Maharashtra State Board Of Technical Education, Mumbai

Learning and Assessment Scheme for Post S.S.C Diploma Courses

Programme Name : Diploma In Electrical Engineering / Electrical Power System

Programme Code : EE / EP | **With Effect From Academic Year** : 2023-24

Duration Of Programme : 6 Semester | **Duration** : 12 Weeks (Industry) + 10 Weeks (Institute)

Semester : Fifth | **NCrF Entry Level** : 4.0 | **Scheme** : K

Sr No	Course Title	Abbrevation	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Assessment Scheme												
						Actual Contact Hrs./ Week			Self Learning (Activity/ Assignment / Micro Project)	Notional Learning Hrs / Week		Paper Duration (hrs.)	Theory				Based on LL & TL Practical				Based on Self Learning		Total Marks
						CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
													Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
(All Compulsory)																								
1	A.C. MACHINES PERFORMANCE	ACM	DSC	315333	-	5	-	2	2	9	3	3	30	70	100	40	25	10	25#	10	25	10	175
2	SWITCHGEAR AND PROTECTION	SGP	DSC	315334	-	5	-	2	2	9	3	3	30	70	100	40	25	10	25#	10	25	10	175
3	ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS	ENDS	AEC	315002	-	1	-	2	-	3	1	-	-	-	-	-	50	20	25@	10	-	-	75
4	SEMINAR AND PROJECT INITIATION COURSE	SPI	AEC	315003	-	-	-	1	2	3	1	-	-	-	-	-	25	10	25@	10	25	10	75
5	INTERNSHIP(12 WEEKS)	ITR	INP	315004	-	-	-	-	-	36 - 40	10	-	-	-	-	-	100	40	100#	40	-	-	200
Elective-I (Any - One)																								
6	ELECTRIC VEHICLE TECHNOLOGY	EVT	DSE	315335	-	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150
	POWER SYSTEM OPERATION AND CONTROL	PSO	DSE	315336	-	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150
	RENEWABLE ENERGY TECHNOLOGY	RET	DSE	315337	-	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150
Total						**15**		**9**	**6**		**20**		**90**	**210**	**300**		**250**		**225**		**75**		**850**

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 average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities. **Note:** Notional learning hours for **internship represents the student engagement hours.**

Course Category : Discipline Specific Course Core (DSC) , Discipline Specific Elective (DSE) , Value Education Course (VEC) , Intern./Apprenti./Project./Community (INP) , AbilityEnhancement Course (AEC) , Skill Enhancement Course (SEC) , GenericElective (GE)

A.C. MACHINES PERFORMANCE **Course Code : 315333**

Programme Name/s	**: Electrical Engineering/ Electrical and Electronics Engineering/ Electrical Power System**
Programme Code	**: EE/ EK/ EP**
Semester	**: Fifth**
Course Title	**: A.C. MACHINES PERFORMANCE**
Course Code	**: 315333**

I. RATIONALE

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

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Test the performance of different AC machines in industries.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Test the performance of three phase induction motor.
- CO2 - Control the speed of three phase induction motor using appropriate technique(s).
- CO3 - Use single phase induction motor for industrial applications.
- CO4 - Test the performance of three phase alternator.
- CO5 - Use special purpose electrical machines for industrial applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315333	A.C. MACHINES PERFORMANCE	ACM	DSC	5	-	2	2	9	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs

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

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

Note :

1. FA-TH represents average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
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.	**Unit - I Three phase induction motors** 1.1 Three phase AC machines: classification. 1.2 Squirrel cage induction motor and slip ring induction motor: constructional details. 1.3 Concept of rotating magnetic field: production of rotating magnetic field (with two and three phases), synchronous speed. 1.4 Squirrel cage induction motor and slip ring induction motor: working principle, comparison. 1.5 Rotor behavior and relations: standstill and running conditions, speed, slip, frequency of induced emf/currents, power factor. 1.6 Slip measurement methods: tachometer, stroboscope, galvanometer. 1.7 Torques: starting, full load and maximum torque & their ratios. 1.8 Torque-slip (T-S) characteristics. 1.9 Squirrel cage induction motor: losses and power stages.	Lecture Using Chalk-Board, Presentations, Video Demonstrations, Flipped Classroom, Collaborative Learning, Case Study, Industry Visit.
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. TLO 2.6 Explain the given method(s) of speed control for the induction motor.	**Unit - II Starting and speed control of three phase induction motors** 2.1 Necessity of starters for three phase induction motors. 2.2 Primary resistance starter, DOL, auto transformer starter, star delta starter, rotor resistance starter: constructional details and working. 2.3 Soft starters: component details and working. 2.4 Speed control methods: stator voltage control, pole changing, rotor resistance, variable frequency drives (VFD).	Lecture Using Chalk-Board, Presentations, Video Demonstrations, Flipped Classroom, Collaborative Learning, Case Study, Industry Visit.

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Explain the double field revolving theory and its significance in single-phase induction motors. TLO 3.2 Describe the given self-starting technique(s) for the single-phase induction motors. TLO 3.3 Describe the constructional details of the given single-phase induction motor. TLO 3.4 Explain the working principles of the given single-phase induction motor. TLO 3.5 Interpret the torque-slip characteristics of the given single-phase induction motor and state its applications.	**Unit - III Single phase induction motors** 3.1 Necessity of single-phase induction motor 3.2 Double field revolving theory. 3.3 Self starting techniques : phase splitting, shaded pole, reluctance. 3.4 Types : capacitor start-induction run, capacitor start-capacitor run (two value and single value capacitor), shaded pole: construction, working, torque-slip (T-S) characteristics and applications.	Lecture Using Chalk-Board, Presentations, Video Demonstrations, Flipped Classroom, Collaborative Learning, Case Study.
4	TLO 4.1 Describe the constructional details of three phase alternators. TLO 4.2 Explain the working principle of alternator. TLO 4.3 State the advantages of rotating field in turbo alternators. TLO 4.4 Calculate the speed and frequency for the given three phase alternator. TLO 4.5 Calculate the pitch factor, distribution factor and EMF for the given three phase alternator. TLO 4.6 Explain the given type of excitation system used in three phase alternator. TLO 4.7 Explain the significance of synchronous reactance. TLO 4.8 Explain the impact of power factors on performance of the three phase alternator. TLO 4.9 Calculate the voltage regulation of three phase alternators for the given loading conditions. TLO 4.10 Explain the working principle of three phase synchronous motor and its use for power factor improvement. TLO 4.11 Explain necessity of synchronisation and describe the	**Unit - IV Three phase synchronous machines** 4.1 Three phase alternators: constructional details, working principle. Types of alternators and their comparison: turbo alternator and hydro alternator. 4.2 Turbo alternators: advantages of rotating field. 4.3 Relations for speed and frequency. 4.4 Winding: advantages of short pitched winding, relations for pitch factor and distribution factor. 4.5 Excitation system: DC, AC, static. 4.6 E.M.F. equation of alternator. 4.7 Synchronous reactance. 4.8 Armature reaction at various power factors. 4.9 Voltage regulation: direct loading method and synchronous impedance method. 4.10 Synchronisation of alternators: definition, necessity and conditions 4.11 Three phase synchronous motor: principle of operation, significance of load angle. 4.12 Synchronous motor for power factor improvement.	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative Learning, Case Study

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	conditions for it.		
5	TLO 5.1 Describe construction of the given type of special purpose machine. TLO 5.2 Explain the working principle of the given special purpose machine. TLO 5.3 Select relevant special purpose machine for the specified application.	**Unit - V Special purpose machines** 5.1 Universal motor, synchronous reluctance motor, permanent magnet synchronous motors (PMSM), stepper motors. 5.2 Constructional details and working of linear induction motor. 5.3 Single and double sided linear induction motor. 5.4 Applications of linear induction motor.	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative Learning, Case Study

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify the different parts of a three phase squirrel cage and slip ring induction motor. LLO 1.2 Reverse the direction of rotation of a three phase induction motors. LLO 1.3 Interpret the nameplate of three phase induction motor.	1	* Identification of different parts of a three phase squirrel cage and slip ring induction motor, interpretation of the nameplate of three phase induction motor and reversal of the direction of rotation	2	CO1
LLO 2.1 Measure slip of a three phase induction motor using tachometer. LLO 2.2 Measure slip of a three phase induction motor using galvanometer. LLO 2.3 Measure slip of a three-phase induction motor using stroboscope.	2	*Measurement of slip of a three-phase induction motor by : a) using Tachometer b) using galvanometer c) using stroboscope	2	CO1
LLO 3.1 Perform brake test on a three-phase induction motor.	3	*Brake test on three-phase induction motor.	2	CO1
LLO 4.1 Measure iron and copper losses in a three-phase induction motor. LLO 4.2 Calculate the efficiency of a three-phase induction motor.	4	* Measurement of iron and copper losses through no-load and blocked rotor test on a three-phase induction motor and calculation of efficiency	2	CO1
LLO 5.1 Start a three phase induction motor using a given starter. LLO 5.2 Set the current rating of DOL/ star-delta starter.	5	* Starting of a three-phase induction motor using (a) auto transformer (b) DOL starter (c) star-delta starter	2	CO2
LLO 6.1 Control the speed of a three phase slip ring induction motor by varying rotor resistance.	6	Speed control of a three-phase slip ring induction motor by varying rotor resistance.	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 7.1 Control the speed of a three phase slip ring induction motor by varying rotor resistance. LLO 7.2 Start the three phase induction motor using VFD. LLO 7.3 Control the speed of three phase induction motor using VFD.	7	Starting and controlling the speed of a three-phase induction motor using variable frequency drive (VFD)	2	CO2
LLO 8.1 Identify different parts of a single phase induction motor. LLO 8.2 Reverse the direction of rotation of a single phase inducction motor.	8	* Identification of different parts of a single phase induction motor and reversing the direction of rotation of a ceiling fan/ single phase induction motor/ universal motor	2	CO3
LLO 9.1 Operate three phase alternator for variable frequency output.	9	Operation of three phase alternator for variable frequency output by controlling speed of its prime mover	2	CO4
LLO 10.1 Perform a direct loading test on a three phase alternator to determine voltage regulation under various loads. LLO 10.2 Calculate up ad down regulation of three phase alternator.	10	Direct loading test of a three-phase alternator for determining voltage regulation with resistive, inductive, and capacitive loads	2	CO4
LLO 11.1 Perform open circuit (OC) and short circuit (SC) test on three-phase alternator. LLO 11.2 Calculate the efficiency of a three-phase alternator. LLO 11.3 Calculate the up and down regulation of three phase alternator.	11	* Open circuit (OC) and short circuit (SC) test on three phase alternator for determining its efficiency and voltage regulation	2	CO4
LLO 12.1 Control the speed of a stepper motor.	12	*Speed control of stepper motor	2	CO5

Note : Out of above suggestive LLOs -

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

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

Assignment

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

conditions for a given slip ring induction motor connected to a rated power supply.
- Solve numerical to calculate voltage regulation of alternator.
- Solve numerical to calculate emf of alternator.

Micro project

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

Suggested Student Activity

- Note: Sign in to perform below activities in virtual lab : " https://portal.coepvlab.ac.in/vlab/ ". Suggested virtual lab practical are the additional activities to be performed by students for the better understanding of the concepts related to AC machines and should not be considered as a substitute for actual laboratory practical experiences.
- Perform short circuit test on three phase alternator.
- Perform speed control of a slip ring induction motor.
- Perform V and inverted V curves of synchronous motor.
- Perform starting of three phase induction motor with a) stator resistance starter b) auto transformer starter c) star-delta starter.
- Perform no load test on three phase induction motor.

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 judicial 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.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Three Phase Induction Motor 3 hp / 5 hp, 415 V, 50 Hz, 1440 RPM Squirrel Cage type with Brake and Pulley arrangement.	1,2,3,4,5,6
2	Three Phase Induction Motor 3 hp / 5 hp, 415 V, 50 Hz, 1440 RPM Slip Ring type.	1,2,4,5,6,7
3	Experimentation kit of speed control of stepper motor for 1.8 degree step angle	12
4	Stroboscope or relative Mobile app (e.g. Strobolight/RPM meter).	2
5	Galvanometer (30-0-30).	2
6	Auto Transformer: 3-Phase, 5kVA, 0 to 470V.	2,3,4,5,6,7,8,9,10,11
7	Ammeters MI Type: AC/DC 0-5-10A, 0-10-20A.	2,3,4,5,6,7,8,9,10,11,12
8	Voltmeters MI Type: AC/DC, 0-150/300V, 0-250/500V.	2,3,4,5,6,7,8,9,10,11,12
9	Clip on Meter Digital/Analog.	2,3,4,5,6,7,8,9,10,11,12
10	Digital Multimeter with standard makes for measurements.	2,3,4,5,6,7,8,9,10,11,12
11	Tachometers: Contact and Non-contact types: 100 to 10000 RPM.	2,3,4,5,6,7,8,9,10,11,12
12	Three Phase Induction Motor 3 hp / 5 hp, 415 V, 50 Hz, 1440 RPM Squirrel Cage type coupled with suitable DC Shunt Machine.	6
13	Wattmeters: Single Phase, Single Element, 2.5/5A, 200/400V.	6,7
14	Wattmeters: Three Phase Double Element, 5/10A, 250/500V.	6,7
15	Low Power Factor Wattmeter: Single Phase, 2.5/5A, 250/500V.	6,7
16	Single Phase Induction Motor, Permanent Capacitor (single value), 1 hp, 230 V, 50 Hz, 1440 RPM.	8
17	Star- Delta Starter (Auto/Manual), DOL Starter, VFD for 3 to 5 hp Motors.	8
18	Ceiling Fan 230V preferably dismantled.	8
19	Mixer Grinder (as a Universal Motor) 230V, 500W, 2800RPM.	8
20	Frequency Meter.	9
21	Load Bank: Resistive, 3-Phase, 5kW, 415V.	9,10
22	Load Bank: Inductive, 3-Phase, 20A, 415V.	9,10
23	Load Bank: Capacitive, 3-Phase, 20A, 415V.	9,10
24	Three Phase Alternator: 5kVA, 415V, 50 Hz, 4 Pole, 1500 RPM coupled with appropriate DC Shunt Motor.	9,10,11

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Three phase induction motors	CO1	19	2	6	12	20
2	II	Starting and speed control of three phase induction motors	CO2	5	2	4	4	10
3	III	Single phase induction motors	CO3	10	2	8	4	14
4	IV	Three phase synchronous machines	CO4	12	2	4	10	16
5	V	Special purpose machines	CO5	4	2	4	4	10
Grand Total				**50**	**10**	**26**	**34**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- 30 Marks of Theory FA shall be obtained from an average mark of two unit tests (each of 30 marks) held in the semester. At least 2 COs should be covered in each unit test.
- Continuous assessment shall be based on process and product related performance indicators and laboratory experiences. Each practical shall be assessed for 25 marks considering appropriate percentage weightage to both process and product.
- Rubrics of continuous assessment of practical, including performance indicators, shall be designed by concerned course teacher.

Summative Assessment (Assessment of Learning)

- End semester, practical summative assessment of 25 marks shall be based on student's performance in end semester practical exam.
- End semester, theory summative assessment of 70 marks shall be based on offline mode of written examination.

XI. 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	-	2	1			
CO2	3	3	-	3	-	2	1			
CO3	3	1	-	3	-	2	1			
CO4	3	1	-	3	1	2	1			
CO5	3	2	1	3	-	2	1			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

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

XIII . LEARNING WEBSITES & PORTALS

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

Note :

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

SWITCHGEAR AND PROTECTION **Course Code : 315334**

Programme Name/s : **Electrical Engineering/ Electrical Power System**

Programme Code : **EE/ EP**

Semester : **Fifth**

Course Title : **SWITCHGEAR AND PROTECTION**

Course Code : **315334**

I. RATIONALE

Switchgear and Protection plays a vital role in maintaining the reliability and stability of the power system. In order to ensure this, operational principles, selection and testing of Switchgear and Protection schemes must be known to the students while performing their duties in electrical sector.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry/employer expected outcome through various teaching learning experiences: "Select and use different switchgears and protection schemes to maintain the reliability and stability of the power system".

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Recognize the different types of faults occuring in power system.
- CO2 - Select the suitable switchgears for different applications.
- CO3 - Test the performance of different protective relays.
- CO4 - Use suitable protection schemes for alternators, motors, transformers, busbars and transmission lines.
- CO5 - Select suitable protection schemes for power system against over voltages.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315334	SWITCHGEAR AND PROTECTION	SGP	DSC	5	-	2	2	9	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : Hrs

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

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

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1. FA-TH represents average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the functions of the given elements of the protective system TLO 1.2 Explain with sketches the given types of faults and abnormalities in a power system TLO 1.3 Explain with sketches the concept of the Backup protection for the given protection zone TLO 1.4 Calculate the short circuit currents of symmetrical faults for the given generators TLO 1.5 Select suitable current limiting reactors for the given situation with justification.	**Unit - I Fundamentals of Protection** 1.1 Protective system: Necessity, functions and components 1.2 Normal and abnormal conditions 1.3 Types of faults and their causes 1.4 Protection zones and backup protection 1.5 Short circuit fault calculations for symmetrical fault on busbars fed through generators 1.6 Current Limiting Reactors : Need, types, arrangements , comparative advantages and disadvantages	Lecture Using Chalk-Board Flipped Classroom Demonstration
2	TLO 2.1 Explain the operation with sketches of the given isolators TLO 2.2 Explain with sketches the given terms related to the specified fuse (s). TLO 2.3 Explain the terms related to arc interruption process of the fuse. TLO 2.4 Explain with sketches arc formation, high resistance and zero current interruption in the given type of circuit breaker. TLO 2.5 Calculate the terms related to circuit interruption based on the given data of the circuit. TLO 2.6 Explain the	**Unit - II Circuit Interrupting Devices** 2.1 Isolators- Vertical break, Horizontal break and Pantograph type with its advantages and disadvantages 2.2 HRC fuses – Construction, types, working, Inverse time current characteristics,characteristics of fuse element, Fuse current rating, Minimum fusing current, Fusing factor, Prospective current, Cut off Current. 2.3 Terms related to Arc interruption process of fuse – pre-arcing time, cut off value, arcing time, total operating time, peak of prospective current and applications 2.4 Arc formation process, methods of arc extinction (High resistance and Low resistance). 2.5 Arc voltage, Recovery voltage, Re-striking voltage, Rate of rise of restriking voltage (RRRV). 2.6 HT circuit breakers: Vacuum circuit breaker , Sulphur-hexa Fluoride (SF_6) - Working, construction, specifications and applications 2.7 L.T. circuit breaker: Miniature circuit breakers (MCB), Moulded case circuit breakers (MCCB), Motor Protection Circuit Breaker (MPCB) , Residual Current Circuit Breaker (RCCB) and Earth leakage circuit breaker(ELCB), Air	Lecture Using Chalk-Board Presentations Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	operation with sketches of the given circuit breaker(s). TLO 2.7 Compare the given circuit interrupting devices on the specified parameters. TLO 2.8 Select the relevant switchgear for the given application with justification. TLO 2.9 Describe the general arrangement of Gas insulated switchgear TLO 2.10 Explain the Insulation coordination for the given installation/ machine. TLO 2.11 Classify the Ring main unit switchgear parameters based on given criteria. TLO 2.12 Compare Air Insulated Substation (AIS) and Gas Insulated Substation (GIS)	circuit breakers (ACB)- Construction, Working and applications 2.8 Selection of LT and HT circuit breakers 2.9 Isolator, fuses and circuit breaker: Comparison 2.10 Gas insulated switchgear 2.11 Insulation Coordination : Type1 & Type2 coordination 2.12 Ring Main Unit Switchgear: Introduction, classification based on: type of insulation (gas, oil, air), installation (outdoor, indoor). 2.13 Air Insulated Substation (AIS) : Concept, Advantages , Disadvantages ; Gas Insulated Substation (GIS) : Concept, Advantages, Disadvantages	
3	TLO 3.1 Explain the given terms related to protective relays TLO 3.2 Calculate the relay time based on the given data in the power system. TLO 3.3 Explain with sketches the working of the given protective relay TLO 3.4 Select relevant protective relay for required application with justification.	**Unit - III Protective Relays** 3.1 Protective Relay: Fundamental quality requirements (Selectivity, Speed, Sensitivity, Reliability, Simplicity, Economy) 3.2 Basic relay terminology- Protective relay, Relay time, Pick up, Reset current, current setting, Plug setting multiplier, Time setting multiplier. 3.3 Electromagnetic disc relay, Thermal relay, over voltage relay, Over current, Earth fault relay: Operation and its characteristics. 3.4 Static, Digital Relay (Microprocessor based): Block diagram, working, advantages and limitations. Numerical relay: Introduction 3.5 Distance relaying- Principle 3.6 Directional relay: Need and operation with block diagram. 3.7 Current and Voltage differential relay: Operation	Lecture Using Chalk-Board Presentations Flipped Classroom
4	TLO 4.1 Describe the causes and remedies of the given faults in the specified machine. TLO 4.2 Explain with sketches the given	**Unit - IV Protection of Alternators, Motors, Transformers, Busbars and Transmission lines** 4.1 Abnormalities and Faults occurring in alternator 4.2 Differential, Overcurrent , Earth fault Protection: Schemes 4.3 Reverse power protection: Scheme	Lecture Using Chalk-Board Presentations Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	protection schemes of the specified machine TLO 4.3 Calculate percentage of winding protected for the specified alternator TLO 4.4 Calculate CT ratio of the specified transformer protection scheme. TLO 4.5 Explain the causes and remedies of the given faults in the busbar and transmission line	4.4 Abnormalities and Faults occurring in transformer 4.5 Differential, over current, earth fault, over heating protection. 4.6 Limitations of differential protection. 4.7 Buchholz relay: Construction, operation. 4.8 Motor: Abnormalities and Faults, Short circuit protection, Overload protection, Single phase preventer. 4.9 Busbar: Faults, busbar protection, differential and fault bus protetion. 4.10 Transmission Line: Faults, Over current, Distance and Pilot wire protection.	

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

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Identify different parts of the Lightning Arrestor.	10	*Demonstration of Thyrite type lightning arrester using video /Dismantling the same.	2	CO5
LLO 11.1 Describe the step by step procedure to carry out Neutral Earthing.	11	Demonstrate process of carrying out neutral earthing at different substations / locations or with suitable media.	2	CO5

Note : Out of above suggestive LLOs -

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

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

Micro project

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

Assignment

- Write a report on causes of overvoltages in power system.
- Write a report on Lightning phenomena.
- Write a report on Protection of power system against travelling waves.
- Write a report on different types of Lightning arrestors.
- Write a report on arcing ground and Neutral grounding.

All Assignments are mandatory as they will contribute to attainment of CO5.

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 judicial 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.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

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

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Protection	CO1	8	2	4	6	12
2	II	Circuit Interrupting Devices	CO2	10	2	8	6	16
3	III	Protective Relays	CO3	12	4	4	10	18
4	IV	Protection of Alternators, Motors, Transformers, Busbars and Transmission lines	CO4	20	2	8	14	24
Grand Total				**50**	**10**	**24**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and average of two unit tests considered. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.

Summative Assessment (Assessment of Learning)

- End Semester assessment of 25 marks for laboratory learning. End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

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

	Knowledge				Sustainability and Environment					
CO1	3	3	3	2	3	2	2			
CO2	3	1	2	2	3	2	3			
CO3	3	1	2	2	3	2	2			
CO4	3	3	3	2	3	2	2			
CO5	3	1	3	2	3	2	2			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mehta V. K ; Rohit Mehta	Principles of Power System	S.Chand and Co., New Delhi., 2016 ISBN: 978-93-5501-077-3
2	Rao.Sunil S.	Switchgear and Protection	Khanna Publishers, New Delhi, 2015 ISBN: 978-93-87394-72-8
3	Gupta. J. B.	Switchgear and Protection	S. K. Kataria and Sons, New Delhi, 2015ISBN: 978-93-5014-372-8.
4	Singh, R. P.	Switchgear and Power System Protection	PHI Learning, New Delhi,2015 ISBN: 978-81-203-3660-5.
5	Ram, Badri Vishwakarma D. N.	Power System Protection and Switchgear	McGraw-Hill, New Delhi. 2015 ISBN : 978-00-7107-774-3
6	Veerapan, N., Krishnamurty, S. R.	Switchgear and Protection	S .Chand and Co., New Delhi. 2014 ISBN: 978-81-2193-212-7.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	www.cgglobal.com	Different types of Switchgears
2	https://nptel.ac.in/ courses/108101039	NPTEL course on Power System Protection (Fundamentals of Power System Protection, Fault Analysis, Over current Protection, Directional Overcurrent Protection, Distance Protection, Numerical Relay Fundamentals, Differential Protection of Busbar, Transformer and Generator)
3	https://new.abb.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgears, Relays.
4	https:// www.elecspare.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgear

Note :

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

Programme Name/s	**: Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Civil & Environmental Engineering/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: AI/ AN/ AO/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ HA/ IE/ IF/ IH/ LE/ SE/ TE**
Semester	**: Fifth**
Course Title	**: ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS**
Course Code	**: 315002**

I. RATIONALE

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

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Develop project proposals for launching small scale enterprises and starts up.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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 starts up
- CO3 - Use support systems available for Starts up
- CO4 - Prepare project plans to manage the enterprise effectively

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/ s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315002	ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS	ENDS	AEC	1	-	2	-	3	1	-	-	-	-	-	50	20	25@	10	-	-	75

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

1. FA-TH represents average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare advantages and disadvantages of Entrepreneurship TLO 1.2 Identify entrepreneurial traits through self-analysis TLO 1.3 Compare risk associated with different type of enterprise	**Unit - I 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	Presentations Lecture Using Chalk-Board
2	TLO 2.1 Explain Important factors essential for selection of product/service and selection of process TLO 2.2 Suggest suitable place for setting up the specified enterprise on the basis of given data/ circumstances with justification. TLO 2.3 Suggest steps for the selection process of an enterprise for the specified product or service with justification. TLO 2.4 Plan a market study / survey for the specified enterprise	**Unit - II 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 Instries Commission[KVIC]	Presentations Lecture Using Chalk-Board
3	TLO 3.1 Explain categorization of MSME on	**Unit - III Support System for Startup** 3.1 Categorization of MSME, ancillary industries	Presentations Lecture Using

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	the basis of turnover and investment TLO 3.2 Describe support system provided by central and state government agencies TLO 3.3 State various schemes of government agencies for promotion of entrepreneurship TLO 3.4 Describe help provided by the non governmental agencies for the specified product/service TLO 3.5 Compute breakeven point, ROI and ROS for the specified business enterprise, stating the assumptions made	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. 3.4 Breakeven point, return on investment (ROI) and return on sales (ROS).	Chalk-Board
4	TLO 4.1 Explain key elements for the given business plan with respect to their purpose/size TLO 4.2 Justify USP of the given product/ service from marketing point of view. TLO 4.3 Formulate business policy for the given product/ service. TLO 4.4 Choose relevant negotiation techniques for the given product/ service with justification TLO 4.5 Identify risks that you may encounter for the given type of business/ enterprise with justification. TLO 4.6 Describe role of the incubation centre and accelerators for the given product/service.	**Unit - IV 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 Preparing strategies of handling business: policy making, negotiation and bargaining techniques 4.5 Risk Management: Planning for calculated risk taking, initiation with low cost projects, integrated futuristic planning, definition of startup cycle, ecosystem , angel investors, venture capitalist 4.6 Incubation centers and accelerators : Role and procedure	Presentations Lecture Using Chalk-Board

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Collect information of successful entrepreneurial traits	1	*Preparation of report on entrepreneurship as	2	CO1
LLO 2.1 Identify different traits as an entrepreneur from various field LLO 2.2 Suggest different traits from	2	Case study on 'Traits of Entrepreneur'	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
identified problem				
LLO 3.1 Explore probable risks for identified enterprise.	3	*Case study on 'Risks associated with enterprise	2	CO1
LLO 4.1 Identify new product for development LLO 4.2 Prepare a newly developed product	4	*Preparation of report on 'Development of new Product	2	CO1 CO2
LLO 5.1 Identify Process for development of product for new startup	5	Preparation of Report on ' Process selection 'for new startup	2	CO1 CO2 CO3
LLO 6.1 Develop questioner for market survey	6	*Market survey for setting up new Start up	2	CO2 CO3
LLO 7.1 Interpret the use of Technology Life Cycle	7	A Case study on ' Technology life cycle' of any successful entrepreneur.	2	CO3
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	8	*Preparation of report on 'Information for setting up new startup' from MCED/ MSME/KVIC etc	2	CO3 CO4
LLO 9.1 Compute ROI of successful enterprise.	9	Case study on 'Return on Investment (ROI)'of any successful startup	2	CO3
LLO 10.1 Calculate of ROS of any successful enterprise	10	Case study on 'Return on sales (ROS)'of any successful startup	2	CO3
LLO 11.1 Calculate Brake even point of any enterprise	11	Preparation of report on 'Brake even point calculation' of any enterprise.	2	CO3 CO4
LLO 12.1 Prepare feasibility report of given business	12	*Preparation of report on 'feasibility of any Techno-commercial business"	2	CO4
LLO 13.1 Plan a USP of any enterprise.	13	*A case study based on 'Unique selling Proposition (USP) of any successful enterprise	2	CO4
LLO 14.1 Prepare a project report using facilities of Atal Incubation center.	14	*Prepare project report for starting new startup using 'Atal incubation center (AIC)	2	CO1 CO2 CO3 CO4

Note : Out of above suggestive LLOs -

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

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

Micro project

- Prepare a 'Pitch- desk' for your start up
- 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 ‘ Women entrepreneurship business plan ‘ Choose relevant government scheme for the product/service
- 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 judicial 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.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computers with internet and printer facility	All

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Entrepreneurship Development	CO1	4	0	0	0	0
2	II	Startup Selection Process	CO2	2	0	0	0	0
3	III	Support System for Startup	CO3	2	0	0	0	0
4	IV	Managing Enterprise	CO4	2	0	0	0	0
Grand Total				**10**	**0**	**0**	**0**	**0**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Assessment during practicals

Summative Assessment (Assessment of Learning)

- End of term examination

XI. 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	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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dr. Nishith Dubey, Aditya Vyas , Annu Soman , Anupam Singh	Un- boxing Entrepreneurship your self 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, A K	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

XIII . 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
3	http://niesbud.nic.in/docs/1standardized.pdf	Courses : The National Institute for Entrepreneurship and Small Business Development
4	https://www.nabard.org/Tenders.aspx?cid=501andid=24	NABARD - Information Centre
5	http://www.startupindia.gov.in/pdffile.php?title=Startup%20India%20Action%20Planandtype=Actionandq=Action%20Plan.pdfandc ontent_type=Actionandsubmenupoint=action	Start Up India
6	http://www.ediindia.org/institute.html	About - Entrepreneurship Development Institute of India (EDII)
7	http://www.nstedb.com/training/training.htm	NSTEDB - Training

Note :

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

ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS **Course Code : 315002**

MSBTE Approval Dt. 24/02/2025 **Semester - 5, K Scheme**

Programme Name/s	**: Automobile Engineering./ Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Production Engineering/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: AE/ AI/ AN/ AO/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ HA/ IE/ IF/ IH/ LE/ ME/ MK/ PG/ SE/ TE**
Semester	**: Fifth**
Course Title	**: SEMINAR AND PROJECT INITIATION COURSE**
Course Code	**: 315003**

I. RATIONALE

Most of the diploma graduates lack the confidence and fluency while presenting papers or interacting verbally and expressing themselves with a large gathering. Seminar presentation boosts the confidence of the students and prepares them precisely for facing the audience, interviews and group discussions. The course on seminar is to enhance student's ability in the art of academic writing and to present it. It also helps broaden the minds of the participants. Through this course on Seminar, students will develop new ideas and perspectives of the subject /themes of emerging technologies and services of their area of studies. Project initiation enhances project planning skill which establishes measurable objectives and interaction skills.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences: Present a seminar on the selected theme/area of study effectively and confidently to the specific audience and stakeholders. Plan innovative solutions independently or collaboratively to the identified problem statement.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify topics of seminar presenting to the large gathering at the institute/conference.
- CO2 - Collect relevant and updated research-based data and information to prepare a paper of seminar presentation.
- CO3 - Apply presentation skills.
- CO4 - Create conducive environment for learning and discussion through seminar presentation.
- CO5 - Identify a problem statement and establish the action plan for the successful completion of the project.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315003	SEMINAR AND PROJECT INITIATION COURSE	SPI	AEC	-	-	1	2	3	1	-	-	-	-	-	25	10	25@	10	25	10	75

V. General guidelines for SEMINAR and Project Initiation

- The seminar must be related to emerging trends in engineering / technology programme or may be inter/ multi-disciplinary, based on the industry expected outcomes of the programme.
- The individual students have different aptitudes and strengths. Therefore, SEMINAR should match the strengths of students. For this purpose, students shall be asked to select the TITLE (Theme)of SEMINAR they would like to prepare and present.

- Seminar titles are to be finalized in consultation with the faculty mentor.
- Seminar must involve logic development of applications of various technologies/ processes applicable in industry.
- Seminar must be assigned to the single student. However, support of other students may be sorted while presenting the seminar
- Students are required to prepare using relevant software tools, write ups for presentation
- Students shall submit One Hard copy and one Soft copy each of the presentation and may be encouraged to keep a recorded copy of the presentation made during the seminar.
- Batch of 3-4 students shall be formed for project initiation.
- Projects give a platform for the students to showcase an attitude of inquiry to identify the problem statement related to the programme. Students shall Identify the information suggesting the cause of the problem and possible solutions
- Students shall study and assess the feasibility of different solutions and the financial implications.
- Students should collect relevant data from different sources (books/internet/market/suppliers/experts through surveys/interviews).
- Students shall prepare required drawings/ designs and detailed plan for the successful execution of the work.
- Students may visit the organisation pertaining to the problem statement as part of initial study.

VI.Guidelines for Seminar preparation and presentation :

Once the title/topic of a seminar has been finalized and allotted to the student, the teacher's role is important as guide, mentor and motivator, to promote learning and sustain the interest of the students.

Following should be kept in mind while preparing and presenting the seminar:

- **Seminar Orientation cum -briefing**: the seminar topics/themes should be innovative, novel and relevant to the curriculum of the programme, and also aligned to the expectations of industry.
- **Seminar Literature surve**y: Information search and data collection: the information and data should be authentic, realistic and relevant to the curriculum of the programme.
- **Seminar Preparation, and presentation**: The seminar shall be present with suitable software tools and supporting handout/notes. The presentation of seminar should not be more than 20 minutes including Q-A session.

The following guidelines may be followed for Project Initiation

- **Establishing project scope:** Determine the boundaries of the project.
- **Defining project objectives:** Set clear and measurable objectives that align with the project's purpose.
- **Stakeholder identification and analysis:** Perform an exercise in identifying all stakeholders involved in the project and analyzing their needs and expectations.
- **Team Formation:** Carefully build a team with the necessary skills and expertise to execute the project successfully.
- **Documentation.** Create a project planner showcasing the action plan, define the project's scope, outline the project definition, and design of the project. The document has to be made available to all stakeholders

VII. Criteria of Assessment /Evaluation of Seminar

A. Formative Assessment (FA) criteria

The assessment of the students in the fifth semester Progressive Assessment (PA) for 50 marks is to be done based on following criteria.

A. Suggestive RUBRICS for assessment

Sr. No.	Criteria	Marks
1	Selection Topic/Theme of seminar	05
2	Literature review and data presentation	05
3	Quality of Preparation and innovativeness	05
4	Q-A handling	05
5	Time Management	05
6	Seminar Presentation report	10

Rubrics for assessment of Project Initiation

Sr. No.	Criteria	Marks
1	Selection of Theme of Problem Statement and its innovativeness	05

2	Stages of development of Action plan	05
3	Prototyping	05

The total marks as per above out of 50, shall be converted in proportion of 25 marks.

