M.Tech. in Renewable Energy Technology
(I Year Courses)

Teaching and Examination Scheme
I Year I Semester: M.Tech. (RET)

S. No.	Course Code	Course Name	Category	Teaching Scheme				Marks			Credit
				L	T	P	Exam Hrs	CIE	SEE	Total	
1	MEPL101	Renewable Energy Sources	PCC	3	0	0	3	40	60	**100**	**3**
2	MEPL102	Solar Photovoltaics	PCC	3	0	0	3	40	60	**100**	**3**
		Elective-I:									
3	MEPL111 MEPL112 MEPL113	a. Solar Heating & Cooling b. Hydrogen Energy c. Energy Conservation & Management	PEC	3	0	0	3	40	60	**100**	**3**
		Elective-II:									
4	MEPL114 MEPL115 MEPL116	a. Energy Storage Technology b. Biofuel Technology & Mechanism c. Energy Economics & Policy Making	PEC	3	0	0	3	40	60	**100**	**3**
5	NP40.01	Optimization Techniques	MCC	3	0	0	3	40	60	**100**	**3**
6	NP99.XX	Audit Course	MCC	-	-	-	3	40	60	**100**	**0**
7	MEPP130	Renewable Technology Lab	PCC	0	0	4	4	60	40	**100**	**2**
8	MEPP131	Solar Photovoltaic Lab	PCC	0	0	4	4	60	40	**100**	**2**
9	MEPA100	Social Outreach, Discipline & Extra Curricular Activities (SODECA)	SODECA							**100**	**1**
Total Credit											**20**

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Syllabus

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Renewable Energy Sources	**Course Code**: MEPL101	**Credit**: : 03
Max Marks: 100	**CIE:** 40	**SEE:**60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Energy Sources & Availability**: World Energy scenario and India Energy Scenario, Conventional and non-conventional, renewable and non-renewable sources of energy, prospects, perspectives & advantages	3
3	**Solar Energy:** Solar constant, solar radiation geometry, local solar time, day length, solar radiation measurement, radiation on an inclined surface, solar radiation data, & solar charts	7
4	**Wind Energy**: Wind as a source of energy, Characteristics of wind, wind data. Horizontal & vertical axis wind turbines	7
5	**Biomass Energy**: Introduction to biomass, biofuels & their heat content, biomass conversion technologies. Aerobic & anaerobic digester, Factors affecting bio-digestion, biogas plants–types, description, utilization of biogas, & use in I.C. engines. Biomass gasification: Gasifier types, direct thermal application of gasifiers. Advantages & problems in the development of gasifiers	9
6	**Other Renewable Energy Sources-I**: Geothermal Energy: Status & estimates, geothermal resources, geothermal systems & their characteristics. Ocean Thermal Energy Conversion (OTEC). Tidal energy. Wave energy, Hydrogen energy	9
7	**Other Renewable Energy Sources**- II: Fuel Cells: Principle & classification, types, conversion, efficiency, polarization, & advantages. Magneto Hydrodynamic (MHD) power conversion: Principle, types, closed & open cycle system, materials. thermionic power conversion, thermoelectric power conversion	9
	Total	**45**

Text Books:

1. G. D. Rai, “Non-Conventional Sources of Energy”, Khanna Publishers.
2. D. P. Kothari, K. C. Singhal, and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies” PHI.
3. S. P. Sukhatme and J. K. Nayak, “Solar Energy: Principles of Thermal Collection and Storage” TMH.

Reference Books:

1. Godfrey Boyle, “Renewable Energy” Oxford University Press.
2. G. D. Rai, “Solar Energy Utilization” Khanna Publishers.

