West Bengal State Council of Technical & Vocational Education and Skill Development

TEACHING AND EXAMINATION SCHEME FOR DIPLOMA COURSES

COURSE NAME: RENEWABLE ENERGY ENGINEERING

COURSE CODE : REE

DURATION OF COURSE : 6 SEMESTERS

SEMESTER - III

Sl. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours /Week	Credit	MARKS	
			L	T	P			IA	ESE
1.	REEPC201	Solar Photovoltaic - I	3	0	0	3	3	40	60
2.	REEPC203	Solar Photovoltaic – I Laboratory	0	0	3	3	1.5	60	40
3.	REEPC205	Solar Thermal	3	0	0	3	3	40	60
4.	REEPC207	Solar Thermal Laboratory	0	0	2	2	1	60	40
5.	REEPC209	Renewable Energy Instrumentation Applications	3	0	0	3	3	40	60
6.	REEPC2011	Renewable Energy Instrumentation Applications Laboratory	0	0	2	2	1	60	40
7.	REEPC2013	Thermodynamics and Fluid Power	3	0	0	3	3	40	60
8.	REEPC2015	Thermodynamics and Fluid Power Laboratory	0	0	2	2	1	60	40
9.	REEPC2017	Electrical Machine and Measurement	3	0	0	3	3	40	60
10.	REEPC2019	Electrical Machine and Measurement Laboratory	0	0	3	3	1.5	60	40
11.	SI201	Summer Internship – I (3 – 4 weeks after 2nd. Semester)	0	0	0	0	2	60	40
		Total	**15**	**0**	**12**	**27**	**23**	**560**	**540**

L- Lecture, T-Tutorial, P-Practical, IA-Internal Assessment , ESE-End Semester Exam

Total Marks : 1100

The student has to obtain 40% marks individually both in Internal Assessment and End Semester Examination to pass.

Semester : Third	
Course Code : REEPC201	
Course Title : Solar Photovoltaic - I	
Number of Credit: 3 (L- 3; T- 0; P- 0)	
Prerequisite: Nil	
Course Category: PC	
Course Objectives: 1. To know the solar cell fundamentals & its characteristics. 2. To learn solar PV technology & its application in renewable energy power plant.	
Course Contents (Theory):	
Unit : 1	**1. Solar cell fundamentals:** 1.1 Current conduction in semiconductor. 1.2 Atomic structure of silicon, Energy band formation in semiconductor, P-Type and N-type material with silicon, Formation of P-N junction of semiconductor. 1.3 Principles for Electron-Hole Pair generation by Photon absorption, Photo-electric effect, Photo-conductive effect and Photovoltaic effect. 1.4 Materials for Opto-Electronic applications. 1.5 Concept of solar cell, Main elements of silicon solar cell.
Unit : 2	**2. Solar cell characteristics:** 2.1 Current-Voltage (I-V) characteristics of a Photovoltaic cell. 2.2 Power-Voltage (P-V) characteristics of a Photovoltaic cell. 2.3 Equivalent circuit of a solar cell, Maximum power point (MPP). 2.4 Design considerations of Solar cells – Short circuit current (Isc), Open circuit voltage (Voc), Fill factor (FF), Energy losses & factors for loss, Efficiency. Factors limiting the efficiency of solar cell. 2.5 Impact of external parameters on solar cell performances – (i) Radiation, (ii) Temperature, (iii) Wind velocity.
Unit : 3	**3. Materials for Photovoltaic Cells:** 3.1 Classification of solar cell, Cell size. 3.2 Single crystalline silicon cell, Polycrystalline silicon cell.

	3.3 Thin film solar cell – Amorphous Silicon, Gallium Arsenide, Cadmium Telluride, Copper Indium Galium Diselenide. 3.4 Multi-junction solar cell. 3.5 Other non-silicon materials for photovoltaic cell fabrications. 3.6 Production technology of Gallium Arsenide and Amorphous Solar Cell. 3.7 Materials required for solar panel and formation of solar panel.
Unit : 4	**4. Technologies for Photovoltaic Cells Fabrication:** 4.1 Dye-sensitised Solar Cell (DSSC) technology, Organic solar cell technology, Quantum Dot Solar cell technology. 4.2 Concept of PV module, PV panel, PV array and its formation. 4.3 Silicon Group and non-Silicon Group, PV cell, PV module, PV panel and PV array fabrication. 4.4 Application of Nano-Technology in Solar Cell. 4.5 Technical data sheet of solar PV panel. 4.6 Basic control diagram of PV system and its components.. 4.7 Power distribution layout of PV system.
Unit : 5	**5. Testing and Evaluation of Photovoltaic Cells:** 5.1 Solar Simulator and its application. 5.2 Current-voltage analysis of solar cell, Power analysis. 5.3 Light soaking and temperature cycling analysis.

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Non-Conventional Energy Resources	B. H. Khan	The McGraw Hill Publications.
2.	Non-Conventional Energy Sources	G.D. Rai	Khanna Publications
3.	Solar Energy – Principles of Thermal Collection and Storage	S. P. Sukhatme, J.K. Nayak	Tata McGraw-Hill, New Delhi
4.	Solar Energy, Fundamentals and Applications	Garg, Prakash	Tata McGraw Hill.
5.	Non-Conventional Energy Resources	Shobh Nath Singh	Pearson
6.	Introduction to Non-Conventional Energy	P.Raja	Scitech Publications(India) Pvt.

			Ltd
7.	Non-Conventional Energy Resources	S.H.Saeed, D.K.Sharma	S.K.Kataria& Sons
8.	Solar energy	A.M. Rehman	Scitech Publications(India) Pvt. Ltd
9.	Introduction to solar principles	Thomas E. Kissell	Pearson

Course Outcomes:

After completing the course the student will be able to:

1. Identify different types of solar cell, its components & materials.
2. Use solar cell in PV system applications.
3. Test solar cell characteristic parameters.
4. Fabricate photovoltaic array, module, and panel components.

END SEMESTER EXAMINATION SCHEME (Solar Photovoltaic - I) – 60 Marks

GROUP	UNIT	OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)				SUBJECTIVE QUESTIONS (40)			
		TO BE SET	TO BE ANSWERED	MARKS PER QUESTION	TOTAL MARKS	TO BE SET	TO BE ANSWERED	MARKS PER QUESTION	TOTAL MARKS
A	1,2,3	11	20	1	1 X 20 =20	5	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5	11				4			

Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.

Semester : Third
Course Code : REEPC203
Course Title : Solar Photovoltaic – I Laboratory
Number of Credit: 1.5 (L- 0; T- 0; P- 3)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To know the solar cell fundamentals & its characteristics. 2. To learn about solar PV technology & its application in renewable energy power plant.
List of Practicals: (At least Eight experiments are to be performed)
1. Perform experiment to plot the current – voltage (I-V) characteristics of single crystalline silicon solar cell and find out the solar cell parameters (O.C. voltage, Short circuit current, Voltage-current-power at Maximum Power point, Fill factor, Efficiency).
2. Perform experiment to plot the current – voltage (I-V) characteristics of poly crystalline silicon solar cell and find out the solar cell parameters (Voc, Vmp, Isc, Imp, Mpp, Fill factor, Efficiency).
3. Study the dependency of current- voltage characteristics of a solar cell on – (i) Light intensity and (ii) Temperature of solar cell.
4. Perform experiment to study the effect of shading on single solar cell current.
5. Perform experiment to study the effect of shading on solar cell current when PV cells are connected in Series-Parallel combination.
6. Perform experiment to study the effect of tilt angle on solar cell parameters (Voc, Vmp, Isc, Imp, Mpp, Fill factor, Efficiency).
7. Perform experiment to plot current – voltage (I-V) characteristics of a solar cell module and find out the cell parameters (Voc, Vmp, Isc, Imp, Mpp, Fill factor, Efficiency).
8. Assemble the solar PV system.
9. Dismantle the solar PV system.
10. Application of Solar Simulator.

Course Outcomes:

After completing the course the student will be able to:

1. Identify different types of solar cell, its components & materials.
2. Use solar cell in PV system applications.
3. Test solar cell characteristic parameters.
4. Assemble photovoltaic panel, array, and module components.

EXAMINATION SCHEME (Solar Photovoltaic – I Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Third
Course Code : REEPC205
Course Title : Solar Thermal
Number of Credit: 3 (L- 3; T- 0; P- 0)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To learn about solar radiation, its measurement procedure & solar geometry. 2. To learn about the characteristics of different types of solar collectors. 3. To understand the heating effects of solar energy in different applications.

Course Contents (Theory):	
Unit : 1	**1. Solar Radiation:** 1.1 The Sun as the source of radiation. 1.2 Spectral Distribution of Extraterrestrial Radiation, Variation of Extraterrestrial Radiation. 1.3 Beam, Diffuse & Global Radiation. 1.4 Solar geometry, Basic Earth-Sun angles & their relationship (Numerical). 1.5 The Solar Constant Solar time & Equation of time, Angles for Tracking Surfaces.
Unit : 2	**2. Measurement of Solar Radiation:** 2.1 Measurement of solar radiation using Pyranometers, Measurement of Direct, Diffuse & Global solar radiation. 2.2 Measurement of duration of Sunshine hours. 2.3 Average Solar Radiation, Clear Sky Radiation, Clear and Cloudy days and its distribution. 2.4 Measurement of Radiation on inclined surfaces. 2.5 Ratio of Beam radiation on Tilted surface to that on Horizontal surface.
Unit : 3	**3. Solar Collectors:** 3.1 Liquid Flat-Plate Collectors – Materials required, Collector efficiency, Overall heat loss coefficient, Bottom loss coefficient, Top loss coefficient, Side loss coefficient, Sky temperature. 3.2 Basic Flat-Plate Energy Balance Equation. 3.3 Temperature distribution in Flat-Plate Collectors, Collector Heat removal Factor and Flow Factor, Improvement of collector efficiency. 3.4 Evacuated tube collector – Basic principle, construction. 3.5 Testing of solar collectors. 3.6 Solar Concentrating Collector – Classification, Parameters of solar concentrators, Concentration Ratio, Thermal Performance of Concentrating Collectors. 3.7 Cylindrical Parabolic Collector. 3.8 Compound Parabolic Collector (CPC). 3.9 Paraboloid Dish Collector. 3.10 Central Receiver Collector.
Unit : 4	**4. Solar Air Heating and Solar Water Heating:**

	4.1 Solar Air Heater – Types of Air Heaters. 4.2 Collector with Non-porous absorber, Collector with porous absorber. 4.3 Testing Procedure of Solar Air Heater, Performance Analysis of Solar Air Heater. 4.4 Solar Water Heating System, Forced-Circulation and Natural circulation. 4.5 Swimming Pool Heating. 4.6 Testing and Rating of Solar Water Heaters. 4.7 Economics of Solar Water Heating.
Unit : 5	**5. Solar Thermal Devices:** 5.1 Solar Cooker – Types, Basic principle. 5.2 Box type solar cooker – Design, Construction and Performance. 5.3 Paraboloid type solar cooker. 5.4 Testing of solar cooker. 5.5 Solar Dryers – Types, Basic principle, Cabinet type Dryer & Indirect Dryer, Applications. 5.6 Solar still – Basic principle, Components required, Schematic diagram, Applications.
Unit : 6	**6. Solar Thermal Applications:** 6.1 Thermal Power Conversion System, Solar Thermal Power Plant. 6.2 Solar Absorption Cooling, Theory of Absorption Cooling. 6.3 Combined Solar Heating and Cooling. 6.4 Solar Air conditioning, Solar Absorption Air Conditioning, Solar-Mechanical Cooling. 6.5 Solar furnace – Basic principle, Applications. 6.6 Solar active heating of Buildings – Basic principle, Components required, Block diagram. 6.7 Solar heat pump – Basic principle, Applications.

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Solar Engineering of Thermal Processes	John A. Duffieand William A. Beckman	WILEY, JOHN WILEY & SONS
2.	Solar Energy Fundamentals & Applications	H.P. Garg, J. Prakash	McGraw Hill Education

3.	Thermal Engineeing	DomKundwar, Kothandaraman	Dhanpat Rai& Co.
4.	Principles of Solar Engineering	D.Yogi,Goswami	CRC Press, Taylor & Francis Group
5	Non-Conventional Energy Resources	B.H. Khan	McGraw-Hill
6	Renewable Energy System	David Buchila, Thomas E. Kissell, Thomas Floyd	Pearson
7	Renewable Energy Sources	D.P Kothari, K.C Singal, RakeshRanjan	PHI Learning Private Limited.
8.	Non-Conventional Energy Resources	ShobhNath Singh	Pearson
9.	Non-Conventional Energy Resources	S.H.Saeed, D.K.Sharma	S.K.Kataria& Sons

Course Outcomes:

After completing the course the student will be able to:

1. Get concept on amount of solar radiation on earth & its measurement technique.
2. Learn different modes of solar energy collection.
3. Learn about characteristics of different types of solar collectors.
4. Apply the heating effect of solar energy in practical applications.
5. Know about differenttypes of solar water heating systems.

END SEMESTER EXAMINATION SCHEME (Solar Thermal) – 60 Marks

GROUP	UNIT	OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)				SUBJECTIVE QUESTIONS (40)			
		TO BE SET	TO BE ANSWERED	MARKS PER QUESTION	TOTAL MARKS	TO BE SET	TO BE ANSWERED	MARKS PER QUESTION	TOTAL MARKS
A	1,2,3	11	20	1	1 X 20 =20	4	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5,6	11				5			

Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.

Semester : Third
Course Code : REEPC207
Course Title : Solar Thermal Laboratory
Number of Credit: 1 (L- 0; T- 0; P- 2)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To learn about solar radiation, its measurement procedure & solar geometry. 2. To learn about the characteristics of different types of solar collectors. 3. To understand the heating effects of solar energy in different applications.
List of Practicals: (At least Eight experiments are to be performed)
1. Experiment to measure beam, diffuse and global radiation on horizontal surface using Pyranometer and plot radiation vs. time characteristics for certain duration.
2.Experiment to measure beam, diffuse and global radiation on tilted surface at different angles of inclination and plot radiation vs. time characteristics for certain duration.
3. Study the different parts of a solar flat plate collector.
4. Experiment for characterization of a solar flat plate collector and evaluate its parameters.
5. Study of different parts of an evacuated tube collector.
6. Experiment for characterization of evacuated tube collector and evaluate its parameters.
7. Study of different parts of a solar concentrating collector.
8. Experiment for characterization of a solar concentrating collector and evaluate its parameters.
9. Experiment to measure thermal performance of a solar cooker with varying reflector.
10. Experiment to measure the parameters of a Solar cooling system.
11. Experiment to measure the parameters of a Solar dryer.
Course Outcomes: After completing the course the student will be able to: 1. Get concept on amount of solar radiation on earth & its measurement technique.

2. Learn different modes of solar energy collection.
3. Learn about characteristics of different types of solar collectors.
4. Apply the heating effect of solar energy in practical applications.
5. Know about different types of solar water heating systems & other solar thermal applications.

EXAMINATION SCHEME (Solar Thermal Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Third
Course Code : REEPC209
Course Title : Renewable Energy Instrumentation Applications
Number of Credit: 3 (L- 3; T- 0; P- 0)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To learn efficient operation of various types of instruments utilized for renewable power applications. 2. To know the characteristics, measurement procedure and applications of different instruments.

Course Contents (Theory):	
Unit : 1	**1. Characteristics of Measurement System:** 1.1 Concept of Static characteristics, 1.2 Definition of different static characteristic – Accuracy, Precision, Sensitivity, Linearity, Repeatability, Reproducibility, Hysteresis, Resolution. 1.3 Dynamic characteristics concept only.
Unit : 2	**2. Measurement of Displacement and Force:** 2.1 Measurement of displacement: (i) Strain gauge, (ii) LVDT. 2.2 Measurement of force: Load cell (column type).
Unit : 3	**3. Measurement of Level & Flow:** 3.1 Level measurement by Gauge glass, Displacer, Ultrasonic, D/p transmitter. 3.2 Bernoulli's theorem. 3.3 Principle of operation, advantages and disadvantages of different flow measuring instruments: (i) Orifice, (ii) Rotameter, (iii) Differential Pressure Transmitter.
Unit : 4	**4. Measurement of Temperature:** 4.1 RTD: Basic principle of operation, Equation, Construction, Types, Range, Specification. 4.2 Thermocouple: Basic principle of operation, Equation, Construction, Types, Range, Specification.
Unit : 5	**5. Measurement of Pressure:** 5.1 Units of pressure, Concept of Absolute pressure, gauge pressure and vacuum. 5.2 Basic principle of operation of different pressure measuring instruments – (i) U tube manometer, (ii) C type bourdon tube. 5.3 Concept of pressure transmitter. 5.4 Dead weight tester.
Unit : 6	**6. Miscellaneous Measurements:** 6.1 Instruments for radiation measurements – 6.1.1 Geiger Counter with Geiger-Mueller (GM) Tube or Probe. 6.1.2 Proportional Counter. 6.1.3 Scintillation Counters.

	6.2 Pyranometer – Design & construction for solar radiation measurement. 6.3 Data logger – Operation, Measurement technique and Application. 6.4 Different instruments used in – Hydroelectric power plant, Solar thermal plant, Wind power plant, Biogas plant (name of instruments and where to use in that plant).

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Introduction to Measurement & Instrumentation	Ghosh	PHI
2.	Industrial Instrumentation and Control	S. K. Singh	TMH
3.	Sensor & Transducers	D. V. S. Murty	PHI
4.	A Course in Electrical & Electronics Measurement & Instrumentation	J. B. Gupta	S. K. Khataria
5.	Principle of Industrial Instrumentation	D. Patranabis	TMH
6.	Measurement System Application & Design	E. O. Doeblin	McGraw Hill
7.	Instrumentation & Control Systems	K.N.Reddy, P.S.R.Krisnudu	Scitech Publications (India) Pvt. Ltd
8.	Instrument Transducer	H. K. P.Neubert	Oxford University Press

Course Outcomes:

After completing the course the student will be able to:

1. Know the characteristics and specification of different instruments.
2. Know the principle of operation, advantages, disadvantages of different process parameter like displacement, force, pressure, Temperature, Level, Flow etc
3. Identify different measuring instruments related to specific plant.
4. Use instruments for specific applications.
5. Operate various types of instruments in renewable power applications.

END SEMESTER EXAMINATION SCHEME (Renewable Energy Instrumentation Applications) – 60 Marks									
GROUP	**UNIT**	**OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)**				**SUBJECTIVE QUESTIONS (40)**			
		TO BE SET	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**	**TO BE SET**	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**
A	1,2,3	11	20	1	1 X 20 =20	4	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5,6	11				5			
Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.									

Semester : Third
Course Code : REEPC2011
Course Title : Renewable Energy Instrumentation Applications Laboratory
Number of Credit: 1 (L- 0; T- 0; P- 2)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To learn efficient operation of various types of instruments utilized for renewable power applications. 2. To know the characteristics of different instruments and their specific use.
List of Practicals: (At least Eight experiments are to be performed)
1. Study of different instruments specification for displacement, force, level, pressure, flow measuring system.

2. Experiment to plot and analyse the characteristics curve of strain gauge.
3. Experiment to plot and analyse the characteristics curve of LVDT with distance as input.
4. Experiment to plot the load cell characteristics using different load as input.
5. Experiment to measure level of a tank using Gauge glass, Rotameter and Differential Pressure Transmitter.
6. Experiment to measure level of a tank using Displacer, Ultrasonic level meter.
7. Experiment to measure the flow of liquid using Rotameter, and Differential Pressure Transmitter.
8. Experiment to measure the temperature using Pt100 and Thermocouple.
9. Identification of different parts of C type burdon tube pressure gauge.
10. Study of operation of dead weight tester and calibration of pressure gauge using it.
Course Outcomes: After completing the course the student will be able to: 1. Know the characteristics and specification of different instruments. 2. Know the principle of operation, advantages, disadvantages of different process parameter like Displacement, Force, Pressure, Temperature, Level, Flow etc. 3. Identify different measuring instruments related to specific plant. 4. Use instruments for specific applications. 5. Operate various types of instruments in renewable power applications.

EXAMINATION SCHEME (Renewable Energy Instrumentation Applications Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Third	
Course Code : REEPC2013	
Course Title : Thermodynamics and Fluid Power	
Number of Credit: 3 (L- 3; T- 0; P- 0)	
Prerequisite: Nil	
Course Category: PC	
Course Objectives: 1. To understand the fundamental concepts of thermodynamics& fluid Mechanics applied in solar collectors and other devices used in renewable energy. 2. To learn operations of various components used in Hydraulic System.	
Course Contents (Theory):	
Unit : 1	**1. Fundamentals of Thermodynamics:** 1.1 Pure substance. 1.2 System, Boundary, Surrounding. 1.3 Classification of system, including open system, closed system, isolated system. 1.4 Properties of system, Intensive and Extensive properties with units and its conversion like Pressure (Atmospheric Pressure, Gauge Pressure and Absolute pressure), Volume, Sp-mass and Temperature. State of a system, change of state, Path, Process and thermodynamic cycle. 1.5 Equilibrium of a system, including Mechanical, Thermal, Chemical and Thermodynamic equilibrium. 1.6 Definition and units of Transient energy (Work and Heat), Stored energy (P.E., K.E and Internal energy). 1.7 Point Function & Path Function. 1.8 Displacement work & Flow work.
Unit : 2	**2. Laws of Thermodynamics and their Applications:** 2.1 Zeroth Law of Thermodynamics and Temperature measurement. 2.2 First law of Thermodynamics, Simple Energy Equation for non-flow process (Q - W) = E, Steady Flow Energy Equation and its applications. 2.3 Second Law of Thermodynamics: Kelvin – Plank Statement & Clausius' Statement, Heat Engine, Heat Pump and Refrigerator, Thermal Efficiency, C.O.P., definition and units of Entropy.

Unit : 3	**3. Ideal gas processes:** 3.1 Definition of Specific heat, Specific heat at constant pressure (Cp), Specific heat at constant volume (Cv) and Adiabatic Index (Cp/Cv). 3.2 Governing equation of processes (Pressure & Volume relations). 3.3 Representation of the processes on P-V and T-S diagram, 3.4 Deduce the expression to calculate Work transfer, Heat Transfer, Change of I.E., Change of Enthalpy and Change of Entropy for the following Processes: Constant Pressure Process, Constant volume Process, Constant temperature Process, Adiabatic Process & Polytropic Process (Simple numerical on Processes).
Unit : 4	**4. Properties of fluid and Fluid Flow:** 4.1 Density, Specific gravity, Specific Weight, Specific Volume. 4.2 Dynamic Viscosity, Kinematics Viscosity, Surface tension. 4.3 Fluid pressure, Pressure head, Pressure intensity. 4.4 Types of fluid flows: steady, unsteady, uniform, non-uniform, laminar, turbulent. 4.5 Continuity equation. 4.6 Bernoulli's theorem (Simple numerical).
Unit : 5	**5. Hydraulic Turbines:** 5.1 Classification of Hydraulic Turbines. 5.2 Construction and working principle of Pelton Wheel, Francis and Kaplan Turbine. 5.3 Velocity Diagrams, Work done, Power and Efficiency of Pelton Wheel. (Simple numerical) 5.4 Specific Speed and Selection of turbine on the basis of head and discharge available.
Unit: 6	**6. Fluid Power Systems and Components of Hydraulic Systems:** 6.1 Introduction, components and General layout of Fluid Power Systems. 6.2 Practical applications of Fluid Power Systems. 6.3 Advantages and Limitations of Fluid Power Systems. 6.4 Types, Construction, Working Principle and Symbols of the following Components: Pumps ,Valves, Actuators 6.4.1 Vane pump, Gear pump, and Piston pump. 6.5 Hydraulic Circuits. 6.6 Pneumatic Circuits.
Text / Reference Books:	

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	A Course in Thermal Engineering.	Domkundwar V. M.	DhanpatRai& Co.
2.	A text book of Thermal Engineering.	R. S. Khurmi	S. Chand & co. Ltd.
3.	Engineering Thermodynamics	Dr. D.S.Kumar	S.K. Kataria& Sons
4.	A Course in Thermal Engineering.	P. L. Ballaney	Khanna Publishers
5	Hydraulic, fluid mechanics & fluid machines	Ramamrutham S.	DhanpatRai and Sons ,New Delhi
6	Fluid Mechanics & Hydraulic machines	R.K.Rajput	S.Chand
7	Fluid Mechanics & Hydraulic machines	R.D.Bansal	Laxmi Publication
8	Fluid Mechanics & Hydraulic machines	Jagadishlal	Metropolitan Book Company
9	Oil Hydraulic System- Principle and maintenance	S.R. Majumdar	Tata McGraw Hill
10	Fluid Power GenerationTransmission & Control	Jagadeesha	Wiley
11	Industrial Hydraulic Control	Peter Rhoner	Prentice Hall

Course Outcomes:

After completing the course the student will be able to:

1. Apply fundamental concepts of thermodynamics to thermodynamic systems.
2. Understand various laws of thermodynamics.
3. Apply various gas laws & ideal gas processes to various thermodynamic systems.
4. Apply Fluid Mechanics in engineering applications in turbo machinery and flow measurement.
5. Identify and Know the working principle of various components used in Hydraulic System.
6. Select appropriate components required for simple Hydraulic System.

END SEMESTER EXAMINATION SCHEME (Thermodynamics and Fluid Power) – 60 Marks									
GROUP	**UNIT**	**OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)**				**SUBJECTIVE QUESTIONS (40)**			
		TO BE SET	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**	**TO BE SET**	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**
A	1,2,3	11	20	1	1 X 20 =20	5	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5,6	11				4			
Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.									

Semester : Third
Course Code : REEPC2015
Course Title : Thermodynamics and Fluid Power Laboratory
Number of Credit: 1 (L- 0; T- 0; P- 2)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To understand the fundamental concepts of thermodynamics & fluid Mechanics applied in solar collectors and other devices. 2. To learn operations of various components used in Hydraulic System.
List of Practicals: (At least Eight experiments are to be performed)
1. Study the specification & different parts of a Pressure Gauge and its application.
2. Study & measure calorific value of solid fuel using Bomb Calorimeter.
3. Calculation of Characteristic Gas Constant of air based on some practical data (data to be taken from standard book or website).

4. Study of different parts of Water Turbines such as Pelton Wheel, Francics and Kaplan.
5. Study of schematic layout of a Hydroelectric Power Plant.
6. Study of different parts of Vane pump / Gear pump generally used in Hydraulic System.
7. Study of Direction Control Valve generally used in Hydraulic System.
8. Study different parts of Rotary / Linear (single acting / double acting) actuator generally used in Hydraulic System.
9. Study the different parts of a Hydraulic Trainer System.
10. Design, prepare & operate of hydraulic circuit for Shaper Machine.
11. Experiment to determine Brake power, Indicated power, Efficiencies of Four stroke cycle Diesel Engine.
Course Outcomes: After completing the course the student will be able to: 1. Apply fundamental concepts of thermodynamics to thermodynamic systems. 2. Understand various laws of thermodynamics. 3. Apply various gas laws & ideal gas processes to various thermodynamic systems. 4. Apply Fluid Mechanics in engineering applications in turbo machinery and flow measurement. 5. Identify and Know the working principle of various components used in Hydraulic System. 6. Select appropriate components required for simple Hydraulic System.

EXAMINATION SCHEME (Thermodynamics and Fluid Power Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Third	
Course Code : REEPC2017	
Course Title : Electrical Machine and Measurement	
Number of Credit: 3 (L- 3; T- 0; P- 0)	
Prerequisite: Nil	
Course Category: PC	
Course Objectives: 1. To understand the fundamental concepts of Electrical machines used in renewable power generation & transmission technology. 2. To know the operations of some basic instruments essential for use in power system.	
Course Contents (Theory):	
Unit : 1	**1. Electro-Mechanical Energy Conversion:** 1.1 Mechanism of Electro-Mechanical energy conversion for generator and motor mode. 1.2 D.C. Generator: Construction, Working principle, Types, E.M.F. equation, O.C. Characteristics. (Numerical) 1.3 D.C. Motor: Construction, Working principle, Types, Torque equation, Load Characteristics (Numerical) 1.4 Commutation method in DC machine. 1.5 Applications of different types of D.C. generators and motors.
Unit : 2	**2. Transformer:** 2.1 Single phase Transformer: 2.1.1 Working principle, E.M.F. equation, Transformation ratio, Specification. 2.1.2 Losses, Efficiency, Voltage Regulation.(Numerical) 2.2 Three phase Transformer: 2.2.1 Construction, Different connections. 2.2.2 Synchronisation of two 3-phase transformers. 2.2.3 Parallel operation of two 3-phase transformers.
Unit : 3	**3. AC Generator:** 3.1 Three Phase Synchronous Generator (Alternator): 3.1.1 Construction, Working principle.

	3.1.2 Methods of excitation systems. 3.1.3 E.M.F. equation. (no derivation) 3.1.4 Terminal voltage at different power factor loads (no derivation), Voltage regulation, Load angle. (Numerical) 3.1.5 Synchronization & Parallel operation of an alternator with infinite bus or with another alternator. 3.2 Permanent Magnet Synchronous Generator (PMSG): 3.2.1 Construction, Working principle, 3.2.2 No load test of PMSG, Load test of PMSG, Characteristics, 3.2.3 Advantages and disadvantages of PMSG. 3.2.4 Applications in renewable power plant.
Unit : 4	**4. Three Phase Induction Machine:** 4.1 Three phase Induction Motor: 4.1.1 Construction, Types, Working principle, 4.1.2 Synchronous Speed, Slip. 4.1.3 Torque equation, Torque- Slip characteristics. 4.1.4 Starting methods. 4.1.5 Methods of Speed control. 4.2 Induction Generator (IG): 4.2.1 Construction, Principle of operation. 4.2.2 Excitation. 4.2.3 Active power Off-grid IG, Capacitor Start IG. 4.2.4 Torque-Slip characteristics, Torque–Speed characteristics. 4.2.5 High efficiency IG. 4.2.6 Applications in renewable power plant. 4.3 Squirrel Cage Induction generator (SCIG): 4.3.1 Construction, Principle of operation. 4.3.2 Power equation. 4.3.4 Torque- Slip characteristics. 4.3.5 Active power Off-grid IG, Capacitor Start IG. 4.3.6 Applications in renewable power plant. 4.4 Doubly Fed Induction generator (DFIG): 4.4.1 Construction, Principle of operation. 4.4.2 Equivalent Circuit of DFIG. 4.4.3 Sub- and Super-synchronous modes. 4.4.4 Torque-slip curve for DFIG in sub- and super-synchronous modes. 4.4.5 Advantages and disadvantages of DFIG. 4.4.6 Principle of slip control for induction generators. . 4.4.7 Applications of DFIG in renewable power plant.

Unit : 5	**5. Measurement of Electrical Power and Energy:** 5.1 Measurements of 3-phase power for balanced and unbalanced load by wattmeter method. 5.2 Electronic Energy Meter – Construction, Basic circuit diagram, Principle of operation. 5.3 Measurements of electrical energy by 3-phase energy meter.
Unit : 6	**6. Instrument Transformer:** 6.1 Current Transformer (CT): Working principle, Burden on CT, Phase angle error, Ratio error, Specifications. 6.2 Potential Transformer (PT): Working principle, Phase angle error, Ratio error, Specifications.

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Electrical Machines	S.K. Bhattacharya	T.M.H Publishing Co. Ltd.
2.	Electrical Technology- Vol-II	B.L. Thereja	S.Chand
3.	Electrical Machines	Ashfaq Hussain	Dhanpat Rai
4.	Electric & Electronic Measurement and Instrumentation	A.K. Sawhney	Dhanpat Rai& Sons
5.	Electrical & Electronic Measurements	J.B. Gupta	S. K. Kataria Publication
6.	Electrical Machines	S.K. Sen	Khanna Publisher

Course Outcomes:

After completing the course the student will be able to:

1. Describe the constructional details & working principles of DC & AC machines & Transformers.
2. Test DC & AC machines, power transformers & instrument transformers.
3. Evaluate the performance of DC & AC machines & Transformers by conducting different tests.
4. Decide the suitability of DC & AC machines for use in renewable power plants.
5. Write specifications of DC & AC machines & Transformers as required.
6. Maintain electrical machines in industry and captive plants.

END SEMESTER EXAMINATION SCHEME (Electrical Machine and Measurement) – 60 Marks									
GROUP	**UNIT**	**OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)**				**SUBJECTIVE QUESTIONS (40)**			
		TO BE SET	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**	**TO BE SET**	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**
A	1,2,3	11	20	1	1 X 20 =20	4	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5,6	11				5			
Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.									

Semester : Third
Course Code : REEPC2019
Course Title : Electrical Machine and Measurement Laboratory
Number of Credit: 1.5 (L- 0; T- 0; P- 3)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To understand the fundamental concepts of Electrical machines for use in renewable power generation & transmission technology. 2. To know the operations of some basic instruments essentially used in power system.
List of Practicals: (At least Eight experiments are to be performed)
1. Identify the different parts of a DC machine and make a report on it.
2. Perform experiment for speed control of a DC shunt motor below and above its rated speed.
3. Identify the different parts of a single-phase transformer and a three-phase transformer (from a slide if machine is not available) & make a report on it.
4. Identify the different parts of a 3-phase induction motor and make a report on it.
5. Perform experiment for No-load test and Blocked-rotor test of a 3-phase induction motor &

determine equivalent circuit parameters.
6. Perform experiment to plot the O.C.C. of an alternator & observe the effect of excitation and speed on induced e.m.f.
7. Perform experiment to find the percentage regulation of 3-phase alternator by synchronous impedance method at various power factor and load.
8. Perform experiment to synchronise two 3-phase alternators by – a) Three lamp method or b) Synchroscope and to study the sharing of load between the alternators.
9. Identify different parts of Squirrel Cage Induction Generator (SCIG) and make a report on it.
10. Identify different parts of Permanent Magnet Synchronous Generator (PMSG) and make a report on it.
11. Identify the different parts of an – a) Electromagnetic energy meter, b) Electronic energy meter make a report on it.
12. Perform experiment to calibrate single phase energy meter using resistive or inductive loads.
13. Perform experiment to measure energy of 3- phase balanced load using Electronic Energy Meter.
14. Perform experiment to measure 3-phase power of balanced 3-phase load by 2-wattmeter method.
15. Perform experiment to measure current ratio, voltage ratio and polarity test of CTand PT.
Course Outcomes: After completing the course the student will be able to: 1. Describe the constructional details & working principles of DC & AC machines & Transformers. 2. Test DC & AC machines, power transformers& instrument transformers. 3. Evaluate the performance of DC & AC machines & Transformers by conducting different tests. 4. Decide the suitability of DC & AC machines & Transformers for use in power system. 5. Write specifications of DC & AC machines & Transformers required for various applications. 6. Operate electrical machines in industry for specific use.

EXAMINATION SCHEME (Electrical Machine and Measurement Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Third
Course Code : SI201
Course Title : Summer Internship-I
Number of Credit: 2
Duration: 3 – 4 weeks after 2nd. Semester.
Course Category: SI
Course Contents:
Summer Internship will be undertaken in an industry/Govt. or Pvt. Certified Agencies which are in social Sector/ Govt. Skill Centre /Institute /Schemes.

EXAMINATION SCHEME (Summer Internship-I) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.** **Internal Assessment by the internal teacher will be based on reports of industry visit & job done there.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.** **End Semester Examination will be based on evaluation by the supervisor of the concerned industry/organization.**