B. Summative Assessment criteria/

The summative assessment of the students in the fifth semester End-Semester-Examination (ESE) for 50 marks is to be done based on following criteria. This assessment shall be done by the Faculty.

Suggestive **RUBRICS** may be developed by the faculty

Sr. No.	Criteria	Marks
1	Quality of information/Knowledge presented in SEMINAR	10
2	Creativity, Innovation in SEMINAR presentation	10
3	Response to the question during seminar presentation	10
4	Establishment of Innovative Problem Statement and its presentation	10
5	Objectives of the project and action plan	10

The total obtained marks shall be converted in proportion of 25 marks.

VIII. Suggestive CO-PO Mapping

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	1	0	-	2	2	3		
CO-2	2		2	-	2	1	3		
CO-3	3	1	1	2	1	2	3		
CO-4	2	0	0	2	1	2	3		
CO-5	3	3	3	2	2	3	3		

VIII.Typographical instructions/guidelines for seminar preparation & presentation

- The seminar PPT shall be computer typed (English- British)
- Text Font -Times New Roman (TNR), Size-12 point
- Subsection heading TNR- 12 point bold normal
- Section heading TNR- 12 capital bold
- Chapter Name/ Topic Name – TNR- 14 Capital
- All text should be justified. (Settings in the Paragraph)
- Different colors text/diagrams /tables may used
- The name of the candidate, diploma (department), year of submission,name of the institute shall be printed on the first slide of PPT.

IX.Seminar and Project Initiation Report

On completion and presentation of Seminar, every student will submit a brief report which should contain the following:

- Cover Page (as per annexure 1)
- Title page (as per annexure 2)

- Certificate by the Guide (as per annexure 3)
- Acknowledgment (The candidate may thank all those who helped in the execution of the project).
- Abstract of Paper presented in the seminar (It should be in one page and include the purpose of the seminar & methodology if any .)
- Index
- List of Figures
- Introduction
- Literature Review
- Information/Chapters related to Seminar topic
- Advantages and Disadvantages
- Conclusion
- Project Initiation : a) Description of problem statement. b) Scope and objectives. c) State holder d) Platform/ Equipment/ Resources identification.
- Bibliography
- References

NOTE: Seminar report must contain only relevant – technology or platform or OS or tools used and shall not exceed 25-30 pages.

Details of Softcopy to be submitted:
The soft copy of seminar presentation is required to be provided on the back cover of the seminar report in clear packet, which should include the following folders and contents:

1.Presentation (should include a PPT about project in not more than 15 slides)
2.Documentation (should include a word file of the project report)

NOTE: Soft copy must be checked for any harmful viruses before submission.

X. Sample Formats

1) Cover Page - Annexure-I

2) Index - Annexure-II

3) Assessment - Annexure-III

Annexure - I

MSBTE LOGO

SEMINAR Report

Institute Logo

"SEMINAR Title_ _ _ _ _ _ _ _ _ _ _ _ _"

as a partial fulfilment of requirement of the

THIRD YEAR DIPLOMA IN

Submitted by

Name of Student **Enrollment Number**

FOR THE ACADEMIC YEAR 20___20___

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

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

Annexure - II

Institute Name

(An Affiliated Institute of Maharashtra State Board of Technical Education)

Table of Contents

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***Students can add/remove/edit chapter names as per the discussion with their guide**

Annexure - III

Format for SEMINAR and PROJECT INITIATION Assessment /Evaluation

Formative Assessment

CRITERIA AND WEIGHTAGE

Enrollment No	**1** Selection Topic/ Theme of seminar (5)	**2** Literature review and data presentation (5)	**3**. Quality of Preparation and innovativeness (5)	**4** Q-A handling (5)	**5** Time Management (5)	6. Seminar Presentation report (10)	**7** Selection of Theme of Problem Statement and its innovativeness (5)	**8** Stages of development of Action plan (5)	**9.** Prototyping (5)	**10.** Total (50)	Scaled to (25)

SummativeAssessment

CRITERIA AND WEIGHTAGE

Enrollment No	**1.** Quality of information/ Knowledge presented in SEMINAR **10**	**2** Creativity, Innovation in SEMINAR presentation 10	**3**. Response to the question during seminar presentation 10	**4** Establishment of Innovative Problem Statement and its presentation 10	**5** Objectives of the project and action plan 10	Total **(50)**	Scaled to **(25)**

Sign: **Name: ----------** **(Course Expert/s)**	**Sign:** **Name: ----------** **(Program Head)** **(Information Technology)**

Programme Name/s	**: Automobile Engineering./ Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Production Engineering/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: AE/ AI/ AN/ AO/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ HA/ IE/ IF/ IH/ LE/ ME/ MK/ PG/ SE/ TE**
Semester	**: Fifth**
Course Title	**: INTERNSHIP(12 WEEKS)**
Course Code	**: 315004**

I. RATIONALE

Globalization has prompted organizations to encourage skilled and innovative workforce. Internships are educational and career development opportunities, providing practical/ hands-on experience in a field or discipline. Summer internship is an opportunity for students to get accustomed to modern industry practices, apply the knowledge and skills they've acquired in the classroom to real-world situations and become familiar with industry environments before they enter the professional world. Keeping this in mind, industrial training is incorporated to all diploma programmes as it enables the student to get equipped with practical skills, soft skills and life skills

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences: Apply skills and practices to industrial processes.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Observe time/resource management and industrial safety aspects.
- CO2 - Acquire professional experience of industry environment .
- CO3 - Establish effective communication in working environment.
- CO4 - Prepare report of assigned activities and accomplishments.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme			Credits	Assessment Scheme				
				Actual Contact Hrs./ Week	SLH	NLH		Paper Duration	Theory	Based on LL & TL	Based on SL	Total Marks

				CL	TL	LL					Practical											
											FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA			
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min		
315004	INTERNSHIP(12 WEEKS)	ITR	INP	-	-	-	-	36 - 40	10	-	-	-	-	-	100	40	100#	40	-	-	200	

Legends: # External Assessment

Note: Credits for Industrial Training are in-line of guidelines of NCrF : The industrial training is of 12 weeks considering 36-40 hours per week engagement of students (as per Guidlines of GR of Maharashtra Govt.) under Self Learning with guidance of industry supervisor / Mentor

V General guidelines for organizing Industrial training

The Industry/organization selected for Industrial training/ internships shall be Government/Public Limited/ Private limited / Startup /Centre of Excellence/Skill Centers/Skill Parks etc.

1. Duration of Training - 12 weeks students engagement time
2. Period of Time slot - Between 4th and 5th semester (12 weeks) i.e. commencement of internships will be immediately following the 4th semester exams.
3. Industry area - Engineering Programme Allied industries of large, medium or small-scale, Organization/ Govt./ Semi Govt Sectors.

VI Role(s) of Department at the Institute:

Following activities are expected to be performed by the concerned department at the Polytechnics.

Table of activities to be completed for Internship

S.No	Activity	Suggested Schedule WEEKS
1	Collection of information about industry available and ready for extending training with its offered capacity of students (**Sample Format 1**)	1st to 3rd week of 4th Semester
2	Allocations of Student and Mentor as per availability (Mentor: Student Ratio (1:15)	4th to 6th week of 4th semester
3	Communication with Industry and obtaining its confirmation Sample letter Format	6th to 8th week of 4th semester
4	Securing consent letter from parents/guardians of students (Sample Format 2)	Before 10th week of 4th semester
5	Enrollment of Students for industrial training (Format 3)	Before 12th week of 4rd semester
6	Issue of letter to industry for training along with details of students and mentor (Format 4)	Before 14th week of 4th Semester
7	Organize Internship Orientation session for students	Before end of 4th Semester

8	Progressive Assessment of industry training by Mentor	Each week during training period
9	Assessment of training by institutional mentor and Industry mentor	5th Semester ESE

Suggestions-

1. Department can take help of alumina or parents of students having contact in different industries for securing placement.
2. Students would normally be placed as per their choices, in case of more demand for a particular industry, students would be allocated considering their potentials. However preference for placement would be given to students who have arranged placement in company with the help of their parents or relatives.
3. Principal/HOD/Faculty should address students about industrial safety norms, rules and discipline to be maintained in the industry during training before relieving students for training.
4. The faculty members during the visit to industry or sometimes through online mode will check the progress of the student in the training, student attendance, discipline, and project report preparation each week.

VII Roles and Responsibilities of students:

1. Students may interact with the mentor to suggest choices for suitable industry, if any. If students have any contact in industry through their parents or relatives then the same may be utilized for securing placement for themselves and their peers.
2. Students have to fill the forms/formats duly signed by institutional authorities along with a training letter and submit it to a training officer/mentor in the industry on the first day of training.
3. Students must carry with him/her Identity card issued by the institute during the training period.
4. Students should follow industrial dressing protocols, if any. In absence of specific protocol students must wear college uniform compulsorily.
5. Students will have to get all necessary information from the training officer/mentor at industry regarding schedule of training, rules and regulation of the industry and safety norms to be followed. Students are expected to observe these rules, regulations and procedures.
6. Students must be fully aware that if they disobey any rule of industry or do not follow the discipline then non-disciplinary action will be taken .
7. Students must maintain a weekly diary (**Format 6**) by noting daily activities undertaken and get it duly signed from industry mentor or Industrial training in charge.
8. In case students face any major problems in industry such as an accident or any disciplinary issue then they should immediately report the same to the mentor at the institute.
9. Prepare a final report about the training for submitting to the department at the time of presentation and viva-voce and get it signed from a mentor as well as industry training in charge.

10. Students must submit the undertaking as provided in **Format 5**.

VIII Typographical guidelines for Industry Training report

Following is the suggestive format for preparing the training report. Actual report may differ slightly depending upon the nature of industry. The training report may contain the following

1. The training report shall be computer typed (English- British) and printed on A4 size paper.
2. Text Font -Times New Roman (TNR), Size-12 point
3. Subsection heading TNR- 12 point bold normal
4. Section heading TNR- 12 capital bold
5. Chapter Name/ Topic Name – TNR- 14 Capital
6. All text should be justified. (Settings in the Paragraph)
7. The report must be typed on one side only with double space with a margin 3.5 cm on the left, 2.5 cm on the top, and 1.25 cm on the right and at bottom.
8. The training report must be hardbound/ Spiralbound with a cover page in black color. The name of the candidate, diploma (department), year of submission, name of the institute shall be printed on the cover.
9. The training report, the title page should be given first then the Certificate followed by the acknowledgment and then contents with page numbers.

IX Suggestive format of industrial training report

Following format may be used for training report. Actual format may differ slightly depending upon the nature of Industry/ Organization.

- Title Page
- Certificate
- Abstract
- Acknowledgement
- Content Page

Chapter 1	Organization structure of Industry and general layout.
Chapter 2	Introduction to Industry / Organization (history, type of products and services, turn over and number of employees etc.)
Chapter 3	Types of Major Equipments/raw materials/ instruments/machines/ hardware/software used in industry with their specifications, approximate cost, specific use and routine maintenance done
Chapter 4	Processes/ Manufacturing Manufacturing techniques and methodologies and material handling procedures
Chapter 5	Testing of Hardware/Software/ Raw materials/ Major material handling product (lifts, cranes, slings, pulleys, jacks, conveyor belts etc.) and material handling procedures.
Chapter 6	Safety procedures followed and safety gears used by industry.
Chapter 7	Particulars of Practical Experiences in Industry/Organization if any in Production/Assembly/ Testing/Maintenance
Chapter 8	Detailed report of the tasks undertaken (during the training).

Chapter 9	Special/challenging experiences encountered during training if any (may include students liking & disliking of workplaces).
Chapter 10	Conclusion
Chapter 11	References / sources of information

X Suggested learning strategies during training at Industry

- Students should visit the website of the industry where they are undergoing training to collect information about products, processes, capacity, number of employees, turnover etc.
- They should also refer to the handbook of the major machines and operations, testing, quality control and testing manuals.
- Students may also visit websites related to other industries wherein similar products are being manufactured.

XI Tentative week wise schedule of Industry Training

Industrial training is a common course to all Diploma programmes , therefore the industry selection will depend upon the nature of the programme and its related industry. The training activity may vary according to nature and size of industry.

The following table details of activities to be completed during industrial training.

Details of Activities to be completed during Industry training
Introduction of Industry and departments.
Study of Layout of Industry, Specifications of Machines , raw materials, components available in the industry
Study of setup and manufacturing processes
Execute given project or work assigned to the students, study of safety and maintenance procedures
Validation from industry mentor regarding project or work allocated
Report writing

XII CO-PO Mapping Table to be created by respective Department/faculty.

XIII. Formative Assessment of training : Suggested RUBRIC
(Note : Allot the marks in proportion of presentations and outcome observed. Marks excluding component of week 11 are to be filled by Institute mentor)

Week No	**Task to be assessed**	**Outcome Achievement - Poor**	**Outcome Achievement - Moderate**	**Outcome Achievement - High**		**Week-wise total Marks**
		Poor Marks	Average Marks	Good Marks	Excellent Marks	
1	Introduction of Industry	Minimal Knowledge of Departments, processes, products and work culture of the company **(Marks –1)**	Moderate Knowledge of Departments, processes, products and work culture of the company **(Marks –2)**	Good Knowledge of Departments, processes, products and work culture of the company **(Marks –3/4)**	Extensive Knowledge of Departments, processes, products and work culture of the company **(Marks –5)**	

2	Presentation of Layout of Industry, Specifications of Machines, raw materials, components available in the industry	Minimal w.r.t. tasks **(Marks –1)**	Moderate w.r.t. tasks **(Marks –2)**	Good w.r.t. tasks **(Marks –3/4)**	Extensive w.r.t. tasks **(Marks –5)**	
3	Participation in setup and manufacturing processes/ platforms	Minimal Participation with poor understanding **(Marks –1-8)**	Moderate Participation with poor understanding **(Marks –9-12)**	Good Participation with poor understanding **(Marks –13-17)**	Extensive Participation with poor understanding **(Marks –18-20)**	
4 to 10	Execution of given project or work to the students, Follow of safety and maintenance procedures	Minimal Participation with poor understanding **(Marks –1-8)**	Moderate Participation with lower level understanding **(Marks – 9-12)**	Good Participation with Good understanding **(Marks – 13-17)**	Extensive Participation with excellent understanding **(Marks – 18-20)**	
11	Validation by industry mentor regarding project or work allocated	Minimal Participation with poor performance **(Marks –1-10)**	Moderate Participation with acceptable performance **(Marks – 11-15)**	Good Participation with Good performance **(Marks – 16-20)**	Extensive Participation with excellent performance **(Marks – 21-25)**	
12	Diary writing	• Results are not Presented properly, • Project work is summarized and concluded not acceptable • Future extensions are not specified **(Marks –1-10)**	• Results are Presented just casually • Project work is summarized and concluded casually • Future extensions are casually specified **(Marks –11-15)**	• Results are Presented well and properly, • Project work is summarized and concluded to a Good level • Future extensions are well specified **(Marks –16-20)**	• Results are Presented exhaustively • Project work is summarized and elaborated in excellent manner , concluded • Future extensions are excellently specified **(Marks – 21-25)**	
Total Out of :100						

Marks for (FA) are to be awarded for each week considering the level of completeness of activity observed as per table specified in Sr.No. XIII above, from the daily diary maintained . Feedback from industry supervisor shall

also be considered.

XIV Summative Assessment (SA) of training:

Academic year : 20 -20

i) Suggested RUBRIC for SA

	Observations from Orals				**Presentations**				**Total (100)**
Enrollment Number	Tasks undertaken (20)	Overall Understanding (20)	Creativity / Innovation demonstrated (10)	Knowledge acquired (10)	Speech Clarity (10)	Body Language (10)	Presentations (10)	Diary , Report writing and / Product (10)	

Name of mentor:
Signature of Mentor

XV FORMATS

Format-1: Collecting Information about Industry/Organization available for training along with capacity

1) Name of the industry/organization:
2) Address/communication details with email :
3) Contact person details:
   a) Name:
   b) Designation:
   c) Email
   d) Contact number/s:

4) Type:

   Govt / PSU / Pvt /

   Large scale / Medium scale / Small scale …..

5) Products/services offered by industry:

6) a) Whether willing to offer Industrial training facility during May/ June for Diploma in Engineering students: **Yes / No.**
   b) If yes, whether you offer 12 weeks training: **Yes/No**
   c) Possible Industrial Capacity:

Students	Programme name/ Title					Total
	Civil	Mechanical	Chemical			
Male						
Female						
Total						

7) Whether accommodation available for interns **Yes / No.**
If yes capacity:_____

8) Whether internship is charged or free:
If charged please specify amount per candidate: _____

Signature of responsible person at Industry:

Format-2: Obtaining Consent Letter from parents/guardians

(Undertaking from Parents)

To,

The Principal,
_____,

Subject: Consent for Industrial Training.
Sir/Madam,

I am fully aware that -

i) My ward studying in _____ semester at your _____ institute has to undergo 12 weeks of Industrial training for partial fulfillment towards completion of Diploma in _____ Engineering.

ii) For this fulfillment he/she has been deputed at_____ industry, located at _____ for Industrial training /internship for the period from _____ to _____ .

With respect to above I give my full consent for my ward to travel to and from the mentioned industry. Further I undertake that –

a) My ward will undergo the training at his/her own cost and risk during training and/or stay.
b) My ward will be entirely under the discipline of the organization where he/she will be placed and will abide by the rules and regulations in face of the said organization.
c) My ward is NOT entitled to any leave during the training period.
d) My ward will regularly submit a prescribed weekly diary, duly filled and countersigned by the training supervisor of the organization to the mentor faculty of the polytechnic.

I have explained the contents of the letter to my ward, who has also promised to adhere strictly to the requirements. I assure that my ward will be properly instructed to take his own care to avoid any accidents/injuries in the industry. In case of any accident neither industry nor the institute will be held responsible.

Signature :
Name : _____
Address : _____

Phone Number :

Format-3: Students Enrollment for Industrial Training

(Academic Year –)

Sr No	Enrollment Number	Name of Student	Name of Industry	Name of Mentor at Institute

Format-4: Issue Letter to the Industry/Organization for the training along with details of students and mentors

To,

The HR Manager,

_____

Subject: Placement for Industrial training of ___ weeks in your organization….

Reference: Your consent letter no: ….

Sir,

With reference to the above we are honored to place the following students from this institute for Industrial training in your esteemed organization as per the arrangement arrived at.

The purpose of this training is to equip the student with some essential skills relevant to the demands of the industry and world of work, as well as to provide exposure to the professional environment and work culture. It is hoped that this training may enhance his/her employability and livelihood opportunities. In view of the above, we kindly request your support in facilitating this Industrial Training for the student. He/she has been adequately oriented and guided on the expectations of this training, including the maintenance of a daily diary during the training period. Additionally, the institute has secured the necessary consent and undertaking from the parent/ guardian regarding the guidelines for exit training. In view of all the above industry shall refrain from involving students into the mundane and housekeeping activities. Your cooperation in this regard will be highly appreciated.

Diploma programme in _____ Engg.

Sr.No	Enrollment No	Name of Student	Name and designation of Mentor

Diploma programme in _____ Engg.

Sr.No	Enrollment No	Name of Student	Name and Designation of Mentor

Kindly extend all possible cooperation to the students for above.

Thanking you

Yours sincerely, (Principal) Cc- To HoD/Mentor

Name of the Institute:

with Seal

Format-5: Undertaking by the students

TO

Principal

Subject: Undertaking regarding Placement for Industrial training of 12/16/18 weeks duration

I …….Reg No:…….. S/o/D/o. ……Studying in ---------- ---------- at ---------- Institute at ----------fully aware of the Industrial Training requirement and related responsibilities and participation in the ……, Industrial training between From: …… To……..

I assure you that I will be of good behavior and be obedient to the staff and mentor during the ……/ Industrial training. I will also abide and will not participate in all activity. I will also discipline myself within the rules and regulations of the Institution. I am also aware that I am participating in the …….. at my own risk and I will not hold the ----------Institute responsible in any way in any eventuality namely Accident / Injury/death or whatever mishap and I myself will be solely responsible for my safety.

Place :Signature of the student

Date :Reg. No.

Format-6: Internships Daily Diary

Name of the Student: _____ Name of the mentor (Faculty) : _____

Enrollment Number: _____ Semester: _____ Academic Year _____

Week	Day & Date	Discussion Topics/ Activity	Details of Work Allotted Till Next Session /Corrections Suggested/ Faculty Remarks	Signature of Industry Mentor
Week 01	Mon, Date			
	Tue, Date			
	Wed, Date			
	Thu, Date			
	Fri, Date			
	Sat, Date			
.	Mon, Date			
	Tue, Date			
.	Wed, Date			
	Thu, Date			
.	Fri, Date			
.	Sat, Date			
Week n	Mon, Date			
	Tue, Date			
	Wed, Date			
	Thu, Date			
	Fri, Date			
	Sat, Date			

ELECTRIC VEHICLE TECHNOLOGY **Course Code : 315335**

Programme Name/s	**: Electrical Engineering/ Electrical and Electronics Engineering/ Electrical Power System**
Programme Code	**: EE/ EK/ EP**
Semester	**: Fifth**
Course Title	**: ELECTRIC VEHICLE TECHNOLOGY**
Course Code	**: 315335**

I. RATIONALE

The global movement towards sustainable energy has positioned electric vehicle (EV) technology as a crucial field for electrical engineers. This course is designed to provide students with the essential knowledge and skills to understand, test, and work with EV systems. Through a blend of theoretical instruction and hands-on laboratory experiments, students will develop a thorough understanding of EV technology, equipping them for careers in the rapidly expanding electric vehicle industry.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Test and use different components of EV systems and compliance of policies & preparing for careers in the electric vehicle industry.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Identify components and subsystems used in electric vehicles.
- CO2 - Select electrical drives for particular EV application.
- CO3 - Test the performance of batteries and energy storage systems used for EV applications.
- CO4 - Apply the concept of converters and charging system in EV.
- CO5 - Implement Indian and state EV policies for EV applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315335	ELECTRIC VEHICLE TECHNOLOGY	EVT	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs

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

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

Note :

1. FA-TH represents average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare electric vehicles and internal combustion engine vehicles on the given points. TLO 1.2 Describe the configuration of given types of EV system. TLO 1.3 Compare given EVs on the basis of given points. TLO 1.4 Describe the function of given EV subsystem.	**Unit - I Basics of Electric Vehicles** 1.1 History and evolution of electric vehicles (EV), need of EV, Electric vehicles and internal combustion engine vehicles: Comparison on the basis of environmental impact, power source, maintenance, gear change, noise level, vibrations level, capital cost, and running cost. 1.2 Electric vehicle architecture, Types of EV: Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV). 1.3 Comparison of different electric vehicle types on the basis of Driving Component, Energy Source used, Features, Problems and models available in market. 1.4 Block diagram of EV subsystems: energy source subsystem, propulsion subsystem and auxiliary subsystem.	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on Video Demonstrations
2	TLO 2.1 Classify Electric Vehicles. TLO 2.2 Interpret the characteristics of the given electric motor(s) used in EV. TLO 2.3 Distinguish between given EV motors on the basis of given points. TLO 2.4 Select given electrical drives for EV applications.	**Unit - II Electric Vehicle Drives** 2.1 Classification of electric drives used in EV: DC Motor drives, AC Motor drives. 2.2 Brushed DC Motor, Brushless DC Motor (BLDC), Permanent Magnet Synchronous Motor (PMSM), Induction Motor (IM), Synchronous Reluctance Motor (SynRM), PM Assisted Synchronous Reluctance Motor, Axial Flux Ironless Permanent Magnet Motor: Salient features, characteristics, advantages, limitations, and usage of different motor types in EV models. 2.3 Comparison of EV motors based on power-weight ratio, torque-speed characteristic, cost of controllers required and cost of motors. 2.4 Physical location of motor in EV, Rating of motors, Connections (Mechanical and Electrical), and Selection criteria of various types of EV motors.	Lecture Using Chalk-Board Presentations Hands-on Flipped Classroom Video Demonstrations
3	TLO 3.1 Describe given terms related to battery parameter. TLO 3.2 Describe the procedure for selection of battery for the given EV.	**Unit - III Batteries and Energy Storage Systems** 3.1 Energy storage technology: EV Batteries, Supercapacitors, flywheel energy storage. Battery Parameters: Cell and Battery Voltages, Charge (or Amphour) Capacity, Energy Stored, Specific Energy, Energy Density, Specific Power, Amphour (or Charge) Efficiency, Energy Efficiency, Self-discharge Rates, Battery Geometry, Battery Temperature, Heating and Cooling	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on Video

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	TLO 3.3 Calculate EV battery capacity based on mileage and load. TLO 3.4 Describe the process of given Battery Management System (BMS). TLO 3.5 Compare given type of fuel cells based on given points.	Needs, Battery Life and Number of Deep Cycles. 3.2 Batteries: Lead-acid, NiMH (Nickel-Metal Hydride), Li-Ion (Lithium-Ion), Ni-Zn (Nickel-Zinc), Ni-Cd (Nickel-Cadmium), Aluminium–Ion batteries (Al–Ion batteries), Aluminium–air batteries (Al–air batteries)- their basic construction components, life time (cycles), efficiency, advantages and disadvantages. Comparison of various batteries. Factors influencing the operation of battery, and selection of battery. Series and Parallel connection of Batteries, Calculation of battery capacity. 3.3 Battery Management Systems (BMS): Need of BMS, Block diagram of BMS, function of each block, Battery Condition Monitoring, "3R" (Reduce, Reuse, Recycle) process for battery. 3.4 Fuel Cell: Difference between fuel cell and batteries, Fuel Cell Terminology: Anode, Cathode, Electrolyte, Catalyst, Reformer, Direct Fuel Cell, Working principle of fuel cell. Types of Fuel Cells used in EVs: Alkaline Fuel Cell (AFC), Polymer Electrolyte Membrane Fuel Cell (PEMFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel cell (SOFC), Their comparison on the basis of Electrolyte type, Cell voltage, Operating temperature, System output (kW), Efficiency (%) and Applications.	Demonstrations
4	TLO 4.1 Describe the configuration and functions of the given type of converter. TLO 4.2 Describe given type of EV charging method(s). TLO 4.3 Distinguish between given charging systems. TLO 4.4 Describe given type of charging station. TLO 4.5 Calculate charging time based on given data.	**Unit - IV Converters and EV Chargers** 4.1 Introduction to power electronics used in EV, Block diagram of typical EV: Description and Functions of DC to DC Converter, DC to AC Converter, AC to DC Converter (Rectifier) and filters. 4.2 Charging methods: Home charging, Trickle charging, Household AC charging, Public charging (DC Fast charging). 4.3 Charging System: Classification- Wireless, On board and Off board charging, V1G (Uni-directional smart charging), V2B/ V2H (Vehicle-to-Building/ Vehicle-to-Home), V2X (Vehicle-to-Everything), V2G (Vehicle-to-Grid, Bi-directional smart charging). 4.4 Charging Stations: Types of charging station, Public charging station: Selection and sizing, components and, single line diagram. Calculation of charging time and concept of battery swapping. Precautions observed while charging.	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on Video Demonstrations
5	TLO 5.1 State the given points related to NEMMP. TLO 5.2 Compare incentives policies for the given types of electric vehicle .	**Unit - V Electric Vehicle (EV) Policies** 5.1 Goal of EV30@30 campaign. Goals of electric vehicles initiative in India. National Electric Mobility Mission Plan 2020 (NEMMP): Objectives, Steps taken by Indian Government for faster adoption of electric vehicles, Barriers to adoption of electric mobility, E-mobility strategy, NEMMP 2020 Implementation structure. 5.2 Maharashtra Electric Vehicle Policy, 2021: Objectives, Basic demand incentives for electric vehicles, Vehicle segment-wise scrappage incentives, Incentives for charging infrastructure.	Lecture Using Chalk-Board Presentations Hands-on Flipped Classroom Video Demonstrations

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify components of various types of electric vehicle.	1	*Identification of electric vehicle components.	2	CO1
LLO 2.1 Identify various subsystems of electric vehicles.	2	*Identification of subsystems of electric vehicles.	2	CO1
LLO 3.1 Identify the terminals of Permanent Magnet Synchronous Motor. LLO 3.2 Identify the terminals of Three-phase Squirrel cage Induction Motor. LLO 3.3 Identify the terminals of Synchronous Reluctance Motor. LLO 3.4 Identify the terminals of Brushless DC motor.	3	*Identification of terminals of motors used in EVs.	2	CO2
LLO 4.1 Determine and compare the characteristics of given EV motors.	4	*Comparison of characteristics of EV motors.	2	CO2
LLO 5.1 Measure open circuit voltage of a given battery using multimeter. LLO 5.2 Identify the charged, discharged and dead battery condition. LLO 5.3 Determine Amphour (Ah) capacity of battery.	5	*Testing of EV batteries.	2	CO3
LLO 6.1 Perform Active Lithium-Ion Cell balancing using Plastic Platform Scale.	6	Battery Cell balancing.	2	CO3
LLO 7.1 Design battery pack for specified capacity of EV.	7	*Design of battery for EV.	2	CO3
LLO 8.1 Charge an EV battery using various methods, and record charging times and efficiency.	8	*Charging of EV battery.	2	CO4
LLO 9.1 Develop a charging station layout. LLO 9.2 Select appropriate components of charging station. LLO 9.3 Draw a single-line diagram of a charging station. LLO 9.4 Simulate the charging process of a charging station using any open-source software.	9	Public charging station for EV.	2	CO4
LLO 10.1 Calculate the charging time for different battery capacities using given formulas.	10	*Calculation of charging time of battery.	2	CO4
LLO 11.1 Prepare a report on Indian EV policy. LLO 11.2 Prepare a report on Maharashtra EV Policy, 2021.	11	*Report on EV policy.	2	CO5

Note : Out of above suggestive LLOs -

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

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

Micro project

- Build and test simple DC-DC converters and inverters.
- Prepare any micro project on EVs.
- Test sensors and systems for autonomous EVs and submit report on it.
- Perform sub-system simulations of an electric vehicle using any open-source software.
- Design and simulate an electric vehicle system model using any open source software.

Assignment

- Prepare a report on comparative study of various two-wheeler EVs available in market.
- Prepare a report on setting of Fast DC charging station.
- Prepare a report on EV battery swapping technology.
- Prepare a report on comparative study of various four-wheeler EVs available in market.
- Prepare a report on Internet of Things (IoT)/ Virtual Reality (VR)/ Augmented Reality (AR) related to EV.
- Prepare report on driverless EV car available in the market.
- Prepare a report on the performance analysis of DC-DC converters and inverters in an EV setup.
- Prepare a report on different EV chargers for two wheeler and four wheeler and make comparative study of them which are available in market.
- Prepare a report on Installation of battery charging unit at Residential Places

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 judicial 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.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Electric Vehicle two-wheeler: Top Speed-23 KM/H, Minimum Range-80 KM/C, Full Charge-4 to 5 HRS, Minimum Motor Power-250 Watts, Wheel Size-12 Inch, Minimum Battery Capacity/Rating-50V / 30Ah.	1,2,3,4
2	3½ Digit Digital Multimeter.	1,2,3,4
3	Brushless DC motor: 1 kW, 3000 rpm, at 3 Nm load torque/ whichever is available.	2
4	Three-phase AC Induction Motor: Max Motor Power: 41hp at 4500rpm, Max Motor Torque: 91Nm at 3000rpm/ whichever is available.	2

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
5	Permanent Magnet Synchronous Motor: Minimum power and torque/ whichever is available.	2
6	Synchronous Reluctance Motor: Minimum power and torque/ whichever is available.	2
7	Plastic Platform Scale Active Lithium Cell Balancing, Size: A3, Capacity: 80Ah.	3
8	Lithium-Ion E-Bike Battery, 20 Ah, Capacity (Ah).	3,4
9	Nickel-Metal Hydride E-Bike Battery, 20 Ah, Capacity (Ah).	3,4

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Electric Vehicles	CO1	7	2	8	0	10
2	II	Electric Vehicle Drives	CO2	11	0	4	16	20
3	III	Batteries and Energy Storage Systems	CO3	9	2	4	10	16
4	IV	Converters and EV Chargers	CO4	9	2	8	6	16
5	V	Electric Vehicle (EV) Policies	CO5	4	4	4	0	8
Grand Total				**40**	**10**	**28**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests, each worth 30 marks, will be conducted, and the average of the two tests will be considered.
- For formative assessment of laboratory learning 25 marks: Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment. and the average of all practical will be considered.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. 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	-	-	1	3	2	3			

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

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles.	CRC Press, 2019, ISBN 13: 978-0367137465.
2	James Larminie, John Lowry.	Electric Vehicle Technology Explained.	Wiley-Blackwell, 2012, ISBN 13: 978-1119942733
3	Dr. Nitesh Tiwari, Dr. Shekhar Yadav.	Electric Vehicle (Green and Sustainable Transportation).	S.K. Kataria & Sons, 2023, ISBN 13: 987-81-963589-0-7.
4	Ali Emadi, Mehrdad Ehsani, John M. Miller.	Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles.	CRC Press, 2003, ISBN 13: 978-0824747510.
5	Sunil R. Pawar.	Electrical Vehicle Technology: The Future Towards Eco-Friendly Technology.	Notion Press Publication, 2021, ISBN 10:1685545610.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/2IgZSDDFW-Y?si=Z1tfZO24ljBppzVA	Identification of terminals of BLDC motor.
2	https://www.niti.gov.in/sites/default/files/2023-02/EV_Handbook_Final_14Oct.pdf	Handbook of electric vehicle charging infrastructure implementation.
3	https://heavyindustries.gov.in/sites/default/files/2023-07/NEMMP-2020.pdf	National Electric Mobility Mission Plan 2020.
4	https://www.cleanenergyministerial.org/initiatives-campaigns/electric-vehicles-initiative/	Goal of EV30@30 campaign.
5	https://maitri.mahaonline.gov.in/PDF/EV%20Policy%20GR%202021.pdf	Maharashtra Electric Vehicle Policy, 2021.
6	https://www.mdpi.com/1996-1073/10/8/1217	Electric vehicle review paper.
7	https://archive.nptel.ac.in/courses/108/103/108103009/	NPTEL electric vehicle course literature.
8	https://onlinecourses.nptel.ac.in/noc22_ee53/preview	NPTEL electric vehicle course videos.
9	https://www.mdpi.com/1996-1073/15/3/1241	DC-AC converters for electric vehicle review paper.
10	https://www.niti.gov.in/sites/default/files/2022-05/Battery_swapping_report_09052022.pdf	Battery swapping.

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested

ELECTRIC VEHICLE TECHNOLOGY **Course Code : 315335**

Sr.No	Link / Portal	Description
	online educational resources before use by the students	

POWER SYSTEM OPERATION AND CONTROL **Course Code : 315336**

Programme Name/s : **Electrical Engineering/ Electrical Power System**
Programme Code : **EE/ EP**
Semester : **Fifth**
Course Title : **POWER SYSTEM OPERATION AND CONTROL**
Course Code : **315336**

I. RATIONALE

Electrical power system operation and control plays a significant role in electric power transfer from generation to consumer's end. The diploma engineers working in power sector have to perform operation and control of power system. He should have understanding about the reactive power control strategies, system stability and role of load dispatch center. This course aims to develop the basic knowledge and required skills to maintain the proper functioning of the power system.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Maintain the effective functioning and operation of electrical power transfer from generation to the consumer's end.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Represent power system by reactance diagram using per unit method
- CO2 - Manage real and reactive power balance within a power system network.
- CO3 - Ensure the effective operation of an automatic generation control system.
- CO4 - Apply various techniques to maintain power system stability.
- CO5 - Operate and manage a load dispatch center.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315336	POWER SYSTEM OPERATION AND CONTROL	PSO	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

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

1. FA-TH represents average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the basic structure of the given power system network. TLO 1.2 Explain the requirements of the given type of power system. TLO 1.3 Develop power system representation using the given single line diagram. TLO 1.4 Explain the concept of per unit method. TLO 1.5 Draw reactance diagram for the given power system by using per unit method.	**Unit - I Representation of Power System.** 1.1 Structure of power system. 1.2 Requirements of stable power system operation. 1.3 Representation of power system by single line diagram, impedance diagram and reactance diagram. 1.4 Concept of per unit method and its advantages. 1.5 Per unit method for representing power system parameters.	Lecture Using Chalk-Board, Model Demonstration Video Demonstrations Flipped Classroom
2	TLO 2.1 Explain the impact of real and reactive power imbalance for the given power flow data. TLO 2.2 Explain the relation between real power balance and frequency on the system. TLO 2.3 Explain the effect of the given condition of the frequency on the power system. TLO 2.4 Explain the relation between reactive power balance and voltage of the system. TLO 2.5 Explain the effect of the given condition of the voltage on the power system. TLO 2.6 Explain the significance of FACT controllers TLO 2.7 Explain different methods of second-generation FACT devices used for	**Unit - II Real And Reactive Power Flow** 2.1 Power flow: real power balance and reactive power balance, impact. 2.2 Relation between real power balance and frequency of the system. 2.3 Impact of variation in frequency on consumers and supply agencies (generation plants). 2.4 Relation between reactive power balance and voltage of the system 2.5 Impact of variation in voltage on consumers and supply agencies (generation plants). 2.6 FACT controllers in reactive power compensation: Need. 2.7 Reactive power injection methods by various second-generation FACT devices 2.7.1. Static synchronous series compensator (SSSC) 2.7.2. Static synchronous shunt compensator (STATCOM) 2.7.3. Unified power flow controller (UPFC) 2.7.4. Interline power flow controller (IPFC) (Introduction Only)	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	Reactive power injection.		
3	TLO 3.1 Describe the functioning of the automatic load frequency control using the block diagram for the given type of generator. TLO 3.2 Suggest suitable governor controller system for the given type of turbine. TLO 3.3 Explain the automatic voltage control (AVC) system. TLO 3.4 Describe the block diagram of automatic generation control (AGC) for the specified generating system.	**Unit - III Automatic Generation Control** 3.1 Automatic load frequency control (ALFC): Schematic diagram and working. 3.2 Governor controller system- electro hydraulic governor (Digital Governor), Restricted governing mode of operation (RGMO), Free governing mode of operation (FGMO) (Introduction Only) 3.3 Automatic voltage control (AVC): Schematic diagram and working. 3.4 Automatic generation control (AGC): Schematic diagram and working.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom Site/Industry Visit
4	TLO 4.1 Define various terms related with stability. TLO 4.2 Explain the effects of power system instability on consumers or power utility companies. TLO 4.3 Differentiate power system related large disturbance and small disturbance in the given specific case. TLO 4.4 Identify the type of power system stability condition for the given power system. TLO 4.5 Explain stability with the help of power angle diagram. TLO 4.6 List the specified method of improving steady state and transient state stability condition of the given power system.	**Unit - IV Power System Stability** 4.1 Power system stability, overall stability, stability limit and instability. 4.2 Effects of power system instability. 4.3 Large disturbance and small disturbance. 4.4 Classification of stability: i) Steady state stability ii) Transient state stability iii) Dynamic stability 4.5 Stability studies with the help of power angle diagram. 4.6 Methods of improving steady state and transient state stability condition.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom
5	TLO 5.1 Describe need of load dispatch center in power system operation and control. TLO 5.2 Explain impact of environmental and social factors on load forecasting. TLO 5.3 State the role of load dispatch center in power	**Unit - V Load Dispatch Centre** 5.1 Load dispatch centre: need and importance. 5.2 Load forecasting: significance, environmental and social factors in load forecasting. 5.3 Types of load dispatch center (NLDC, RLDC, SLDC) and their functions.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	system operation for the given situation.		Site/Industry Visit

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Calculate per unit values of parameters of power system components for low voltage power system by using MATLAB/ Scilab	1	*Reactance diagram of low voltage Power system by using per unit method	2	CO1
LLO 2.1 Calculate per unit values of parameters of power system components for high voltage power system by using MATLAB/ Scilab	2	Reactance diagram of high voltage power system by using per unit method	2	CO1
LLO 3.1 Use static VAR compensator for the given three phase induction motor. LLO 3.2 Calculate rating of reactive power compensator.	3	*Balancing reactive power at consumers ends.	2	CO2
LLO 4.1 Control bus voltages through onload tap changer by using Virtual Lab	4	*Voltage control through onload tap changer (OLTC)	2	CO2
LLO 5.1 Corelate the relationship between output of alternator and field excitation.	5	*Demonstration of the automatic voltage control system (AVC) in electrical generation by Visit / Animations/ Video programme.	2	CO3
LLO 6.1 Corelate relationship between the different generators in a generating station.	6	Demonstration of the automatic generation control (AGC) in electrical generation by Visit / Animations/ Video programme.	2	CO3
LLO 7.1 Identify the different parts of electro hydro governor system LLO 7.2 Describe the operation of the electro hydraulic governor (digital governor)	7	Observation of electro hydraulic governor (digital governor) by Visit /Animations/ Video programme of Hydro Power station.	2	CO3
LLO 8.1 Identify the different parts of Restricted Governing Mode of Operation (RGMO) and Free Governing Mode of Operation (FGMO). LLO 8.2 Describe the operation of Restricted Governing Mode of Operation (RGMO) and Free Governing Mode of Operation (FGMO)	8	Observation of Restricted Governing Mode of Operation (RGMO) and Free Governing Mode of Operation (FGMO) by Visit /Animations/ Video programme on Thermal Power station.	2	CO3
LLO 9.1 Identify type of disturbance from the given video clip/ case studies on Blackouts in India	9	*Case study of large disturbance and small disturbance.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 9.2 Prepare report with proper reason behind blackout.				
LLO 10.1 State the specific function of load dispatch center. LLO 10.2 Prepare report on load dispatch center.	10	*Demonstration of load dispatch center operation by Visit /Animations/ Video programme.	2	CO5
LLO 11.1 Identify specific reasons for load shedding adopted by DISCOM in specific area from given video clip. LLO 11.2 Prepare report on reasons and action taken by DISCOM with proper Justification.	11	Case study of load shedding methodology.	2	CO5

Note : Out of above suggestive LLOs -

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

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

Assignment

- Collect the data on Incidents of blackouts happened in India.
- Collect the information on governor used in Hydro Power plant and Thermal Power plant
- Prepare report on role of SCADA in load dispatch center operation.

Micro project

- Prepare a chart/ Model on automatic load frequency control used in power plant.
- Observe power consumption pattern of your Institute or nearby commercial center and prepare daily load curve.
- Prepare a chart/ Model on automatic generation control used in power plant.

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 judicial 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.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Software – MATLAB / Scilab or any other open sources.	1,2
2	Induction motor (3phase /1 phase,3kW)	3
3	Ammeters MI Type: AC/ DC 0-5-10Amp (03 Nos.)	3
4	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V (01 No.)	3
5	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V, (02 Nos.)	3
6	Dimmer: 3-phase, 5kVA	3
7	Capacitor bank, 3-phase, 5kW, 415V	3
8	MCB :10Amp	3
9	Virtual Lab (V-Lab)	4
10	Chart relevant to practical	5,6,7,8
11	LCD, PA System, Internet facility	5,6,7,8,9,10,11
12	Relevant videos	5,6,7,8,9,10,11

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Representation of Power System.	CO1	8	2	4	6	12
2	II	Real And Reactive Power Flow	CO2	12	4	8	8	20
3	III	Automatic Generation Control	CO3	6	2	4	6	12
4	IV	Power System Stability	CO4	8	4	4	6	14
5	V	Load Dispatch Centre	CO5	6	2	6	4	12
Grand Total				**40**	**14**	**26**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and average of two unit tests considered.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks through offline mode of examination.
- End semester summative assessment of 25 marks for laboratory learning.

XI. 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	3	1	1	2			
CO2	3	2	2	2	2	2	2			
CO3	3	2	2	3	2	2	2			
CO4	3	2	2	1	2	2	2			
CO5	3	2	3	1	2	2	2			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Nagrath I. J., Kothari D. P.	Modern Power System Analysis	5th Edition, McGraw Hill Education, New Delhi 2003 ISBN-978-9354600968
2	Gangadhar K. A.	Electric Power Systems (Analysis, Stability and Protection)	Khanna Publishers, Delhi. India, 2006. ISBN 9788174090041
3	K.R. Padiyar	Facts Controllers in Power Transmission and Distribution	3rd Edition, New Age International Private Limited, 2006. ISBN 978-9389802047
4	Abhijit Chakrabarty	Power System Analysis, operation and control	PHI Learning, New Delhi, New Delhi, 2010 ISBN: 788120340152
5	Chakrabarti, D P A Kothari, A K Mukhopadhyay, D E Abhinandan	An introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems	PHI Learning, New Delhi, 2015 ISBN: 9788120340503
6	A. J. Wood, B. F. Woolenberg,	Power Generation Operation and Control	John Wiley and Sons, UK ISBN:978-0-471-79055-6
7	Prabha S. Kundur, Om P. Malik	Power System Stability and Control	2nd Edition, 2022 McGraw Hill ISBN: 9781260473544

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://iitr.ac.in/Departments/Hydro%20and%20Renewable%20Energy%20Department/static/Modern_hydroelectric_engg/vol_1/Chapter-6_Hydro-Turbine_Governing_System.pdf	Governor Controller System-ElectroHydraulic Governor (Digital Governor)
2	WRLDC-TP-019-Implementation-of-Free-Governor-Mode-of-Operation-in-Western-Region-of-India-2004.pdf (posoco.in)	Free Governing Mode of Operation (FGMO)
3	https://cercind.gov.in/2017/draft_reg/GC-copy/Power%20System%20Operation%20Corporation%20Limited%20(POSOCO).pdf	Details of Restricted governing mode of operation (RGMO) and free governing mode of operation (FGMO)

POWER SYSTEM OPERATION AND CONTROL **Course Code : 315336**

Sr.No	Link / Portal	Description
4	https://posoco.in/reports/monthly-reports/monthly-reports-2024-25/	Statistics and current scenario of NLDC/ RLDC/SLDC
5	https://www.mahatransco.in/information/details/load_despatch	Statistics and current scenario of NLDC/ RLDC/SLDC
6	https://sa-nitk.vlabs.ac.in/exp/onload-tap-changes/	Control of Bus Voltages Through Onload Tap Changes
7	https://cercind.gov.in/2016/whatsnew/anx1.pdf	Details of Restricted governing mode of operation (RGMO) and free governing mode of operation (FGMO)

Note :

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

RENEWABLE ENERGY TECHNOLOGY **Course Code : 315337**

Programme Name/s	**: Electrical Engineering/ Electrical and Electronics Engineering/ Electrical Power System**
Programme Code	**: EE/ EK/ EP**
Semester	**: Fifth**
Course Title	**: RENEWABLE ENERGY TECHNOLOGY**
Course Code	**: 315337**

I. RATIONALE

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

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain basic electrical components of various renewable energy systems".

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Test the performance of the solar panels.
- CO2 - Maintain working of small wind turbines.
- CO3 - Utilize small-capacity hydrogen fuel cell systems for various applications.
- CO4 - Maintain basic components of biogas plant.
- CO5 - Identify major components of the geothermal, ocean and small hydro power plants.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315337	RENEWABLE ENERGY TECHNOLOGY	RET	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs

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

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

Note :

1. FA-TH represents average of two class tests of 30 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.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Define the given terminology related to solar radiation. TLO 1.2 Calculate the given parameter related to solar radiation geometry. TLO 1.3 Explain working principle of the given instrument used for solar radiation measurement. TLO 1.4 Illustrate the working principle of solar cell using equivalent circuit. TLO 1.5 Explain the concept of maximum power point using current intensity verses output voltage graph. TLO 1.6 Calculate the electrical parameters of the given solar array arrangement. TLO 1.7 Describe basic photovoltaic system using block diagram. TLO 1.8 Explain working principle of given solar collector.	**Unit - I Solar Power Technology** 1.1 Solar radiation: Beam radiation or direct radiation, diffused radiation, insolation, absorption. 1.2 Solar radiation Geometry: Declination, hour Angle, altitude angle, incident angle, zenith angle, solar azimuth angle, surface azimuth angle, day length, local solar time. 1.3 Instruments for measuring solar radiation: Pyrheliometer, Pyranometer, Sunshine recorder; Working principle, types. 1.4 Principle of conversion of solar radiation into: electricity and heat 1.5 Solar Cell: Working Principle, Equivalent Circuit, Current intensity verses output voltage graph 1.6 Solar Cell modules and arrays: Solar cell connecting arrangements 1.7 Basic Photovoltaic system for power generation: Concept and Block Diagram 1.8 Flat plate collectors: Typical liquid collector, Solar Air Heaters; Construction, Working Principle and applications and advantages. 1.9 Solar concentrating collectors: Focusing Type, Non-Focusing Type; Working Principle and applications	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Site/Industry Visit
2	TLO 2.1 Define the given terms related to wind power. TLO 2.2 Explain the principles applicable in the wind turbine rotation. TLO 2.3 Derive expression for governing wind power. TLO 2.4 State the criteria for site selection of wind energy conversion system. TLO 2.5 Describe wind energy conversion system using block diagram.	**Unit - II Wind Power Technology** 2.1 Basic terminologies: Cut-in, cut-out and survival wind speeds, Threshold wind speeds, Power in wind, Power coefficient, Maximum power and Betz Limit 2.2 Wind Turbine Rotation Principles: Forces on the blades, lift and drag, thrust and torque on wind turbine rotor 2.3 Mathematical Expression Governing Wind Power 2.4 Site selection consideration 2.5 Wind energy conversion system (WECS): Concept, Block diagram, Working principle	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	TLO 2.6 Describe the given type of wind mill system. TLO 2.7 Explain wind electric conversion system block diagram. TLO 2.8 Explain working principle of variable speed and constant frequency scheme. TLO 2.9 Explain pitch control and yaw control.	2.6 Wind mill: Horizontal axial, Vertical axial, small and large wind turbine. 2.7 Wind power generators: Permanent Magnet DC Generator, Synchronous Generator, Squirrel-Cage rotor Induction Generator (SCIG), Doubly-Fed Induction Generator (DFIG); working principle 2.8 Gearbox arrangement 2.9 Variable speed and constant frequency scheme - Concept and working principle 2.10 Pitch system: Pitch Control and Yaw control	
3	TLO 3.1 Describe the given hydrogen production method. TLO 3.2 Describe the hydrogen storage and transportation method. TLO 3.3 Compare hydrogen with the other given fuel source(s). TLO 3.4 Explain the hazards and its preventive measures related to hydrogen storage and transportation. TLO 3.5 Define the given terminology related to fuel cell. TLO 3.6 Describe the fuel cell system. TLO 3.7 Explain the resistance polarization in fuel cell.	**Unit - III Hydrogen Energy and Fuel cell** 3.1 Hydrogen Production: Electrolyser, Thermochemical Method, Coal Gasification, Photo-electrolysis; Working principle 3.2 Hydrogen Storage and transportation: Need, methods, limitations 3.3 Hydrogen as an alternative fuel for motor vehicle 3.4 Comparison of hydrogen over other fuels 3.5 Handling of Hydrogen: Hazard and its Preventive measures 3.6 Fuel cell: Terminology, working principle, types, main components of fuel cell system, advantages, disadvantages and applications 3.7 Polarization in fuel cell: Concept, Resistance polarization	Lecture Using Chalk-Board Video Demonstrations Presentations Flipped Classroom
4	TLO 4.1 Explain the given biomass conversion process. TLO 4.2 State the materials used for biomass generation. TLO 4.3 Explain the factors affecting the biomass generation. TLO 4.4 Describe the given biogas plant using schematic diagram. TLO 4.5 State the criteria for selection of site for the biogas plant.	**Unit - IV Biomass Energy** 4.1 Biomass conversion Process: Anaerobic digestion, Ethanol Fermentation, Pyrolysis, Digestion, Gasification, Hydrolysis 4.2 Materials used for Biogas generation 4.3 Factors affecting Biomass generation 4.4 Classification of Biogas Plant: Continuous and Batch type; Dome and Drum type 4.5 Biogas Plants: KVIC digester; Schematic diagram, construction; Chinese Digester; Concept; Pragati Biogas plant; Schematic diagram, working Principle 4.6 Selection of site for Biogas plant	Lecture Using Chalk-Board Video Demonstrations Presentations Flipped Classroom
5	TLO 5.1 Describe the general arrangement of the given type of geothermal power plant. TLO 5.2 Explain the working principle of the given type of geothermal power plant. TLO 5.3 State the types of ocean	**Unit - V Other Renewable Sources of Energy** 5.1 Geothermal power plant: General arrangements, types (Dry type, Wet Type and Binary type), working principle, advantages and limitations 5.2 Ocean Energy: Ocean Thermal Electric Conversion, Tidal energy, wave energy, marine current; General arrangement and working	Lecture Using Chalk-Board Video Demonstrations Presentations Flipped Classroom Case Study

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	energy power plant. TLO 5.4 Describe the general arrangement of the given type of ocean energy power plant. TLO 5.5 Explain the working principle of the given type of ocean energy power plant. TLO 5.6 Describe the general arrangement of the given type of small hydroelectric power plant. TLO 5.7 Explain the working principle of the given type of small hydroelectric power plant. TLO 5.8 State the site selection criteria for the small hydroelectric power plant.	principle, Prospects in India 5.3 Small Hydroelectric Power Plant (SHP): Classification; Mini and Micro, General arrangement and working principle, Prospects in India 5.4 Site selection for the Small Hydroelectric Power Plant	

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Measure current, voltage and power output of the solar cells/panel. LLO 1.2 Measure current, voltage and power output of the solar panel for shadow effect.	1	*Measurement of electrical parameters of the solar cells/panel.	2	CO1
LLO 2.1 Measure the current, voltage and power output of the solar panel connected to variable resistive/inductive load. LLO 2.2 Locate the maximum power generation point by analysing the graph of power verses load resistance. LLO 2.3 Measure power output of the solar panel at different inclination angles. LLO 2.4 Locate the maximum power generation point by analysing the graph of power verses inclination angle.	2	*Effect of load and inclination angle on solar panel output.	2	CO1
LLO 3.1 Connect solar panels in series and parallel combination. LLO 3.2 Measure voltage and current of the solar array by connecting solar panels in series and parallel.	3	*Series parallel connection of solar panels.	2	CO1
LLO 4.1 Design solar panel for the residential unit based on annual consumption. LLO 4.2 Prepare layout for the installation of solar panels.	4	Sizing of Solar panels required for a residential house having 500 W electrical load.	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Measure wind speed using given meters at different heights and locations.	5	*Measurement of windspeed at different heights and locations.	2	CO2
LLO 6.1 Dismantle small wind turbine. LLO 6.2 Identify different parts of small wind turbine.	6	Components of small wind turbine (Horizontal axis / Vertical axis).	2	CO2
LLO 7.1 Measure output voltage and current of given type of induction generator for different wind speeds.	7	*Performance of Induction Generator.	2	CO2
LLO 8.1 Identify different components of fuel cell by dismantling experimental kit. LLO 8.2 Assemble the fuel cell kit and operate fuel cell on load.	8	*Demonstration of hydrogen fuel cell.	2	CO3
LLO 9.1 Identify different components of biogas operated plant. LLO 9.2 Observe the output of biogas plant OR Prepare a report on biogas operated Plant	9	*Demonstration of biogas operated plant. OR Visit to biogas operated Plant.	2	CO4
LLO 10.1 Identify different components of geothermal power plant.	10	Demonstration of geothermal power plant using video/animation.	2	CO5
LLO 11.1 Prepare a report on tidal and wave power plant.	11	Demonstration of tidal and wave power plant using video/animation.	2	CO5
LLO 12.1 Prepare a report on marine power plant and ocean thermal energy conversion (OTEC) plant.	12	Demonstration of marine power plant and ocean thermal energy conversion (OTEC) plant using video/animation.	2	CO5
LLO 13.1 Identify different components of small hydro power. OR Prepare a report on small hydro power.	13	*Demonstration of small hydro power plant using video/animation. OR Visit to hydro power plant.	2	CO5

Note : Out of above suggestive LLOs -

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

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

Suggested Activities

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

Note:

- Self learning activity (SLA) is not given in this course. However, it is recommended that student continue to learn

in the advancements in renewable energy technology area on their own.

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 judicial 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.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Solar cell: Maximum Power (Pmax)-7.33 W, Voltage at Maximum Power Point (Vmpp)-0.605 V, Current at Maximum Power Point (Impp)- 12.12 A, Open Circuit Voltage (Voc)-0.683 V, Short Circuit Current (Isc)- 13.35 A	1
2	Energy Sensor, Source Input Potential Range: ± 30 V Source Input Current Range: ± 1000 mA	1,2,3
3	Solar Panel: 75 Watt 12 Volt polycrystalline or monocrystalline solar panel OR 100 Watt 12 Volt polycrystalline or monocrystalline solar panel.	1,2,3,4
4	AC and DC Voltmeter: 0 to 300V, Sensitivity = 1V/div. TRIAC: It = 4A, IGT = 10mA, Vt = 600V.	1,2,3,4,7
5	AC and DC Ammeter: Range = 0 to 20A, Sensitivity = 0.5A/div.	1,2,3,4,7
6	Multimeter: 2000 count digital display, 1000V DC/750 V AC ranges, 10 A AC/DC ranges	1,2,3,4,7
7	Biogas experimental kit, Plant Capacity-0.8 Cubic Meter, Waste Input 25 kg	10
8	Rheostat: Nicrome wire, 300ohm, 10A, 400V	2
9	Anemometer, Wind Speed Measuring Range 0.3~30m/s Accuracy of Temperature ±5% ±0.1dgt	5
10	Small wind turbine (Horizontal/Vertical axis) experimental kit, Output-20W/50W/75W/100W/ whichever is available in small size	6,7,8
11	Fuel cell experimental kit. Power in Hydrogen and Oxygen Mode: 900 mW Power in Hydrogen and Air Mode: 300 mW Generated Voltage: 0.45 - 0.96 V DC	9

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Solar Power Technology	CO1	12	4	6	10	20
2	II	Wind Power Technology	CO2	8	2	6	8	16
3	III	Hydrogen Energy and Fuel cell	CO3	7	2	6	4	12
4	IV	Biomass Energy	CO4	7	2	6	4	12

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
5	V	Other Renewable Sources of Energy	CO5	6	0	6	4	10
Grand Total				**40**	**10**	**30**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- 30 Marks of Theory FA shall be obtained from an average mark of two unit tests (each of 30 marks) held in the semester. At least 2 COS should be covered in each unit test.
- Continuous assessment shall be based on process and product related performance indicators and laboratory experiences. Each practical shall be assessed for 25 marks considering 60% weightage to process and 40% weightage to product.
- Rubrics of continuous assessment of practical, including performance indicators, shall be designed by concerned course teacher.

Summative Assessment (Assessment of Learning)

- End semester, practical summative assessment of 25 marks shall be based on student's performance in end semester practical performance exam.
- End semester, theory summative assessment of 70 marks shall be based on offline mode of written examination.

XI. 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	1	2	3	3	1	2			
CO2	3	1	1	3	3	1	2			
CO3	3	-	-	1	3	1	2			
CO4	3	-	-	1	3	-	2			
CO5	3	-	-	-	3	-	2			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Chetan Singh Solanki	Renewable Energy Technologies- A Practical guide for beginners	PHI Learning Pvt. Ltd. ISBN:9788120334342

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

XIII . LEARNING WEBSITES & PORTALS

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

Note :

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