Prerequisite:

1. Engineering Thermodynamics
2. Heat and mass transfer

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL101.1	Describe various conventional and non-conventional sources of energy.	BL2	3.1, 3.2	1.1, 1.2, 1.3, 1.4
MEPL101.2	Analyse various parameters of solar radiation geometry.	BL4	3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.6
MEPL101.3	Explain types and characteristics of wind and wind turbines.	BL2	3.1, 3.2	1.1, 1.2, 1.3, 1.4
MEPL101.4	Describe various sources of biomass energy and its application in IC engines.	BL2	3.1, 3.2	1.1, 1.2, 1.3, 1.4
MEPL101.5	Compare the merits, demerits and justify the selection of various non-conventional energy sources for particular application.	BL3	3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL101.1	-	-	3	3	-
MEPL101.2	-	-	3	3	-
MEPL101.3	-	-	3	3	-
MEPL101.4	-	-	3	3	-
MEPL101.5	-	-	3	3	-

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Solar Photovoltaics	**Course Code**: MEPL102	**Credit**: : 03
Max Marks: 100	**CIE:** 40	**SEE:**60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Photovoltaic effect:** Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure. I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature	9
3	**Commercial solar cells**: Production process of single crystalline silicon cells, multi-crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells, and high-efficiency solar cells. Design of solar PV systems and cost estimation. A case study of commercial buildings.	9
4	**Classification:** Central Power Station System, Distributed PV System, Standalone PV system, Grid Interactive PV System, hybrid solar PV system, concentrator solar photovoltaic. System components: PV arrays, inverters, batteries, charge controls, and net-meters. PV array installation, operation, costs, reliability	9
5	**Building-integrated photovoltaic** units, grid-interacting central power stations, stand-alone devices for distributed power supply in remote and rural areas, stand-alone PV systems. - Home lighting and other appliances, solar water pumping systems. Case study of residential buildings.	9
6	Socio-economic and environmental analysis of photovoltaic systems	8
	Total	**45**

Text Books:

1. Chetan Singh Solanki, “Solar Photovoltaic: Fundamentals, Technologies and Application”, PHI.
2. A.R. Jha, “Solar Cell Technology and Applications”, CRC Press.
3. N.K. Bansal, “Non-Conventional Energy Sources”, Vikas Publishing House.

Reference Books:

1. John Balfour, Michael Shaw, and Sharlene Jarosek, “Introduction to Photovoltaics”, Jones and Bartlett Publishers.
2. Antonio Luque and Viacheslav Andreev, “Concentrator Photovoltaic”, Springer.

Prerequisite:

1. Engineering Thermodynamics
2. Engineering Mechanics
3. Engineering Chemistry
4. Heat and Mass Transfer

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL102.1	Explain the photovoltaic effect, I-V characteristics of the PV module, and the effect of irradiation & temperature on it.	BL2	3.1, 3.2	1.2, 1.3, 1.4, 1.6, 2.2, 2.3, 2.6, 2.7
MEPL102.2	Examine the various types of commercial solar cells.	BL3	3.1, 3.2	1.2, 1.3, 1.4, 1.6, 2.2, 2.3, 2.6, 2.7
MEPL102.3	Classify various types of PV systems, PV array installations, operation, costs, and reliability.	BL3	3.1, 3.2	1.2, 1.3, 1.4, 1.6, 2.2, 2.3, 2.6, 2.7
MEPL102.4	Explain integrated PV units with other systems and applications of PV systems in various areas.	BL3	3.1, 3.2	1.2, 1.3, 1.4, 1.6, 2.2, 2.3, 2.6, 2.7
MEPL102.5	Analyze the socio-economic and environmental effects of PV systems.	BL4	3.1, 3.2	1.2, 1.3, 1.4, 1.6, 2.2, 2.3, 2.6, 2.7

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL102.1	-	-	3	3	2
MEPL102.2	-	-	3	3	2
MEPL102.3	-	-	3	3	2
MEPL102.4	-	-	3	3	2
MEPL102.5	-	-	3	3	2

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Solar Heating & Cooling	**Course Code**: MEPL111	**Credit**: : 03
Max Marks: 100	**CIE:** 40	**SEE:**60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Potential and scope** of solar heating and cooling, Types of solar heating and cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning. Economics of heating and cooling systems	9
3	**Building heating and cooling**: Heat transmission in buildings - Bioclimatic classification. Passive heating concepts - Direct heat gain, indirect heat gain, isolated gain, and sunspaces. Passive cooling concepts - Evaporative cooling, radiative cooling, Energy efficient landscape design - Concept of solar temperature and its significance, calculation of instantaneous heat gain through the building envelope	9
4	**Solar Heating Systems**: solar water heating systems commercial and domestic, solar thermal collectors: types, overall heat loss coefficient, heat capacity effect - Thermal analysis solar air heaters, Greenhouse solar dryer, solar pond, case study on any of two above.	9
5	**Solar thermo-mechanical refrigeration system**: Carnot refrigeration cycle, solar electric compression air conditioning, simple Rankine cycle air conditioning system	8
6	**Solar Cooling Systems**: Solar vapor absorption cooling systems, solar vapor adsorption cooling system: classification, design, thermodynamic analysis, Calculations of COP and second law efficiency, Solar desiccant dehumidification, Case study on solar powered vapor absorption/ adsorption cooling systems	9
	Total	**45**

Text Books:

1. Kalogirou S.A., “Solar Energy Engineering: Processes and Systems”, Academic Press, 2009.
2. Vogel. W., Kalb H., “Large-Scale Solar Thermal Power Technologies”, Wiley, 2010.

Reference Books:

1. Duffie J. A., Beckman.W. A., “Solar Engineering of Thermal Process”, Wiley, 3rd ed. 2006.
2. Khartchenko N.V., “Green Power: Eco-Friendly Energy Engineering”, Tech Books, Delhi, 2004.
3. Goswami D.Y., Kreith F, Kreider J.F., “Principles of Solar Engineering”, 2nd ed., Taylor and Francis, 2000, Indian reprint, 2003.
4. Garg H.P, Prakash J., “Solar Energy Fundamentals and Applications”, Tata McGraw-Hill, 2005.
5. Laughton C., “Solar Domestic Water Heating”, Earthscan, 2010.
6. Yannas S., Erell E., Molina J., Roof Cooling Techniques: Design Handbook, Earthscan, 2006.

Prerequisite:

1. Engineering Thermodynamics
2. Heat Transfer
3. Refrigeration and Air Conditioning

Course Outcomes:

After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL111.1	Explore the potential of passive heating and cooling for buildings.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL111.2	Apply different techniques of passive heating and cooling for buildings.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL111.3	Analyze the performance parameters of solar flat plate collectors.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL111.4	Analyze thermodynamic cycles for solar thermo-mechanical refrigeration.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL111.5	Investigate the thermodynamic cycle for vapour absorption refrigeration systems.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6

Mapping of COs with POs-PSOs:

COs/POs-PSOs	PO 1	PO 2	PO 3	PSO 1	PSO 2
MEPL111.1	3	2	2	-	2
MEPL111.2	3	2	2	-	2
MEPL111.3	3	2	2	-	2
MEPL111.4	3	2	2	-	2
MEPL111.5	3	2	2	-	2

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Hydrogen Energy	**Course Code**: MEPL112	**Credit**: : 03
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Introduction of Hydrogen Energy Systems:** Hydrogen pathways – current uses, infrastructure requirement for hydrogen production, Hydrogen production power plants. Comparison of physical and chemical properties of hydrogen with conventional liquid and gaseous fuels, safety requirements	8
3	**Hydrogen Production Processes:** Thermal-Steam Reformation – Thermo chemical Water Splitting – Gasification – Pyrolysis, Nuclear thermo catalytic and partial oxidation methods. Electrochemical – Electrolysis – Photo electro chemical. Biological – Anaerobic Digestion – Fermentative Micro-organisms. Renewable Sources: Hydrogen production methods using solar energy and wind energy.	9
4	**Hydrogen Storage:** Physical and chemical properties – General storage methods, compressed storage – Composite cylinders – Glass micro sphere storage - Zeolites, Metal hydride storage, chemical hydride storage, and cryogenic storage	9
5	**Hydrogen Utilization:** I.C. Engines: performance, emission and combustion characteristics of Spark Ignition engines, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NOx controlling techniques, dual fuel engine, durability studies, field trials, emissions and climate change. Gas turbines, hydrogen burners, power plants, refineries, domestic and marine applications. Hydrogen fuel quality, case study on hydrogen and its blend as a fuel in automotive vehicles.	9
6	**Hydrogen Safety:** Safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, flame trap, safety management, and simulation of crash tests, containment cylinders for hydrogen of various grades.	9
	Total	**45**

Text Books:

1. Ram B. Gupta, “Hydrogen Fuel: Production, Transport, and Storage”, CRC Press.

Reference Books:

1. Michael Ball and Martin Wietschel, “The Hydrogen Economy: Opportunities and Challenges”.
2. M. K. G. Babu and K. A. Subramanian, “Alternative Transportation Fuels: Utilization in Combustion Engines”.
3. Krishnan Rajeshwar, Robert McConnell, and Stuart Licht, “Solar Hydrogen Generation: Toward a Renewable Energy Future”. Ram B. Gupta, “Hydrogen Fuel: Production, Transport, and Storage”.

Prerequisite:

1. Knowledge of I.C. Engines, Engineering Chemistry.

Course Outcomes:

After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL112.1	Identify the potential and use of hydrogen energy.	BL2	1.1, 1.2, 2.1, 2.2, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL112.2	Compare the various techniques of hydrogen production.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL112.3	Evaluate the feasibility and long-term stability of various hydrogen storage methods.	BL5	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL112.4	Analyze field performance of hydrogen-operated engines, turbines, and power plants.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL112.5	Apply safety management practices for hydrogen utilities.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL112.1	3	3	3	3	-
MEPL112.2	3	3	3	3	-
MEPL112.3	3	3	3	3	-
MEPL112.4	3	3	3	3	-
MEPL112.5	3	3	3	3	-

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Energy Conservation & Management	**Course Code**: MEPL113	**Credit**: 03
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Energy Scenario:** Classification of Energy, Indian energy scenario, Sectoral energy consumption (domestic, industrial, and other sectors), energy needs of the growing economy, energy intensity, long-term energy scenario, energy pricing, energy security, energy conservation and its importance, energy strategy for the future	8
3	**Energy Conservation in Electrical Utilities:** Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses **Electric motors:** Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors **Illumination**: Lux, Lumens, types of lighting, history, efficacy, LED lighting and scope of energy conservation in lighting, comparison of illumination level and energy consumption.	9
4	**Energy Efficiency in Thermal Utilities and systems:** Thermal systems, Boilers, Furnaces, Heat exchangers, Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories. Waste heat recovery and Cogeneration systems, conservation opportunities.	9
5	**Heating, Ventilation, Air-Conditioning (HVAC) and Refrigeration System:** Factors affecting Refrigeration and Air conditioning system, Energy saving opportunities in Cooling Towers, Vapour absorption refrigeration system, heat pump, vapor compression refrigeration system, window and split room air conditioners. Star-labeled pumps, cold storage refrigeration, and humidification system, ASHRAE and ISHRAE standards.	9
6	**Energy Conservation Acts and related policies:** Energy conservation Act 2001 and its features, notifications under the Act, role of Bureau of Energy Efficiency (BEE), Star rating of electrical appliances, State Designated Agencies, Electricity Act 2003, ECBC code for Building Construction, IGBC Guidelines. **Energy and environment, air pollution, climate change:** United Nations Framework Convention on Climate Change (UNFCC), Kyoto Protocol, Conference of Parties (COP), Clean Development Mechanism (CDM), Prototype Carbon Fund (PCF)	9
	Total	**45**

Text Books:

1. Bureau of Energy Efficiency Reference book: No.1, 2, 3 4
2. Dale R Patrick, Stephen W Fardo ,Energy Conservation Guidebook, 2nd Edition, CRC Press.

Reference Books:

1. Albert Thumann, Handbook of Energy Audits, The Fairmont Press, 6th Edition.
2. W.C. Turner, Energy Management Handbook, John Wiley and Sons.
3. Callaghan P.W., "Design and Management for Energy Conservation", Pergamum Press, Oxford.
4. Murphy W.R. and McKay G., "Energy Management", Butterworth's, London, 1987.

Prerequisite:

1. Electrical Energy Conservation and Auditing
2. Basics of Mechanical & Electrical Engineering
3. Energy and Environment

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL113.1	Recognize the importance of energy conservation and management.	BL3	1.1, 1.2, 2.1, 2.2, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL113.2	Identify opportunities for energy conservation within electrical utilities.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL113.3	Analyze energy-efficient strategies in thermal utilities.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL113.4	Apply energy-saving strategies in HVAC and refrigeration systems.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6
MEPL113.5	Assess initiatives or policies related to energy, environment, air pollution, and climate change.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL113.1	3	3	3	3	3
MEPL113.2	3	3	3	3	3
MEPL113.3	3	3	3	3	3
MEPL113.4	3	3	3	3	3
MEPL113.5	3	3	3	3	3

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Energy Storage Technology	**Course Code**: MEPL114	**Credit**: : 03
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Energy storage technology:** requirement for energy storage, Current status, Future prospect of storage, Aspects for adoption among various energy storage storage technology.	7
3	**Mechanical energy storage systems:** Flywheel energy storage (FES), pumped hydropower storage (PHS), and compressed-air energy storage (CAES). Comparison and application of state-of-arts including principle, function and deployments. Technical characteristics in terms of power rating and discharge time, storage duration, energy efficiency, energy density, cycle life and life time, etc. Case study on any two from the above.	9
4	**Electrochemical energy storage:** Battery, Fuel Cell, and Capacitor. Comparison and application of state-of-arts including principle, function and deployments. Technical characteristics of various electrochemical energy storage systems. Capacitor-battery hybrid systems. Advanced technologies in electrochemical energy storage.	9
5	**Hydrogen energy:** Hydrogen economy, Hydrogen production, Hydrogen Transportation, and Hydrogen storage methods, Utilization of hydrogen in fuel cells and fuel for automotive applications.	9
6	**Thermal energy storage:** Sensible heat storage (SHS), latent heat storage (LHS) or phase-change materials (PCMs), and thermo-chemical energy storage (TCES). Comparison and technical characteristics, Aspects of selection of PCMs for any application such as availability, thermo-physical properties, cost, disposal, etc. Hybrid PCMs energy storage.	10
	Total	**45**

Text Books:

1. B. H. Khan, “Non-Conventional Energy Resources”, McGraw Hill.
2. S. Singh, “Energy Storage Systems: An Introduction”, Nova Science Publishers.
3. R.A. Huggins, “Energy Storage”, Springer.

Reference Books:

1. G. D. Rai, “Non-Conventional Sources of Energy”, Khanna Publishers.
2. V.K. Mathew, “Energy Storage Systems”, Springer.
3. M. Sterner, Stadler, “Handbook of Energy Storage”, Springer.

Prerequisite:

1. Engineering Thermodynamics
2. Engineering Mechanics
3. Engineering Chemistry
4. Heat and Mass Transfer

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL114.1	Identify the requirement, current status and future prospectus of energy storage.	BL3	1.1, 1.2, 2.1, 2.3, 3.1	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4
MEPL114.2	Compare various mechanical energy storage systems.	BL2	1.1, 1.2, 2.1, 2.3, 3.1	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4
MEPL114.3	Analyze technical characteristics of various electrochemical energy storage systems.	BL4	1.1, 1.2, 2.1, 2.3, 3.1	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4
MEPL114.4	Discuss various techno-economical aspects of the production and storage of hydrogen.	BL2	1.1, 1.2, 2.1, 2.3, 3.1	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4
MEPL114.5	Compare various thermal energy storage technologies.	BL2	1.1, 1.2, 2.1, 2.3, 3.1	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL114.1	3	2	1	3	2
MEPL114.2	3	2	1	3	2
MEPL114.3	3	2	1	3	2
MEPL114.4	3	2	1	3	2
MEPL114.5	3	2	1	3	2

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Biofuel Technology & Mechanism	**Course Code**: MEPL115	**Credit**: : 03
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Biofuel Technology:** Introduction, the potential of biofuels in the energy scenario of India, Biofuels in relation to the environment, ecology, agriculture, health and sanitation, Factors enhancing/inhibiting biofuel production	8
3	**Bio-chemical and Microbial Aspects of Biogas**: Biogas mechanism, enhancement of biogas production by different additives (Chemicals, organic substances, enzymes), pre-treatment process, etc. Scrubbing process, biogas bottling, biogas liquefaction. Uses, merits and demerits of biogas.	9
4	**Biogas Plants and Applications**: Types of biogas plants, design of a biogas plant (cow dung and organic waste) and structural strength, selection of site and size, construction technique, material requirement, recent advances in high rate bio-methanation reactors design and material, night soil linked biogas plant. Cold condition biogas plant design concept, cost and financial viability. Principles of dual fuel biogas engines, its limitations, biogas appliances including thermal and cooking efficiency test. Comparison of various running biogas plants.	9
5	**Production and Applications of Biodiesel:** Trans-esterification reaction and process, Raw materials and pre-treatment, Environmental conditions and operational process, Separation and purification stages, Qualities of biodiesel and associated regulations, properties of biodiesel, application in diesel engines and environmental effects, economic impact of biodiesel	9
6	**Alcohols and Biofuels:** Types of feedstock for alcohols and biofuels and their availability. Alcohols and other oxygenated biofuels-applications, advantages and limitations. Physico-chemical properties of biofuels. Combustion characteristics of biofuels in spark ignition and compression ignition engines.	9
	Total	**45**

Text Books:

1. B.T. Nijaguna ,"Biogas Technology", New Age International Publishers.
2. N. S. Rathore and A. K. Kurchania,"Biomethanation Technology",Apex Publishing House, 2007.

Reference Books:

1. R. S. Khoiyangbam, Navindu Gupta and Sushil Kumar,"Biogas Technology:Towards Sustainable Development", TERI.
2. V. Ganesan,"Internal Combustion Engines", TMH.
3. Samir Sarkar ,"Fuels and Combustion", University Press.

Prerequisite:

1. Knowledge of I.C. Engines

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL115.1	Explore the significance of biofuels in the current energy scenario.	BL3	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL115.2	Compare different biogas production techniques, their merits and demerits.	BL2	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL115.3	Design different types of biogas plants on the basis of technical and economic viability.	BL3	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL115.4	Describe the production methods and environmental impact of biodiesel for IC engines.	BL2	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL115.5	Evaluate the use and combustion characteristics of alcohols in IC engines.	BL4	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL115.1	1	3	2	3	1
MEPL115.2	1	3	2	3	1
MEPL115.3	1	3	2	3	1
MEPL115.4	1	3	2	3	1
MEPL115.5	1	3	2	3	1

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Energy Economics & Policy Making	**Course Code**: MEPL116	**Credit**: 03
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	World Energy Scenario and India Energy Scenario, Fossil Fuel Reserves – Estimates, Energy and Quality of Life, Energy Inequality, Energy Security	7
3	Energy Economics - Simple Payback Period, Time Value of Money- discount rate, Criteria for Assessing Energy Projects, Net Present Value (NPV), Benefit/Cost Ratio (B/C), Inflation, Internal Rate of Return (IRR)	7
4	Resources & Reserves Growth Rates in Consumption, Estimates of Duration of Fossil Fuels, Peak oil, Materials used in renewable energy (Kuznet's Curve), Non-Renewable Energy Economics	7
5	Energy Policy: Preferences and Utility, Social factors, Public and private, pros and cons, Demand curves, Externalities	7
6	Financing Energy – Debt/ Equity- Sources of funds, innovative financing models, Input-Output Analysis, Primary Energy Analysis, Net Energy Analysis	8
7	Cost of Energy, Life Cycle Analysis of Bioenergy, Future energy scenarios and elements of sustainability	8
	Total	**45**

Text Books:

1. Efstathios E. Michaelides , "Energy, the Environment, and Sustainability", CRC Press, 2018.
2. Jeffrey D. Sachs, Ki-moon Ban, "The Age of Sustainable Development", Columbia University Press, 2015.
3. Bala Bhaskar, "Energy Security and Economic Development in India", The Energy and Resources Institute, TERI.

Reference Books:

1. Subhes C. Bhattacharyya, "Energy Economics", Springer, 2011.
2. Conrad, J. M. Cambridge, "Resource Economics", Universities Press, New Delhi, 2010.
3. Mary Ann Curran, "Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products", Wiley, 2012.

Prerequisite:

1. Basic Arithmetic
2. Fundamental knowledge of energy and environment

Course Outcomes:

After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL116.1	Describe the present energy scenario and energy security.	BL2	1.1, 2.1,.2.3, 2.4, 3.2	1.1, 1.3, 1.6, 2.1, 2.3
MEPL116.2	Apply technical and quantitative approaches to economics on various energy projects.	BL3	1.3, 2.2, 2.3, 2.4, 3.2, 3.3	1.1, 1.3, 1.5, 2.2, 2.6, 2.7
MEPL116.3	Analyze the impact of environmental and social factors on energy policy.	BL4	1.1, 2.1, 3.1, 3.2, 3.3	1.2, 1.3, 1.5, 2.1, 2.2, 2.6, 2.7
MEPL116.4	Analyze the impact of financial factors on energy economics.	BL4	1.1, 1.3, 2.1, 2.3, 3.1, 3.2, 3.3	1.2, 1.3, 1.4, 2.1, 2.2, 2.5, 2.6
MEPL116.5	Apply Life cycle assessment (LCA) of energy projects.	BL3	1.1, 1.3, 2.1, 2.3, 3.1, 3.2, 3.3	1.2, 1.3, 1.6, 2.2, 2.4, 2.5, 2.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL116.1	1	3	1	2	1
MEPL116.2	1	3	2	2	2
MEPL116.3	1	1	3	2	2
MEPL116.4	3	2	3	2	2
MEPL116.5	3	3	3	2	2

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Optimization Techniques	**Course Code**: NP40.01	**Credit**: 03
Max Marks: 100	**CIE:** 40	**SEE:**60
End Term Exam Time: 03 hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	Introduction to optimization: Engineering applications of optimization, Mathematical Modeling and simulation, Formulation of structural optimization problems as programming problems. Graphical method.	7
3	Linear Programming: Theory of Simplex Method, Standard form of LPP, feasible solution and basic feasible solution, Improving BFS, Optimality condition, Unbounded solution, Alternative optimal solution, Simplex method, Big M Method, Two phase method.	9
4	Metaheuristics in Optimization: Genetic algorithms, Tabu search, particle swarm intelligence and their applications in Engineering	8
5	PERT & CPM: Objective of CPM & PERT, elements of network, network rules, constraints, error in network, Critical Path Analysis, Activity time and floats, optimization through CPM techniques, PERT and three estimates, critical path analysis of a PERT network, probability of completion of project, controlling and monitoring.	9
6	Non-linear Programming: Local and global minima of one and two variables, constraints optimization, Lagrange's Method, K-T conditions, Steepest descent method, Conjugate gradient method.	11
	Total	**45**

Text Books:

1. S. S. Rao, Engineering Optimization: Theory and Practice, Wiley, 2008.
2. K. Deb, Optimization for Engineering design algorithms and Examples, Prentice Hall, 2nd Edition 2012.

Reference Books:

1. Operations Research, Hira& Gupta,
2. C.J. Ray, Optimum Design of Mechanical Elements, Wiley, 2007.
3. R. Saravanan, Manufacturing Optimization through Intelligent Techniques, Taylor & Francis Publications, 2006.
4. D. E. Goldberg, Genetic algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Longman Publishing, 1989.

Prerequisite:

1. Basic knowledge of calculus.

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
NP40.01.1	Comprehend the basic concepts of Optimization Techniques and its importance in Engineering Applications.	BL3	1.1, 1.3, 2.1, 2.3	1.1, 1.2, 1.3, 1.4, 2.3
NP40.01.2	Model various engineering problems as optimization problems and achieve optimal solutions using the Simplex method, Revised simplex method and Duality.	BL3	1.1, 1.3, 2.1, 2.3	1.1, 1.2, 1.3, 1.4, 2.3
NP40.01.3	Formulate Transportation, