output of fully controlled rectifier for R load. LLO8.3 Connect CRO to the experimental trainer kit.	Observe the output of single phase fully controlled bridge rectifier using R load	2	CO3
9	LLO9.1 The effect of change in firing angle on the output LLO9.2 Compare output of fully controlled	Observe the output of single phase fully controlled bridge rectifier using RL load	2	CO3

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	various inverter configurations. TLO 4.3: Develop the ability to compare different inverter types and choose appropriate configurations for specific applications. TLO 4.4 Explain working principle of sinusoidal pulse width modulation	Basic Parallel inverter 4.3 Circuit diagram , working ,waveforms of Single phase half bridge inverter Single phase full bridge inverter 4.4 Voltage control in single phase inverters (PWM Inverters): Different Techniques 4.5 Application: AC Drives Speed control of three phase Induction Motor with Variable frequency • Voltage source inverter fed induction motor drive. • Pulse width modulated inverter fed induction motor drive Course Outcome: CO 4 Teaching Hours:12Hrs Marks: 10 (R- 02,U-06,A-02)
5	TLO 5.1: Develop a understanding of chopper circuits, their classification, and applications. TLO 5.2: Analyze the operation of different chopper types through circuit diagrams, working principles, and waveforms. TLO 5.3: Compare various chopper Configurations in terms of functionality, operational quadrants, and typical applications.	5: Choppers 5.1 Chopper Principle 5.2 Control Techniques: • Constant Frequency System • Variable Frequency System 5.3 Step down (buck)chopper Step Up Chopper (boost) and 5.4 Circuit diagram and working of Class A, Class B, Class C, Class D and Class E choppers 5.5 Application: Chopper based DC drive for separately excited DC motor. Course Outcome: CO 5 Teaching Hours: 10 Hrs. Marks: (R-02,U-08,A-02)
6	TLO 6.1: Develop a understanding of gate drive circuit for BJT and MOSFET , Snubber circuit for transistors , Temperature control in semiconductor devices TLO 6.2: Analyze the operation of gate drive circuit for BJT and MOSFET Snubber circuit for transistors , Temperature control in semiconductor devices through circuit diagrams, working principles, and waveforms. TLO 6.3: Understand the Electromagnetic Interference (EMI), Sources of EMI, shielding, EM I standard	6. Gate Drive, Protection of devices and circuits 6.1 Simple gate drive circuit for BJT and MOSFET 6.2 Snubber circuit for transistors 6.3 Temperature control in semiconductor devices: Heat transfer, Thermal resistance and thermal model, Heat sink specifications 6.4 Electromagnetic Interference: Sources of EMI, Minimizing EMI generation, EMI shielding, EM I standard Course Outcome: CO 6 Teaching Hours: 6Hrs. Marks:(R-00,U-04 ,A-02)

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- Construct boost converter using MOSFET on general purpose PCB, use suitable IC for gate drive
OR
- Construct Full bridge inverter using MOSFET on general purpose PCB, use suitable IC for gate drive
OR
- Construct Inverter using Arduino and MOSFET
OR
- Prepare PCB with tested circuit mounted on it for any Industrial electronics application circuit. and /or any circuit from practical list.

Any other relevant micro project assigned by subject teacher.

VII. Specifications Table (Theory):

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Power Electronics Devices	4	6	0	10
2	SCR turn on and turn off methods and protection circuits	2	6	2	10
3	Phase Controlled Rectifier	2	8	2	12
4	Inverters	2	6	2	10
5	Choppers	2	8	2	12
6	Gate Drive, Protection of devices and circuits		4	02	06
Total		12	38	10	60

VIII. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

End term examination, Viva-voce, Workshop performance (25 marks)

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

CO1	Select appropriate power semiconductor device for specific application.
CO2	Select appropriate turn on and turn off circuits of SCR for specific application
CO3	Use appropriate power converter for specific application and drive.
CO4	Select appropriate inverter for specific application
CO5	Select appropriate chopper for specific application
CO6	Troubleshoot simple gate drive and protection circuits for power devices

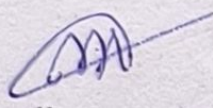
IV. Course Content Details:

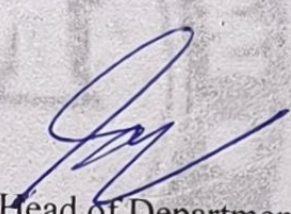
Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	TLO 1.1 Illustrate the power electronic system using block diagram. TLO 1.2 Explain the general characteristics of the given power electronic switch. TLO 1.3 Describe the construction of the given power electronic device. TLO 1.4 Explain the working principle of the given power electronic device. TLO 1.5 State the applications of the given power electronic device.	Power Electronics Devices: 1.1. Introduction to Power Electronics 1.2. Power Electronics definition, Block diagram of power electronic system, Power semiconductor devices classification, power semiconductor devices ratings and application, Ideal switch characteristic, Desirable characteristic of real switch 1.3. Structure, symbol, working and VI characteristic of power diode, Power Transistor, Power MOSFET and IGBT 1.4. Thyristor family: 1.5. Definition of thyristor, SCR Construction, symbol, working two transistor analogy & V-I characteristics 1.6. Definitions: Holding current, latching current, break overvoltage. 1.7. Construction, symbol, V-I characteristics and application of LASCR, Triac, and Diac 1.8. Phase control using TRIAC: Light dimmer. Course Outcome: CO1 Teaching Hours: 12Hrs Marks: 10 (R-04, U-06, A-00)
2	TLO2.1: Develop an understanding of various SCR turn on methods and their significance in power electronics. TLO2.2 : Analyze the design and operation of gate trigger circuits and protection mechanisms.	2: SCR turn on and turn off methods and protection circuits: 2.1 SCR turn on methods: Voltage Triggering, Gate Triggering, dv/dt Triggering and Light Triggering, Temperature triggering. Gate triggering circuits for SCR – Circuit diagram, working principle, waveforms of • Resistor triggering

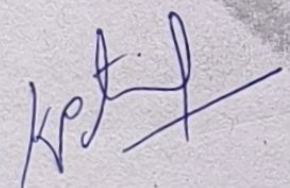
6	https://3dcircuits.engineering.dartmouth.edu/powani.html	Animation on Chopper and Rectifier
7	https://nptel.ac.in/courses/108105066	Course on Power Electronics by IIT Kharagpur

XII. Academic Consultation Committee / Industry Consultation Committee:

Sr. No.	Name	Designation	Institute/Organisation
1	Mr Kalpak Raut	Director , Kalpak Electro-tech	Kalpak Electro-tech, Badlapur.
2	Mr. Sandeep Ushkewar	Assistant Professor , Electrical Engineering	Shri Vile Parle Kelvani Mandal's Institute of technology Dhule
3	Mrs Vaishali Bhosale	Lecturer in Electrical Engg.	Government Polytechnic, Nashik
4	Mrs. Pritam Khande	Lecturer in Electronics Engg.	Government Polytechnic, Mumbai
5	Mrs. Jyoti Mane	Lecturer in Electronics Engg.	Government Polytechnic, Mumbai
6	Ms. Minakshi Shirsat	Lecturer in Electrical Engg.	Govt. Polytechnic Mumbai

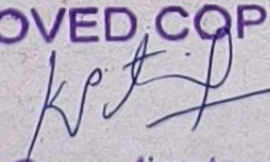

Coordinator
Curriculum Development,
Department of Electrical Engineering


Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

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CDC Co-ordinator
G. P. Mumbai

Programme: Diploma in Electrical Engineering (Sandwich Pattern)

Course Code: EE23 111

Course Title: Electrical Estimation & Costing

Compulsory / Optional: Compulsory

Teaching Scheme and Credits

Examination Scheme

CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	2	8	4	20	20	60	-	--	25#	25	150

Total IKS Hrs. for course:

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

Electrical Diploma holders should be able to collect the required information for estimating and costing of product of any given project. The student will be compatible to plan, draw layout, find load current and make survey to know current market rate of each component and material required. Knowledge of this subject will be helpful to work as a Contractor, an entrepreneur and execute different electrical installations. The knowledge of this course is also useful to do testing of any new installation. The IE rules/NEC 2011 rules related to an electrical installation are helpful while making an electrical installation and testing of an electrical installation.

II. Industry / Employer Expected Outcome: Install and testing various electrical installations used in industry, commercial and residential premises.

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

CO1	Follow National Electrical Code 2011 in electrical installations.
CO2	Estimate the electrical installation works
CO3	Estimate the work of non-industrial electrical installations.
CO4	Estimate the work of industrial electrical installations.
CO5	Prepare abstract, tender, quotation of public lighting and other installations.
CO6	Prepare abstract, tender, quotation of low tension (LT) substations.

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Course Content Details:

Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1.1 Describe the scope and features of NEC 2011. TLO 1.2 Enlist the electrical installation. TLO 1.3 Explain the electrical installation principles. TLO 1.4 Describe the procedure of permit to work. TLO 1.5 State the safety instructions and practices. TLO 1.6 Explain the Purpose of estimating and Costing.	1: Electric Installation and Safety. 1.1 Scope and features of National electric code 2011 1.2 Types of electrical installation 1.3 Fundamental principles for electrical installation 1.4 Permit to work, safety instructions and safety practices 1.5 Purpose of estimating and costing. 1.6 PWD (Electrical) Current Schedule of Rates for Electrical Works Course Outcome: CO1 Teaching Hours :06 hrs Marks: 04
2	TLO 2.1 State the meaning and purpose of all types of estimates. TLO 2.2 Describe the Factors to be considered for preparation of detailed estimate and economical execution of work. TLO 2.3 Enlist the types of contracts. TLO 2.4 Explain the Concepts of contracts and role of contractor TLO 2.5 Explain the tendering process. TLO 2.6 Differentiate between tender and quotation. TLO 2.7 Describe the procedure for placing of purchase order. TLO 2.8 Explain the Principles of execution of works and Billing of work.	2: Topic Title: Estimation and Costing 2.1 Meaning and purpose of- Rough estimate, detailed estimate, supplementary estimate, annual maintenance estimate and revised estimate. 2.2 Factors to be considered while preparation of detailed estimate and economical execution of work. 2.3 Contracts- Concepts of contracts, types of contracts, contractor, role of contractor 2.4 Tenders and Quotations- Type of tender, tender notice, preparation of tender document, and method of opening of tender 2.5 Quotation, quotation format, comparison between tender and quotation 2.6 Comparative statement, format comparative statement. Order format, placing of purchasing order. 2.7 Principles of execution of works, planning, organizing and completion of work, Billing of work Course Outcome: CO2 Teaching Hours : 14 Marks : 12
3	TLO 3.1 Elist the types of non- industrial installations. TLO 3.2 Explain electric service and supply. TLO 3.3 Describe design consideration and procedure of electrical installation in commercial buildings. TLO 3.4 Explain the earthing in commercial installation. TLO 3.5 Explain the design scheme of electrical installation in commercial installation. TLO 3.6 Explain procedure of Erection, Inspection and testing of installation.	3: Topic Title: Non-Industrial Installations 3.1 Types of Non-industrial installations-- Office buildings, shopping and commercial centre, residential installation, Electric service and supply 3.2 Design consideration of electrical installation in commercial buildings. 3.3 Design procedure of installation- steps involved in detail, Estimating and costing of unit 3.4 Earthing of commercial installation. 3.5 Design electrical installation scheme of commercial complex. 3.6 Erection, Inspection and testing of installation as per NEC Course Outcome: CO3 Teaching Hours : 10 Marks: 12

4 TLO 4.1 Enlist the types of industrial buildings based on power consumption. TLO 4.2 Draw wiring diagram and single line diagram for single and three phase Motors. TLO 4.3 Describe design consideration and procedure of electrical installation in industry. TLO 4.4 Interpret electrical installation scheme in small industrial unit. TLO 4.5 Explain electrical installation and estimation of agricultural pump and flourmill.	4: Industrial Installation 4.1 Classification of industrial buildings Classification based on power consumption, 4.2 Drawing of wiring diagram and single line diagram for single phase and three phase Motors. 4.3 Design consideration in industrial installations Design procedure of installation-detailed steps 4.4 Design electrical installation scheme of factory/ small industrial unit, Preparation of material schedule and detailed estimation 4.5 Installation and estimation of agricultural pump and flourmill Course Outcome: CO4 Teaching Hours: 10 Marks: 10
5 TLO 5.1 Enlist the types outdoor electrical installations. TLO 5.2 Interpret the street light pole. TLO 5.3 Describe the cabling and controlling of street lighting. TLO 5.4 Explain estimation and costing of street light with design.	5: Topic Title: Public Lighting Installation 5.1 Classification of outdoor installations streetlight/ public lighting installation 5.2 Street light pole structures. Selection of equipment's, sources used in street light installations. 5.3 Cables, recommended types and sizes of cable. Control of street light installation. 5.4 Design, estimation and costing of streetlight Course Outcome: CO5 Teaching Hours : 10 Marks: 10
6 TLO 6.1 Describe overhead and underground distribution line. TLO 5.2 Enlist the material used for distribution line HT and LV. TLO 5.3 Explain the LT/ HT power Cables laying and termination method. TLO 5.4 Describe estimation and costing of HT/ LT overhead line and underground cabling with design. TLO 5.5 Interpret the 11kV distribution substations. TLO 5.6 Describe estimation and costing of outdoor and indoor 11 KV substation.	6. Distribution Lines and LT Substation 6.1 Introduction to overhead and underground distribution line. 6.2 Materials used for distribution line HT and LV 6.3 Cables used for distribution line, factors determining selection of LT/ HT power Cables, cable laying and cable termination method according to IS 6.4 Design, estimation and costing of HT LT overhead line and underground cabling. 6.5 Types of 11 KV Distribution substations their line diagram, Estimation of load, Load factor, diversity factor and determination of rating of distribution Transformer. 6.6 Design, estimation and costing of outdoor and indoor 11 KV substation. Course Outcome: CO6 Teaching Hours : 10 Marks: 10

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IV. List of Laboratory Experiments. (Minimum 10)

Sr No	Laboratory outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Draw circuit diagram for various lamps and fans controlling circuit.	Draw sheet on circuit diagrams for various lamps and fans controlling circuit like Staircase and Go-down wiring, Distribution system,	02	CO1
2	LLO 2.1 Draw different types of Earthing.	Draw a sheet on different types of Earthing.	02	CO3
3	LLO 3.1 Interpret installation scheme for Flat/Independent bungalow with single line and wiring diagram.	Design electrical installation scheme for Flat/Independent bungalow / House: Draw Installation plan, single line diagram & wiring diagram Prepare material schedule & detailed estimate & costing	04	CO2,3
4	LLO 4.1 Explain wiring diagram for residential installation using Inverter as backup supply.	Design and draw wiring diagram for residential installation by using Inverter as backup supply	02	CO3
5	LLO 5.1 Interpret installation scheme for commercial Complex with single line and wiring diagram.	Design electrical Installation scheme for any one commercial Complex/Hospital/Drawing hall: Draw Installation plan, single line diagram & wiring diagram. Prepare material schedule & detailed estimate & costing	04	CO2,3
6	LLO 6.1 Interpret installation scheme for agriculture pump room with single line and wiring diagram.	Design Electrical Installation scheme for agriculture pump room /Floor mill: Draw Installation plan, single line diagram & wiring diagram. Prepare material schedule & detailed estimate & costing	04	CO2,4
7	LLO7.1 Interpret installation scheme for small unit/workshop/Machine Lab with single line and wiring diagram.	Design electrical Installation scheme for small unit/workshop/Machine Lab: Draw Installation plan, single line diagram & wiring diagram. Prepare material schedule & detailed estimate & costing	04	CO2,4
8	LLO8.1 Explain Panel Wiring for electrical laboratory / institute /control panel of electrical equipment's.	Draw Panel Wiring of the electrical laboratory / institute /control panel of electrical equipment's.	02	CO3
9	LLO 9.1 Describe estimate proposal of the electrical Installation for streetlight scheme.	Estimate with a proposal of the electrical Installation of streetlight scheme for small premises after designing.	02	CO5
10	LLO10.1 1Describe estimate proposal of the electrical Installation for L.T. line.	Estimate with a proposal of the L.T. line installation. Prepare report and draw sheet	02	CO6
11	LLO11.1 1Describe estimate proposal of the electrical Installation for 500 KVA, 11/0.433 KV outdoor substation.	Estimate with a proposal of the 500 KVA, 11/0.433 KV outdoor substation and prepare a report	02	CO6
			30	

I. List of Tutorial NIL

II. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 5)

- Carry out market survey of electrical materials for comparison of quality and cost.
- Collect an electrical engineering drawing of the existing electrical installation. Interpret it. Prepare a report on it.
- Collect industrial installation plan and prepare estimation for the same using suitable software.
- Collect existing installation plan of distribution lines and prepare an estimation for the same.
- Collect the existing installation plan of the street lighting scheme and prepare an estimation for the same.
- Collect the existing installation plan of the High-mast lighting scheme and prepare an estimation for the same.
- Collect the existing installation plan of the low-tension (LT) line and prepare an estimation for the same.
- Collect the existing installation plan of the high-tension (HT) line and prepare an estimation for the same.
- Collect any tender document related to electrical installation and fill all related documents.
- Collect list of vendors and specifications of electrical goods from GeM portal.

III. Specification Table:

Unit No	Topic Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Electric Installation and Safety	06	02	02	--	04
2	Estimation and Costing	14	04	04	04	12
3	Non-Industrial Installations	10	04	04	04	12
4	Industrial Installation	10	--	04	06	10
5	Public Lighting Installation	10	04	04	04	12
6	Distribution Lines and LT Substation	10	02	08	--	10
Total		60	16	26	18	60

IV. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

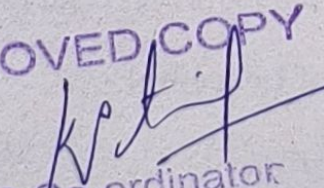
- End term examination, Viva-voce (25 marks)

V. 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
CO1	2	2	--	3	1	--	2	3	2	3
CO2	3	3	--	3	2	1	3	2	3	2
CO3	3	3	--	3	2	1	3	2	3	2
CO4	3	3	--	3	2	1	3	2	3	2
CO5	3	3	2	3	1	3	3	--	3	2
CO6	3	3	2	3	1	3	3	--	3	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --										

VI. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Electrical Design Estimating and Costing	Raina K.B.; Dr. S. K. Bhattacharya New Age International Publisher First, Reprint 2010	ISBN: 978-81-224-0363-3
2	Electrical Estimating and Costing	Allagappan N. S. Ekambarram, Tata Mc-Graw Hill Publishing Co. Ltd,	ISBN 13: 9780074624784
3	Electrical Estimating and Costing.	Singh Surjit, Ravi Deep Singh, Dhanpat Rai and Sons.	ISBN 13:1234567150995
4	A Course in Electrical Installation Estimating and Costing	Gupta J.B. S.K. Kataria and Sons Reprint Edition,	ISBN 10: 935014279113: 978-9350142790.
5	Code of Practice for Electrical Wiring Installation	Bureau of Indian Standard. IS: 732-1989.	
6	National Electrical Code 2011	Bureau of Indian Standard. SP-30:2011.	

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 CDC Co-ordinator
 G. P. Mumbai

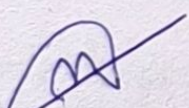
VII. Learning Websites & Portals

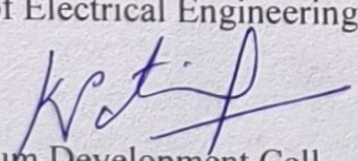
E-References:

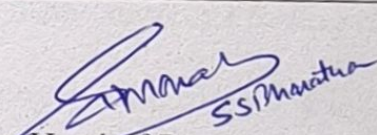
Sr.No	Link/ Portal	Description
1	https://law.resource.org/pub/in/bis/S05/is.sp.30.2011.pdf	NEC 2011
2	https://www.electricaltechnology.org/2013/09/electrical-wiring.htm	Basics of Electrical wiring system
3	https://www.electrical4u.com/types-of-electrical-insulator-overhead-insulator/	Distribution line materials
4	https://www.electrical4u.com/lamps-types-and-performance-comparison/	Different types of lamps
5	https://youtu.be/yhzhloBF_eo?si=Esgl05OzWNCOQaiD	High mast light wiring
6	https://www.youtube.com/watch?v=loMXX6xctlg	Streetlight wiring
7	https://standardsbis.bsedge.com/	SP:30 NEC 2023
8	https://gem.gov.in/	GeM portal for procurement.

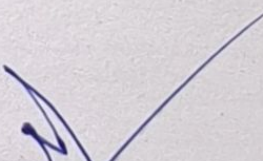
VIII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. D.D. Rathod	Executive Engineer	METRO Pune
2	Prof. Jyothi Jagaldas	HOD	Saboo Siddiq Polytechnic Mumbai
3	Dr.P.N. Padghan	Lecturer in Electrical Engineering	Govt. Polytechnic Mumbai
4	A.K. Dhulshette	Lecturer in Electrical Engineering	Govt. Polytechnic Mumbai


Coordinator,
Curriculum Development,
Department of Electrical Engineering


I/C, Curriculum Development Cell


Head of Department
Department of Electrical Engineering


Principal

Government Polytechnic, Mumbai

Programme : Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 109						Course Title: AC Machines							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	2	8	4	20	20	60	25	25#	--	25	175

Total IKS Hrs. for course:

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

This is the subject aspire to teach facts, concepts, principle and procedure for operation and testing of electrical machine, such as 3-phase induction motors, 3-phase synchronous generators, 3-phase synchronous motors and 1-phase induction motors. Students will be able to analyze the characteristics of 3-phase AC Machines and 3-phase Synchronous Machines with qualitative parameters of these machines. They also learn applications of 1-phase induction motors.

These machines are used in various fields, industries and many more utilization systems. Knowledge gained by the students will be helpful in the study of technological subjects such as testing and maintenance of electrical machines, utilization of electrical energy, switchgear & protection, power electronics & drives, special machines. Learning & the skills obtained will be helpful in discharging duties such as supervisor, controller, R & D technician and machine maintenance engineer.

II. Industry / Employer Expected Outcome: Operate various electrical utilities used for industrial and commercial applications.

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

CO1	Explain various types of three phase induction motors.
CO2	Demonstrate starters, speed control methods & circle diagram of three phase induction motor.
CO3	Interprets the three phase alternators.
CO4	Comprehend three phase synchronous motors.
CO5	Select single phase induction motors.

Course Content Details:

Unit No.	Learning Outcome	Topics / Sub-topics
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 and state its applications.	Topic Title: Three Phase Induction Motors 1.1 General information of three phase machines. 1.2 Working principle of 3-phase I.M. 1.3 Construction and types of 3- phase induction motor. 1.4 Comparison between squirrel-cage and slip-ring induction motor. 1.5 Production of rotating magnetic field. 1.6 Three phase induction motor speed, slip, frequency, rotor frequency and their relations. (Simple Numerical) 1.7 Equation of rotor induced emf, current, frequency, reactance, and impedance under steady and running condition. (Simple Numerical). 1.8 Torque equation of three phase induction motor. (Simple Numerical). 1.9 Starting and running torque of squirrel cage and slip ring induction motor. 1.10 Condition for maximum and starting torque. 1.11 Torque slip characteristics of three phase induction motor. 1.12 Effect of change in rotor circuit resistance on torque-slip characteristics. 1.13 Effect of change in supply voltage on torque-slip characteristics. 1.14 Torque Ratios (Numerical) 1.14.1 Starting torque to Maximum torque 1.14.2 Full load torque to Maximum torque 1.15 Power stages of three phase induction motor. 1.16 Relationship between rotor Cu loss, rotor input, rotor output (Numerical) Course Outcome : CO1 Teaching Hours :16 hrs Marks: 16
2	TLO 2.1 Justify the need of starter for three phase induction motor. TLO 2.2 Describe constructional details of the given type of starter for the induction motor. TLO 2.3 Explain working of the given starter for three phase induction motors. TLO 2.4 List all the components used in the given soft starter. TLO 2.5 Explain the working of the given soft starter.	Topic Title: Starting, Speed Control & Circle Diagram of Three Phase Induction Motor 2.1 Need of Starter. 2.2 Various starters used to start 3-phase IM. 2.2.1 Starting of squirrel cage and slip ring induction motor. 2.2.2 Compare starters with DOL starter (simple numerical) 2.3 Double cage 3-phase induction motor. 2.3.1 Construction 2.3.2 Concept of double cage 2.4 Speed control of three phase induction motor by--

	TLO 2.6 Explain the given method(s) of speed control for the induction motor	2.4.1 Pole Changing method 2.4.2 Frequency Control method 2.4.3 By Stator Voltage Control method 2.4.4 Rotor Resistance Control method 2.5 I.M. as a generalized transformer. 2.6 Equivalent Circuit of 3-phase IM. 2.7 Construction of Circle Diagram. 2.7.1 Importance of circle diagram 2.7.2 No load test and Blocked rotor test on 3-phase IM (Simple Numerical) 2.8 Applications of three phase induction motor. 2.9 Introduction to Energy Efficient Induction Motor Course Outcome: CO2 Teaching Hours : 12 Marks : 14
3	TLO 3.1 Describe the constructional details of three phase alternators. TLO 3.2 Explain the working principle of alternator. TLO 3.3 State the advantages of rotating field in turbo alternators. TLO 3.4 Calculate the speed and frequency for the given three phase alternator. TLO 3.5 Calculate the pitch factor, distribution factor and EMF for the given three phase alternator. TLO 3.6 Explain the given type of excitation system used in three phase alternator. TLO 3.7 Explain the significance of synchronous reactance. TLO 3.8 Explain the impact of power factors on performance of the three phase alternator. TLO 3.9 Calculate the voltage regulation of three phase alternators for the given loading conditions	Topic Title: Three Phase Alternator 3.1 Construction of three phase Alternator. 3.1.1 Stator 3.1.2 Rotor - Smooth Cylindrical & Projected type 3.2 Advantages of stationary armature construction. 3.3 Derivation of e.m.f. equation of Alternator. (Numerical) 3.3.1 Chording (Pitch) Factor 3.3.2 Distribution Factor 3.4 Factors affecting the terminal voltage of 3-phase Alternator. 3.4.1 Armature resistance drop 3.4.2 Leakage reactance drop 3.4.3 Armature reaction drop 3.5 Significance of Synchronous Reactance & Synchronous Impedance. 3.6 Armature reaction and their effects. 3.7 Regulation of 3-phase Alternator & various methods to find regulation. 3.7.1 Direct method (Numerical) 3.7.2 Synchronous impedance method (Numerical) 3.8 Need of Parallel Operation of 3-phase Alternator 3.8.1 Conditions to run 3-phase Alternators in parallel 3.9 Synchronizing Methods. 3.9.1 Synchronoscope method 3.9.2 One dark two bright lamp method Course Outcome: CO3 Teaching Hours : 14 Marks: 14
4	TLO 4.1 Explain the working principle of three phase synchronous motor its use for power factor improvement. TLO 4.2 Explain the working principle of three phase synchronous motor TLO 4.3 Explain Various methods of starting of synchronous motor. TLO 4.4 Describe V curve & inverted V curve with their parameters.	Topic Title: Three Phase Synchronous Motors 4.1 Construction of three phase synchronous motor. 4.2 Principle of operation. 4.3 Starting of synchronous motor, 4.3.1 Various methods of starting 4.4 Synchronous Motor on load with constant excitation. 4.5 Effect of change of excitation at constant load. 4.6 Power flow within a synchronous motor.

	TLO4.5 State comparison between 3-phase induction motor & 3-phase synchronous motor. TLO 4.6 Explain necessity of synchronization and describe the conditions for it.	4.7 V curve & inverted V curve with their parameters. 4.8 Comparison between 3-phase induction motor & 3-phase synchronous motor. 4.9 Applications of 3-phase synchronous motor. 4.10 Hunting or Surging or Phase Swinging. 4.11 Different torques of a synchronous motor. Course Outcome: CO4 Teaching Hours : 12 Marks: 10
5	TLO 5.1 Explain the double field revolving theory and its significance in single-phase induction motors. TLO 5.2 Describe the given self-starting technique(s) for the single phase induction motors. TLO 5.3 Describe the constructional details of the given single-phase induction motor. TLO 5.4 Explain the working principles of the given single phase induction motor. TLO 5.5 Interpret the torque-slip characteristics of the given single phase induction motor and state its applications	Topic Title: Single Phase Motors 5.1 Broad classification of all 1-phase motors. 5.2 Double field revolving theory. 5.2.1 Split phasing principle of starting 5.3 Single phase induction motors & their types. 5.4 Principle of working, schematic diagram and applications of 1-phase induction motors. 5.4.1 Resistance split phase 5.4.2 Capacitor split phase 5.4.3 Capacitor split phase & run 5.4.4 Shaded pole 5.5 Comparison between 1-phase induction motor & 3-phase induction motor. Course Outcome: CO5 Teaching Hours : 06 Marks: 06

IV. List of Laboratory Experiment. (Minimum 10)

Sr No	Laboratory outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Measure slip of a three phase induction motor using tachometer.	To measure the value of slip of 3-phase induction motor by Tachometer method	02	CO1
2	LLO 2.1 Reverse the direction of rotation of a three phase induction motors.	To reverse the direction of rotation of 3-phase induction motor	02	CO2
3	LLO 3.1 Calculate the efficiency of a three-phase induction motor.	To perform the direct load test on 3-phase induction motor	04	CO3
4	LLO 4.1 Start a three phase induction motor using a given starter. LLO 4.2 Set the current rating of DOL/ star-delta starter.	To use various types of starters to start and run 3-phase induction motor.	02	CO4
5	LLO 5.1 Study of Double Cage 3-phase induction motor	Study of Double Cage 3-phase induction motor	02	CO5
6	LLO 6.1 Measure iron and copper losses in a three-phase induction motor. LLO 6.2 Calculate the efficiency of a three-phase induction motor.	Perform the No Load Test & Blocked Rotor Test on 3-Phase IM and construct the circle diagram to know its performance. (Determine the line current, power factor, & full load efficiency at rated output)	04	CO5
7	LLO7.1 Test performance of 3- phase generated emf.	To perform O.C.C. of the 3-phase Alternator	02	CO4

8	LLO 8.1 Perform a direct loading test on a three phase alternator to determine voltage regulation under various loads.	To Determine Voltage Regulation of 3 Phase Alternator by Direct Loading.	02	CO1
9	LLO 9.1 Perform a Synchronous Impedance method (Z_s) on a three phase alternator to determine voltage regulation by indirect method (Z_s).	To Determine voltage regulation of three-phase Alternator by Synchronous Impedance method (Z_s).	04	CO2
10	LLO10.1 Test performance to run 3-phase alternators in parallel operation	To perform parallel operation of 3-phase alternators	04	CO4
11	LLO11.1 Plot V & Inverted V Curves of a Synchronous Motor.	To start Synchronous motor by any one method. To Plot V & Inverted V Curves of a Synchronous Motor.	04	CO2
12	LLO 12.1 Reverse the direction of rotation of a single phase induction motor	To start and reverse the direction of capacitor type single phase IM	02	CO2

(Out of above experiments, practice the available experiments on Virtual Lab of COEP Technological University - <https://portal.coepvlab.ac.in/vlab/>)

List of Tutorial

NIL

II. 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 on equivalent circuit of 3- phase I.M.
- Solve numerical to calculate voltage regulation of alternator.
- Solve numerical to calculate emf of alternator.

III. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Three Phase Induction Motors	02	06	08	16
2	Starting, Speed Control & Circle Diagram of Three Phase Induction Motor	02	06	06	14
3	Three Phase Alternator	02	06	06	14
4	Three Phase Synchronous Motors	04	06	00	10
5	Single Phase Motors	02	04	00	06
Total		12	28	20	60

IV. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

End term examination, Viva-voce, Workshop performance (25 marks)

V. 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
CO1	3	2	1	2	3	1	3	3	--	3
CO2	2	2	2	3	3	1	3	3	--	3
CO3	2	2	1	2	3	1	3	3	--	3
CO4	2	2	1	2	3	1	3	3	1	3
CO5	2	2	--	1	3	1	3	3	--	3

Legends: - High:03, Medium:02, Low:01, No Mapping: --

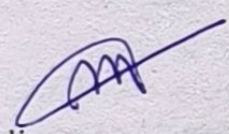
VI. Suggested Learning Materials / Books

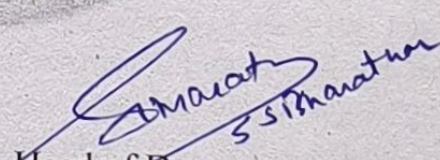
Sr.No	Author	Title	Publisher
1	G.C. Garg & P.S. Bimbhra,	Electrical Machines, Vol-I, II	Khanna Book Publishing House, New Delhi. ISBN: 978-9386173-447, 978-93-86173-607
2	Theraja B.L	Electrical Technology Vol-II	S. Chand and Co. Ltd., New Delhi, ISBN: 9788121924375
3	Bhattacharya S. K	Electrical Machines.	McGraw Hill Education, New Delhi., ISBN: 9789332902855
4	Kothari D. P. and Nagrath, I. J.	Electrical Machines.	McGraw Hill Education. New Delhi. ISBN: 9780070699670
5	Mehta V. K. and Mehta Rohit, .	Principles of Electrical Machines.	S. Chand and Co. Ltd., New Delhi. ISBN: 9788121930888
6	Bandyopadhyay M. N	Electrical Machines Theory and Practice.	PHI Learning Pvt. Ltd., New Delhi, .ISBN: 9788120329973 Vi

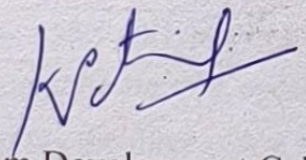
Sr. No	Link / Portal	Description
1	https://ems-iitr.vlabs.ac.in/exp/speed-control-slip-ring/	Speed Control of Slip Ring Induction Motor(VLAB)
2	https://archive.nptel.ac.in/courses/108/106/108106072/	Operation of Induction Machine and Synchronous Machine
3	https://archive.nptel.ac.in/courses/108/105/108105131/	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-familiarization/index.html	Familiarization of the electrical machine laboratory apparatus (VLAB)

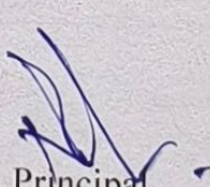
VIII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Umesh Chendra Pal	Senior Manager, Electrical Design & Consultant	Thyssenkrupp Industrial Solution (formaly UHDE India)
2	Mr. Sandeep D. Tajane	Deputy Engineer, Testing Section Operation & Maintenance Dept. (North West Zone)	BEST Undertaking (Supply Division) Mumbai
3	Mr. Sunil Asthaputre	Selection Grade Lecturer	Govt. Polytechnic, Awasari
4	Mrs. R.U. Patil	Selection Grade Lecturer	VPM Polytechnic, Thane
5	Dr. P.N. Padghan	Selection Grade Lecturer	Govt. Polytechnic, Mumbai
6	Miss A. V. Pail	Lecturer in Electrical Engineering	Govt. Polytechnic, Mumbai


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Curriculum Development,
Department of Electrical Engineering

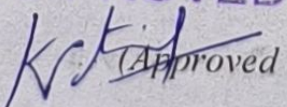

Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

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AC Machines (EE23 109)


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CDC Co-ordinator
G. P. Mumbai

P-23scheme

Programme : Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE 23502						Course Title: Entrepreneurship Development and Startup							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2:30 Hrs.)	FA-PR	SA		SLA	Total
						T1	T2			PR	OR		
-	-	2	2	4	2	-	-	-	25	-	#25	25	75

Total IKS Hrs. for course: 1

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale

Entrepreneurship and Startup is introduced in this curriculum to develop the entrepreneurship traits among the students before they enter into the professional life. By exposing and interacting with entrepreneurship and start-up eco-system, student will develop the entrepreneurial mindset. The innovative thinking with risk taking ability along with other traits are to be inculcated in the students through micro projects and training. This exposure will be instrumental in orienting the students in transforming them to be job generators after completion of Diploma in Engineering.

II. Industry / Employer Expected Outcome

- Develop project proposals for launching small scale enterprises and startup.

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

CO1	Identify one's entrepreneurial traits.
CO2	Use information collected from stakeholder for establishing/setting up/founding start up
CO3	Use support systems available for Start up
CO4	Prepare project plans to manage the enterprise effectively

Course Content Details:

Unit No.	Topics / Sub-topics
1	1. Introduction to Entrepreneurship Development 1.1 Entrepreneurship as a career – charms, advantages, disadvantages, scope- local and global. 1.2 Traits of successful entrepreneur: consistency, creativity, initiative, independent decision making, assertiveness, persuasion, persistence, information seeking, handling business communication, Commitment to work contract, calculated risk taking, learning from failure. 1.3 Types of enterprises and their features: manufacturing, service and trading.
2	2. Startup Selection Process 2.1 Product/Service selection: Process, core competence, product/service life cycle, new product/ service development process, mortality curve, creativity and innovation in product/ service modification / Development. 2.2 Process selection: Technology life cycle, forms and cost of transformation, factors affecting process selection, location for an industry, material handling.. 2.3 Market study procedures: questionnaire design, sampling, market survey, data analysis. 2.4 Getting information from concerned stakeholders such as Maharashtra Centre for Entrepreneurship Development[MCED], National Institute for Micro, Small and Medium Enterprises [NI-MSME], Prime Minister Employment Generation Program [PMEGP], Directorate of Industries[DI], Khadi Village Industries Commission[KVIC].
3	3. Support System for Startup 3.1 Categorization of MSME, ancillary industries 3.2 Support systems- government agencies: MCED, NI- MSME, PMEGP,DI, KVIC 3.3 Support agencies for entrepreneurship guidance, training, registration, technical consultation, technology transfer and quality control, marketing and finance.
4	4. Managing Enterprise 4.1 Techno commercial Feasibility study, feasibility report preparation and evaluation criteria. 4.2 Ownership, Capital, Budgeting, Matching entrepreneur with the project. 4.3 Unique Selling Proposition [U.S.P.]: Identification, developing a marketing plan. 4.4 Breakeven point, return on investment (ROI) and return on sales (ROS). 4.5 Preparing strategies of handling business: policy making, negotiation and bargaining techniques. 4.6 Risk Management: Planning for calculated risk taking, initiation with low cost projects, integrated futuristic planning, definition of startup cycle, ecosystem , angel investors, venture capitalist 4.7 Incubation centers and accelerators: Role and procedure.

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IV. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Sr. No.	Laboratory Learning Outcomes (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant CO
1	LLO 1.1 Collect information of successful entrepreneurial traits	*Preparation of report on entrepreneurship as a career	2	1
2	LLO 2.1 Identify different traits as an entrepreneur from various field LLO 2.2 Suggest different traits from identified problem	Case study on 'Traits of Entrepreneur'	2	1
3	LLO 3.1 Explore probable risks for identified enterprise.	*Case study on 'Risks associated with enterprise	2	1
4	LLO 4.1 Identify new product for development LLO 4.2 Prepare a newly developed product	*Preparation of report on 'Development of new Product'	2	1,2
5	LLO 5.1 Identify Process for development of product for new startup	Preparation of Report on 'Process selection' for new startup	2	1,2,3
6	LLO 6.1 Develop questioner for market survey	*Market survey for setting up new Startup	2	2,3
7	LLO 7.1 Interpret the use of Technology Life Cycle	A Case study on 'Technology life cycle' of any successful entrepreneur.	2	3
8	LLO 8.1 Use information related to support of startups from Government and non-government agencies' LLO 8.2 Prepare report for setting up startup	*Preparation of report on 'Information for setting up new startup' from MCED/MSME/KVIC etc	2	3,4
9	LLO 12.1 Prepare feasibility report of given business	*Preparation of report on 'feasibility of any Techno-commercial business'	2	4
10	LLO 11.1 Calculate Brake even point of any enterprise	Preparation of report on 'Brake even point calculation' of any enterprise.	2	4
11	LLO 9.1 Compute ROI of successful enterprise.	Case study on 'Return on Investment (ROI)' of any successful startup	2	4
12	LLO 10.1 Calculate of ROS of any successful enterprise	Case study on 'Return on sales (ROS)' of any successful startup	2	4
13	LLO13.1 Plan a USP of any enterprise.	*A case study based on 'Unique selling Proposition (USP) of any successful enterprise	2	4
14	LLO 14.1 Prepare a project report using facilities of Atal Incubation center.	*Prepare project report for starting new startup using 'Atal incubation center' (AIC)	2	1,2,3,4

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V. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

- Prepare a 'Women entrepreneurship business plan' Choose relevant government scheme for the product/service
- Prepare a 'Pitch- desk' for your startup
- Prepare a business plan for a. Market research b. Advertisement agency c. Placement Agency d. repair and Maintenance agency e. Tour and Travel agency
- Prepare a 'Social entrepreneurship business plan, plan for CSR funding.
- Prepare a business plan for identified projects by using entrepreneurial eco system for the same (Schemes, incentives, incubators etc.)

Note:

Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.

The faculty must allocate judicious mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.

If a microproject is assigned, it is expected to be completed as a group activity. SLA marks shall be awarded as per the continuous assessment record.

For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.

If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

Note: if any**Formative Assessment (Assessment for Learning) for PR and SLA**

- Rubrics for continuous assessment based on process and product related performance indicators (___ marks)

Summative Assessment (Assessment of Learning)

End term examination, Viva-voce, Workshop performance (___ marks)

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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 Lifelong Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	2	-	-	3	2			
CO2	2	2	2	2	-	3	2			
CO3	2	2	2	2	-	3	2			
CO4	2	2	2	2	-	3	2			

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

a) Suggested Learning Materials / Books

Sr. No.	Author	Title	Publisher
1	Dr. Nishith Dubey, Aditya Vyas, Annu Soman, Anupam Singh	Un- boxing Entrepreneurship yourself help guide to setup a successful business	Indira Publishing House ISBN-2023,978-93-93577-70-2
2	Gujral, Raman	Reading Material of Entrepreneurship Awareness Camp	Entrepreneurship Development Institute of India (EDI), GOI, 2016 Ahmedabad
3	Chitale, AK	Product Design and Manufacturing	PHI Learning, New Delhi, 2014; ISBN: 9788120348738
4	Charantimath, Poornima	Entrepreneurship Development Small Business Entrepreneurship	Pearson Education India, New Delhi; ISBN: 9788131762264
5	Khanka, S.S.	Entrepreneurship and Small Business Management	S. Chand and Sons, New Delhi, ISBN:978-93-5161-094-6

b) Learning Websites & Portals

Sr. No.	Link/Portal	Description
1	http://www.mced.nic.in/allproduct.aspx	MCED Product and Plan Details
2	http://niesbud.nic.in/Publication.html	The National Institute for Entrepreneurship and Small Business Development Publications

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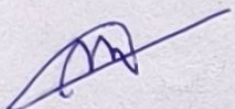
Entrepreneurship Development and Startup (EE23502) Approved Copy P-23 scheme

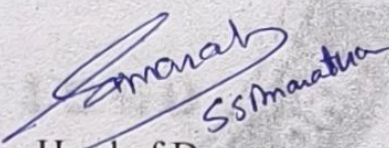
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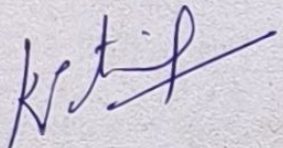
3	http://niesbud.nic.in/docs/1standardized.pdf	Courses : The National Institute for Entrepreneurship and Small Business Development
4	https://www.nabard.org/content1.aspx?id=23andcatid=23andmid=530	Government Schemes
5	https://www.nabard.org/Tenders.aspx?cid=501andid=24	NABARD-Information Centre
6	http://www.startupindia.gov.in/pdfFile.php?title=Startup%20India%20Action%20Planandtype=Actionandq=Action%20Plan.pdfandcontent_type=Actionandsubmenupoint=action	Start Up India
7	http://www.ediindia.org/institute.html	About - Entrepreneurship Development Institute of India (EDI)

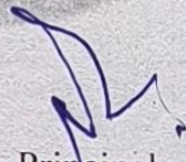
c) Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Raju Alone	Superintendent Engineer	MAHAGENCO, PRAKASHBAVAN, Bandra, Mumbai
2	Dr. S.V. Bhangale	HOD Electrical Engineering	Government Polytechnic, Pune
3	Dr. S.S. Bharatkar	HOD Electrical Engineering	Government Polytechnic, Mumbai
4	Mr. R.S. Shukla	Lecturer in Electrical Engineering	Government Polytechnic, Mumbai

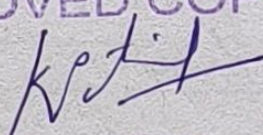

Coordinator,
Curriculum Development,
Department of Electrical Engineering


Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

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CDC Co-ordinator
G. P. Mumbai

Programme : Diploma Electrical Engineering(Sandwich Pattern)													
Course Code: EE 23701						Course Title : Internet of things (IoT)							
Compulsory / Optional: Optional													
Learning Scheme and Credits						Assessment Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2:30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	-	6	3	20	20	60	25	-	#25	-	150

Total IKS Hrs. for course: 1

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale

The Internet of Things (IoT) integrates a large number of technologies and allows granular control and automation of tasks. With better Internet and cloud infrastructure, the world of technology has allowed for the rise of IoT, which now connects millions of devices together through the Internet. A sound knowledge of IoT is important because it enhances efficiency, automates processes, improves data collection, enables smart decision-making, and enhances daily life through connectivity between devices. It drives innovation, supports sustainability, and creates new opportunities across industries.

II. Industry / Employer Expected Outcome

The aim of this course is to help the student to attain the following industry identified outcome through various teaching learning experiences:

- i. Understand given IoT system.
- ii. Develop and maintain IoT system for particular application.

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III. **Course Outcomes:** Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Understand the fundamental concepts / architecture of IOT.
CO2	Understand the basic pin configuration and programming of controller required for IoT.
CO3	Apply sensors and actuators to design efficient IoT system.
CO4	Apply communication protocol for data handling.
CO5	Develop IoT based applications

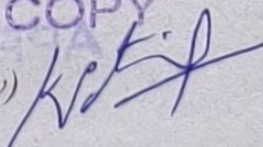
Course Content Details:

Unit No.	Theory Learning Outcomes (TLO)	Topics / Sub-topics
1	TLO 1.1 Describe the architecture of IoT system. TLO 1.2 List types of IoT system. TLO 1.3 Illustrate Physical and logical design of IoT system. TLO 1.4 Elaborate IoT enabling technology for the given application. TLO 1.5 List challenges in IoT based system. TLO 1.6 State the applications of IoT	Unit - I Basics of Internet of Things (IoT) 1.1. Embedded System: Definition, Concepts, architecture, Major components of the embedded system- Hardware, Software, and Operating System. 1.2. Basics of IoT: definition, characteristics, features, advantages, disadvantages, architecture of IoT with block diagram, types of IoTs 1.3. Physical design of IoT, Logical design of IoT : IoT functional blocks and IoT communication Models (Request-Response, Publish-Subscribe, Push-Pull, Exclusive Pair) 1.4. IoT enabling technologies : Wireless Sensor Networks, Cloud Computing, Big Data Analytics 1.5. Design and Security challenges in IoT 1.6. Applications of IoT Course Outcome: CO1 Teaching Hours: 10 hrs
2	TLO 2.1 Draw Pin diagram of Arduino. TLO 2.2 Describe the procedure for creating, compiling and uploading the programs TLO 2.3 Develop sketches for basic built in examples	Unit - II Fundamentals of Arduino 2.1 Introduction and Pin diagram of Arduino 2.2 Arduino Integrated Development Environment - (IDE), Arduino IDE setup, creating, compiling and uploading programs 2.3 Arduino Built-in Examples (Codes) : Basics : Analog Read Serial, Bare minimum code needed, Blink, Digital Read Serial, Fading a LED, Read Analog Voltage (Hardware Required, Circuit, Schematic, Code) Course Outcome: CO2 Teaching Hours: 12 hrs

3	TLO 3.1 Select relevant sensor for the given application. TLO 3.2 Select relevant actuators for the given application. TLO 3.3 Describe the function of different input and out pins of the given sensors and actuators along with its technical specifications. TLO 3.4 Draw the schematic diagram to explain the connections of sensors and/or actuators with Arduino	Unit - III IoT Sensors and Actuators 3.1 Sensors: LDR, PIR, LM35, DHT11, IR, Gas sensor-MQ 4. 3.2 Actuators: relay, DC motor, stepper motor, buzzer. 3.3 Interfacing sensors and actuators with Arduino: Interfacing Temperature sensor- LM-35, Gas sensor - MQ 4, Humidity sensor- DHT11, Photo sensors- LDR, PIR, IR (only working principle, technical specifications, pin diagram, and interfacing diagram showing connections with Arduino board expected. No programming) Course Outcome: CO3 Teaching Hours: 14 hrs
4	TLO 4.1 Describe the given IoT communication protocol with suitable example. TLO 4.2 Write steps to connect Arduino to Wi-Fi network. TLO 4.3 Write step by step procedure to create web Server with Arduino. TLO 4.4 Select IoT platform for the given application with suitable reason. TLO 4.5 Describe the procedure for data communication using MQTT protocol. TLO 4.6 Describe the given IoT network technology with suitable application.	Unit - IV IoT Communication 4.1 Basic Computer Networking Terminologies : Definition of Network, Node, Protocol, IP address, Router, Switch, Firewall, DNS, LAN, WAN, DHCP, TCP/IP 4.2 Types of Computer Network Architecture : Client - Server, Peer -to-Peer (Only Definition and difference) 4.3 Network devices : Router, Hub, Bridge, Wireless router, Switch, Wireless Bridge (Only functions) 4.4 Different Network Topologies (Bus, Star, Ring, Mesh, Tree, Hybrid) 4.5 Different Network Protocols and their functions (TCP/IP, HTTP, HTTPS, SMTP, FTP, DHCP, DNS) 4.6 Unique Identifiers of Network (Host name, IP address, MAC address, Port) 4.7 Working of DNS 4.8 Key aspects of Network Security (Firewalls, Encryption, Intrusion Detection System, Access Control, Regular updates and patches) 4.9 Benefits of Computer Network 4.10 Types of IOT Communication 4.11 Communication Models in IoT 4.12 Main networking Technologies in IoT (Standard Wireless access, Private Long Range, Mobile IoT) (Only features and applications) 4.13 IEEE 802.15.4 Wireless Networking Standard (Definition, Basic Architecture, Types of Devices, Applications, Benefits) Course Outcome: CO4 Teaching Hours: 12 hrs

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5	TLO 5.1 Explain the challenges involved in developing IoT technology. TLO 5.2 Explain the security challenges involved in IoT. TLO 5.3 Illustrate basic concept with required components for IoT application in Smart Cities. TLO 5.4 Illustrate basic concept with required components for IoT application in Smart Homes. TLO 5.5 Illustrate basic concept with required components for IoT application in Smart Agriculture. TLO 5.6 Illustrate basic concept with required components for IoT application in Smart Transportation. TLO 5.7 Illustrate basic concept with required components for IoT application in Smart Grid. TLO 5.8 Illustrate basic concept with required components for IoT application in Connected Vehicles TLO 5.9 Illustrate basic concept with required components for IoT application in Smart Healthcare.	Unit - V IoT Applications 5.1 IoT Technology development challenges 5.2 IoT Security challenges 5.3 IoT Applications in : a) Smart Cities (Smart Traffic Management , Smart Parking, Public Transport Management, Utility Management, Street Lighting) b) Smart Homes (Smart Lighting, Smart Kitchen, Smart Safety and Security Systems, Smart Bathrooms) c) Smart Agriculture (Real time Weather Conditions, Smart Green house) d) Smart Transportation (Efficient Traffic Management, Automated Toll and Ticketing, Self-Driving Cars) e) Smart Grid f) Connected Vehicles g) Smart Healthcare (IoT for Patients, Physicians, Hospitals, Health Insurance Companies, Remote Patient Monitoring, Glucose Monitoring, Heart rate monitoring, Hand Hygiene monitoring, Depression Monitoring, Parkinson's disease monitoring) (only basic concept/features , components required) Course Outcome: CO5 Teaching Hours: 12 hrs
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IV. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences. (Any 10)

Sr No	Laboratory Learning Outcomes (LLO)	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant CO
1	LLO 1.1 - Connect the IR sensor and Servo motor to the IoT Gateway LLO 1.2 - Write the application program logic LLO 1.3 - Verify the notifications sent to the mobile device on execution of the program. LLO 1.4 - Decode and understand the science concept/principle behind the sensor construction	Circuit Design for IoT System — Door Automation Solution	2	CO1

2	LLO 2.1 - Connect the Keypad and Servo motor to the IoT Gateway LLO 2.2 - Write the application program logic LLO 2.3 - Verify the notifications sent to the mobile device on execution of the program. LLO 2.4 - Decode and understand the science concept/principle behind the sensor construction	Block-Based IoT Programming for Home Security Solution (Digital Lock)	2	CO1
3	LLO 3.1 - Connect the R sensor, USB Camera and Buzzer to the IoT Gateway LLO 3.2 - Write the application program logic LLO 3.3 - Verify the notifications sent to the mobile device on execution of the program LLO 3.4 - Decode and understand the science concept/principle behind the sensor construction	Build the IOT Home Security Solution using IR, Camera and Buzzer	2	CO1, CO2, CO3
4	LLO 4.1 - Connect the IR sensors and LED (using breadboard) to the IoT Gateway LLO 4.2 - Write the application program logic LLO 4.3 - Verify the notifications sent to the mobile device on execution of the program LLO 4.4 - Decode and understand the science concept/principle behind the sensor construction	Build the Energy Saving Solution with Smart Lighting	2	CO1, CO2, CO3, CO4
5	LLO 5.1 - Connect the Soil Moisture sensor, RTC, Solenoid Valve to the IoT Gateway LLO 5.2 - Write the application program logic LLO 5.3 - Verify the notifications sent to the mobile device on execution of the program LLO 5.4 - Decode and understand the science concept/principle behind the sensor construction	Demonstrate a timer based Smart Irrigation Solution	2	CO1, CO2, CO3
6	LLO 6.1 - Connect the pH Sensor and TDS sensor to the IoT Gateway LLO 6.2 - Write the application program logic LLO 6.3 - Verify the notifications sent to the mobile device on execution of the program	Build the IOT based Water Quality Testing Solution	2	CO1, CO2, CO3, CO4, CO5

	LLO 6.4 - Decode and understand the science, concept/principle behind the sensor construction			
7	LLO 7.1 - Connect the Pulse Oximeter sensor and Led board to the IoT Gateway LLO 7.2 - Write the application program logic LLO 7.3 - Verify the notifications sent to the mobile device on execution of the program LLO 7.4 - Decode and understand the science concept/principle behind the sensor construction	Demonstrate IOT in Healthcare - Smart, Pulse Rate and Oxygen Monitoring Solution	2	CO1, CO2, CO3, CO4, CO5
8	LLO 8.1 - Connect the Weight sensor, Led board and Buzzer to the IoT Gateway LLO 8.2 - Write the application program logic LLO 8.3 - Verify the notifications sent to the mobile device on execution of the program LLO 8.4 - Decode and understand the science concept/principle behind the sensor construction	Demonstrate IOT in Healthcare - Smart Saline Monitoring Solution	2	CO1, CO2, CO3, CO4, CO5
9	LLO 9.1 - Connect the IR sensor and Buzzer to the IoT Gateway LLO 9.2 - Write the application program logic LLO 9.3 - Verify the notifications sent to the mobile device on execution of the program LLO 9.4 - Decode and understand the science concept/principle behind the sensor construction	Demonstrate IOT in Healthcare - Assistive Communication Solution	2	CO1, CO2, CO3, CO4, CO5
10	LLO 10.1 - Connect the Temperature Sensor, Hall effect sensor, LED board to the IoT Gateway LLO 10.2 - Write the application program logic LLO 10.3 - Verify the notifications sent to the mobile device on execution of the program LLO 10.4 - Decode and understand the science concept/principle behind the sensor construction	Construct IOT application in Weather Forecasting - Wind Speed, Temperature and Humidity Monitoring	2	CO1, CO2, CO3, CO4, CO5
11	LLO 11. - Connect the Moisture sensor, Relay, LoRa Hub, LoRa nodes to the IoT Gateway LLO 11.2 - Write the application	Build IOT in Agriculture - Smart Scalable Irrigation Solution using LoRa Protocol		

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	program logic LLO 11.3 - Verify the notifications sent to the mobile device on execution of the program LLO 11.4 - Decode and understand the science/concept/principle behind the sensor construction		2	CO1, CO2, CO3, CO4, CO5
12	LLO 12.1 - Connect the Energy device, Relay to the IoT Gateway LLO 12.2 - Write the application program logic LLO 12.3 - Verify the notifications sent to the mobile device on execution of the program LLO 12.4 - Decode and understand the science concept/principle behind the sensor construction	Create a Smart Energy Monitoring Solution (PF, Voltage, Current, Energy consumption etc.)	2	CO1, CO2, CO3, CO4, CO5
13	LLO 13.1 - Connect the USB Camera, Keypad and Servo motor to the IoT Gateway LLO 13.2 - Write the application program logic LLO 13.3 - Verify the notifications sent to the mobile device on execution of the program LLO 13.4 - Decode and understand the science concept/principle behind the sensor construction	Build a Home Security Solution - Digital Lock with Camera	2	CO1, CO2, CO3, CO4, CO5
14	LLO 14.1 - Connect the Moisture sensor, Solenoid valve to the IoT Gateway LLO 14.2 - Write the application program logic LLO 14.3 - Verify the notifications sent to the mobile device on execution of the program LLO 14.4 - Decode and understand the science concept/principle behind the sensor construction	Build IoT solution for Rain Sensing Automatic Roof	2	CO1, CO2, CO3, CO4, CO5
15	LLO 15.1 - Connect the IR sensor, Temperature sensor and Motor to the IoT Gateway LLO 15.2 - Write the application program logic LLO 15.3 - Verify the notifications sent to the mobile device on execution of the program LLO 15.4 - Decode and understand the science concept/principle behind the sensor construction	Create IoT solution for Vehicle Overload Detection & Warning	2	CO1, CO2, CO3, CO4, CO5

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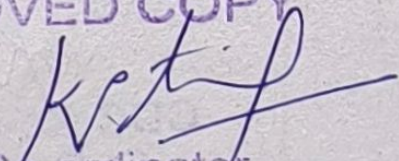
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16	LLO 16.1 - Connect the Flame sensor and Solenoid valve to the IoT Gateway LLO 16.2 - Write the application program logic LLO 16.3 - Verify the notifications sent to the mobile device on execution of the program LLO 16.4 - Decode and understand the science concept/principle behind the sensor construction	Develop a Home and Building Fire Safety Solution	2	CO1, CO2, CO3, CO4, CO5
17	LLO 17.1 - Connect the Alcohol sensor, Ultrasonic sensor, Motor and Buzzer to the IoT Gateway LLO 17.2 - Write the application program logic LLO 17.3 - Verify the notifications sent to the mobile device on execution of the program LLO 17.4 - Decode and understand the science concept/principle behind the sensor construction	Build a Transportation and Safety Solution	2	CO1, CO2, CO3, CO4, CO5
18	LLO 18.1 - Connect the IR sensors and Servo motors to the IoT Gateway LLO 18.2 - Write the application program logic LLO 18.3 - Verify the notifications sent to the mobile device on execution of the program LLO 18.4 - Decode and understand the science concept/principle behind the sensor construction	Create a Public Safety - Smart Crowd Management System	2	CO1, CO2, CO3, CO4, CO5
19	LLO 19.1 - Connect the Weight sensor, Gas sensor, Flame sensor, Led board, Buzzer, Solenoid valve to the IoT Gateway LLO 19.2 - Write the application program logic LLO 19.3 - Verify the notifications sent to the mobile device on execution of the program LLO 19.4 - Decode and understand the science concept/principle behind the sensor construction	Build a Smart LPG Monitoring Solution	2	CO1, CO2, CO3, CO4, CO5
20	LLO 20.1 - Connect the IR sensor, Ultrasonic sensor, LED board, Servo motor and Buzzer to the IoT Gateway LLO 20.2 - Write the application program logic			

	LLO 20.3 - Verify the notifications sent to the mobile device on execution of the program LLO 20.4 - Decode and understand the science concept/principle behind the sensor construction	Build a Smart City - Waste Management Solution	2	CO1, CO2, CO3, CO4, CO5
21	LLO 21.1 - Connect the Moisture sensor, Flow sensor, Ultrasonic sensor and Solenoid valve to the IoT Gateway LLO 21.2 - Write the application program logic LLO 21.3 - Verify the notifications sent to the mobile device on execution of the program LLO 21.4 - Decode and understand the science concept/principle behind the sensor construction	Create IoT application for Air Quality Monitoring	2	CO1, CO2, CO3, CO4, CO5
22	LLO 22.1 - Connect the IR sensors, Led board and Servo motor to the IoT Gateway LLO 22.2 - Write the application program logic LLO 22.3 - Verify the notifications sent to the mobile device on execution of the program LLO 22.4 - Decode and understand the science concept/principle behind the sensor construction	Develop a Smart City - Smart Parking Management System	4	CO1, CO2, CO3, CO4, CO5
23	LLO 23.1 - Connect the sensors to the IoT Gateway LLO 23.2 - Write the application program logic LLO 23.3 - Verify the notifications sent to the mobile device on execution of the program	Create a Smart Stress Monitoring Solution using GSR sensor	2	CO1, CO2, CO3, CO4, CO5
24	LLO 24.1 - Connect the sensors to the IoT Gateway as per your application requirements LLO 24.2 - Write the application program logic LLO 24.3 - Verify the notifications sent to the mobile device on execution of the program	Create your own IoT Solution	4	CO1, CO2, CO3, CO4, CO5

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Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

1. Construct a Timer based Automatic Bell/Buzzer
2. Design an Alcohol Sensing & Alert System for vehicle drivers.
3. Automate a fan based on room temperature monitoring.
4. Electronic Smart Blind Stick- If someone is in front of blind person, LED and Buzzer should on otherwise LED and Buzzer will remains off
5. Electronic Notice Board- Any Message send from mobile application should get displayed on LCD. When new message sends, previous message gets automatically erased and replaced with new message.

Assignment:

- a. Solve Assignment covering all COs given by Course Teacher.

II Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Basics of Internet of Things (IoT)	2	4	4	10
2	Fundamentals of Arduino	2	4	6	12
3	IoT Sensors and Actuators	2	6	8	16
4	IoT Communication	2	4	4	10
5	IoT Applications	2	4	6	12
Total		10	22	28	60

Note:

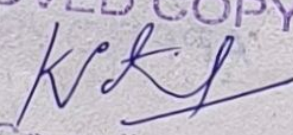
Formative assessment (Assessment for Learning) for PR and SLA

- Rubrics for continuous assessment based on process and product related performance indicators (__ marks)

Summative Assessment (Assessment of Learning)

End term examination, Viva-voce

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

Legends: - High:03, Medium:02, Low:01, No Mapping: --

a) Suggested Learning Materials / Books

Sr. No	Author	Title	Publisher
01	Arshdeep Bahga, Vijay Madisetti	Internet of Things: A Hands-On Approach	University Press, ISBN: 9788173719547
02	Raj Kamal	INTERNET OF THINGS Architecture and Design Principles	McGraw Hill Education (India) Private Limited, ISBN: 9789390727384
03	Adrin McEwen & Hakim Cassimally	Designing the Internet of things	Wiley India, ISBN: 9781118430620
04	Sudip Misra, Anandarup Mukherjee, Arijit Roy	Introduction to IoT	Cambridge University Press, ISBN: 9781108842952
05	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things	Cisco Press, ISBN: 9781587144561
06	Richard Blum	Sams Teach Yourself Arduino™ Programming in 24 Hours	Pearson Education, Inc. ISBN: 9780672337123
07	Rahul Dubey	An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications	Cengage India Private Limited, ISBN: 9789353500931931

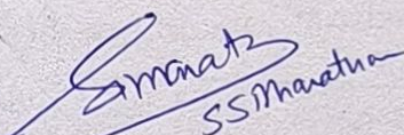
b) Learning Websites & Portals

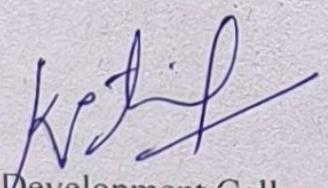
Sr.No	Link / Portal	Description
1	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_0130009449730539521875_shared/overview	IoT Platform
2	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01329474210427699229893_shared/overview	"Mastering IoT with Arduino". Infosys Spring board online course for Thinkspk platform.
3	https://www.arduino.cc/en/software	Arduino IDE software
4	https://www.tinkercad.com/projects?subject=arduino&sort=views	Arduino projects on Tinkercad
5	Introduction to Internet of Things - Course (nptel.ac.in)	Complete coverage of IoT
6	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01384301295320268828657_shared/overview	IoT Automation with ESP8266 with Projects
7	https://www.guru99.com/iot-tutorial.html	IoT Tutorial: Introduction to Internet of Things (IoT Basics)
8	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_0130009449730539521875_shared/overview	IoT Platform

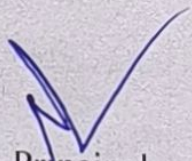
c) Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Ms.Asmata Patil	Executive Engineer	Prakash Gad, Head Office, MSEDCL, Bandra (East) Mumbai
2	Dr.D.D.Lulekar	HOD Electrical Engineering	Government Polytechnic, Nashik
3	Dr.Mahesh S.Narkhede	Lecturer in Electrical Engineering	Government Polytechnic, Mumbai
4	Dr.S.S.Bharatkar	HOD Electrical Engineering	Government Polytechnic, Mumbai


Coordinator,
Curriculum Development,
Department of Electrical Engineering


Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

Programme: Diploma in Electrical Engineering (Sandwich Pattern)

Course Code: EE23 201

Course Title: Advanced Renewable Energy Sources.

Compulsory / Optional: Compulsory

Teaching Scheme and Credits

Examination Scheme

CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	2	8	4	20	20	60	25	--	25#	--	150

Total IKS Hrs. for course:

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

Due to the extensive use of energy the conventional energy sources like fossil fuel are depleting very fast & the thrust is to be given on renewable energy sources for power generation. An Electrical Engineer should be aware of methods of extracting energy from Non-Conventional energy sources like Fuel cell, Hydrogen, Solar, Wind, Geothermal etc. Energy is an important aspect in all sectors of country's economy. The energy crisis is mainly caused due to increased population and enhanced standard of living and life style of people. The conventional sources of energy are insufficient to meet these demands. Hence, alternative energy sources are utilized for power production. The use of alternate energy sources is increasing day by day. Diploma engineers are expected to operate and maintain these systems. It is therefore essential to know basics of energy conversion, conservation, and energy audit and waste heat recovery techniques.

II. Industry / Employer Expected Outcome: Install and testing various electrical installations used in industry, commercial and residential premises.

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

CO1	Describe the environmental aspects of renewable energy resources.
CO2	Explain principle and operation of chemical energy source
CO3	Interpret electricity generation from hydrogen energy source
CO4	Describe power generation from MHD systems
CO5	Interpret electricity generation from ocean energy source
CO6	Explain power generation from geothermal energy

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Course Content Details:

Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1.1 Describe Energy future in world TLO 1.2 Introduce new energy technology TLO 1.3 Compare Renewable energy source with non-renewable energy sources	1: An Introduction to Energy Sources. 1.1 General. 1.2 Energy consumption as a major of prosperity. 1.3 World energy futures. 1.4 Energy sources and their availability. - Commercial or conventional energy sources. - New energy technology. 1.5 Renewable energy sources. Advantages over non-renewable energy sources. Course Outcome: CO1 Teaching Hours :06 hrs Marks: 06
2	TLO 2.1 Describe principal of operation of a Fuel cell. TLO 2.2 Explain Classification of Fuel Cell. TLO 2.3 State advantages and disadvantage of Fuel Cell TLO 2.4 Explain Types of electrodes used in fuel cell. TLO 2.5 State application of Fuel cell.	2: Chemical Energy Sources-Fuel Cell 2.1 Introduction Fuel Cell. 2.2 Design and principal of operation of a Fuel cell 2.3 Classification of Fuel Cell. 2.4 Types of Fuel Cell. 2.5 Advantages and disadvantage of Fuel Cell. 2.6 Conversion efficiency of Fuel cell. 2.7 Types of electrodes. 2.8 Work output and EMF of Fuel Cells 2.9 Application of Fuel Cells. Course Outcome: CO2 Teaching Hours : 14 Marks : 14
3	TLO3.1 Explain Hydrogen production through different methods. TLO3.2 Describe storage process for Hydrogen. TLO3.3 State utilization of hydrogen gas. TLO 3.4 Explain how hydrogen as an alternative fuel for motor vehicles TLO 3.5 Explain Safety and management for hydrogen gas.	3: Hydrogen Energy. 3.1 Introduction. 3.2 Hydrogen production - introduction. - Electrolysis. - Thermo-chemical methods. - Some thermochemical cyclic processes. - Fossil fuel methods. - Solar energy methods. 3.3 Hydrogen storage. 3.4 Hydrogen transportation. 3.5 Utilization of hydrogen gas. 3.6 Hydrogen as an alternative fuel for motor vehicles. 3.7 Safety and management 3.8 Hydrogen technology development in India. Course Outcome: CO3 Teaching Hours : 10 Marks: 10
4	TLO 4.1 Explain working principles and operation of MHD systems TLO 4.2 Describe MHD design problems and development.	4: Magneto Hydro Dynamic (MHD) Power Generation. 4.1 Introduction. 4.2 Principles of MHD power generation. 4.3 MHD systems

	TLO 4.3 Explain materials used for MHD generators TLO 4.4 State International status of MHD power generation.	- Introduction. - Open cycle systems. - Closed cycle systems. 4.4 MHD design problems and development 4.5 Advantages of MHD systems. 4.6 Electrical conditions: voltage and power output of MHD generator 4.7 Gas conductivity. 4.8 Materials for MHD generators. 4.9 Magnetic field. 4.10 Super-conductivity. 4.11 International status of MHD power generation and its feature prospects. Course Outcome: CO4 Teaching Hours: 10 Marks: 10
5	TLO 5.1 Explain energy conversion process from ocean to electric TLO 5.2 Describe methods of Ocean thermal electric power generation. TLO 5.3 State factors consider while selecting site for ocean energy TLO 5.4 Draw and explain Hybrid cycle	5: Topic Title: Energy from Oceans. 5.1 Introduction. 5.2 Ocean thermal electric conversion (OTEC) - Introduction - Methods of Ocean thermal electric power generation - - Open cycle OTEC system. - The Closed or Anderson, OTEC Cycle. 5.3 Heat exchangers (Evaporator) 5.4 Boil-fouling 5.6 Site selection. 5.7 Energy Utilization. 5.8 Hybrid cycle. 5.9 Prospects of Ocean thermal energy conversion in India Course Outcome: CO5 Teaching Hours : 10 Marks: 10
	TLO 6.1 Enlist geothermal sources. TLO 6.2 Explain hydrothermal resources TLO 6.3 State system used to generate electricity. TLO 6.4 Describe types of geothermal power plants TLO 6.5 Explain Hybrid System. TLO 6.7 State Primer for geothermal energy conversion. TLO 6.8 Explain advantage and limitation of geothermal energy over other energy forms.	6. Geothermal energy. 6.1 Introduction. 6.2 Estimates of Geothermal power. 6.3 Nature of geothermal fields. 6.4 Geothermal sources. 6.5 Hydrothermal (Convective) resources. - Vapour dominated systems. - Liquid dominated systems. 6.6 Geopressured resources. 6.7 Hot dry Rock resources of petro thermal systems. 6.8 Magma resources (molten Rock chamber systems) 6.9 Comparison of flashed steam and total flow concept. 6.10 Interconnection of geothermal Fossil system (hybrid system) 6.11 Primer for geothermal energy conversion - Impulse reaction machines - Positive displacement machine. - Impulse machine. 6.12 Advantages and disadvantage of geothermal energy over other energy forms. 6.13 Application of geothermal energy. Course Outcome: CO6 Teaching Hours : 10 Marks: 10

IV. List of Laboratory Experiment.

Sr No	Laboratory outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Distinguish between renewable energy sources and Non renewable energy sources	Prepare report on comparing renewable energy sources with Non renewable energy sources	02	CO1
2	LLO 2.1 Explore new energy technologies available in the future	Prepare report on new energy technologies available in the future through internet/literature /books	02	CO3
3	LLO 3.1 Compare different types of Fuel Cell.	Prepare chart on comparison between different types of Fuel Cell through internet/literature /books	04	CO2,3
4	LLO 4.1 Explain how hydrogen as an alternative fuel for motor vehicles	Prepare presentation on Hydrogen as an alternative fuel for motor vehicles and make report on it.	04	CO3
5	LLO 5.1 Draw and explain classification of MHD	Draw a sheet on MHD open cycle system and Closed cycle system and prepare report through internet/literature /books	04	CO2,3
6	LLO 6.1 Explain hybrid cycle of ocean energy	Prepare a report on Hybrid cycle of Ocean thermal electric conversion system through internet/literature /books	04	CO2,4
7	LLO7.1 Describe Hydrothermal Convective system for geothermal energy	Prepare report on Hydrothermal Convective system for geothermal energy production through internet/literature /books	04	CO2,4
8	LLO8.1 Explain Hybrid System for geothermal energy.	Prepare a report on Hybrid System for geothermal energy production through internet/literature /books	02	CO3
9	LLO 9.1 Describe Prime movers used for geothermal energy	Prepare a report on Prime movers used for geothermal energy conversion through internet/literature /books	02	CO5
10	LLO10.1 Compare hydrogen energy, ocean energy and geothermal energy	Prepare Chart of comparison between Hydrogen energy, Ocean Energy and geothermal energy	02	CO6
			30	

I. List of Tutorial

NIL

II. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 5)

NA

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CDC Co-ordinator
G. P. Mumbai

III. Specification Table:

Unit No	Topic Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	An Introduction to Energy Sources	06	02	04	--	06
2	Chemical Energy Sources-Fuel Cell	14	04	04	06	14
3	Hydrogen Energy	10	02	04	04	10
4	Magneto Hydro Dynamic (MHD) Power	10	02	04	04	10
5	Energy from Oceans	10	02	04	04	10
6	Geothermal energy	10	02	08	--	10
Total		60	14	28	18	60

IV. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce (25 marks)

V. Suggested COs - POs Matrix Form

Course Outcome (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
CO1	2	1	1	2	3	1	3	3	1	3
CO2	2	1	1	2	3	1	3	3	1	3
CO3	2	1	1	2	3	1	3	3	1	3
CO4	2	1	1	2	3	1	3	3	1	3
CO5	2	1	1	2	3	1	3	3	1	3
CO6	2	1	1	2	3	1	3	3	1	3

Legends: - High:03, Medium:02, Low:01, No Mapping: --

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VI. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Fuel cell fundamentals.	O'Hayre R. P., Cha S. W., Colella W., and Prinz F. B.,	John Wiley (2008).
2	Chemical and Electrochemical Energy Systems	Narayan R. Biswanathan B University Press (India) Ltd. 1998.	ISBN-10 : 8173710694 ISBN-13 : 978-8173710698
3	Non- Conventional Energy Sources	G.D.Rai ,Khanna Publishers 2017	ISBN : 9788174090738
4	Renewable Energy Sources & Conversion technology	Bansal N. K., Kleemann M. & Michael, Meliss, Tata McGraw-Hill Co. New Delhi	ISBN : 0074600230, 9780074600238
5	Renewable energy resources and emerging technologies	Kothari D. P, Prentice Hall of India Pvt. Ltd.	ISBN-10 : 8120344707 ISBN-13 : 978-8120344709
6	Nonconventional Energy	Ashok V. Desai, New Age International Publishers Ltd	ISBN-10 : 8122402070 ISBN-13 : 978-8122402070

VII. Learning Websites & Portals

E-References:

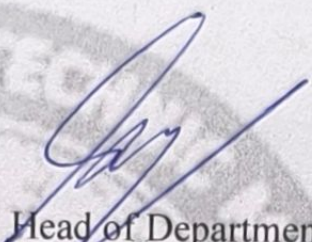
Sr. No	Link / Portal	Description
1	https://www.gtweed.com	Hydrogen Fuel Cell
2	https://www.nextias.com	Hydrogen Energy
3	https://www.electrical4u.com/mhd-generation-or-magneto-hydro-dynamic-power-generation/	MHD Generation
4	https://www.ocean-energy-systems.org/ocean-energy/what-is-ocean-energy/	Ocean Energy.
5	https://www.bing.com/videos/riverview/relatedvideo?q=geothermal+energy&mid=BD8BF3603FCFEF51445DBD8BF3603FCFEF51445D&FORM=VIRE	Video showing the Geothermal energy

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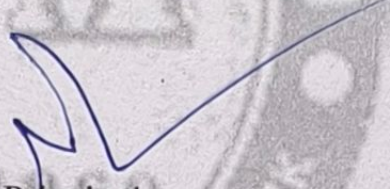
VIII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. D.D. Rathod	Executive Engineer	METRO Pune
2	Prof. Urvi Sawant	Lecturer in Electrical Engg.	SBM Polytechnic Mumbai
3	A.K. Dhulshette	Lecturer in Electrical Engineering	Government Polytechnic Mumbai
4	Dr.P.N.Padghan	Lecturer in Electrical Engineering	Government Polytechnic Mumbai

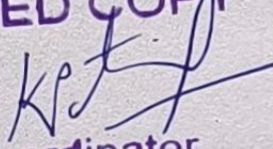

Coordinator,
Curriculum Development,
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Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

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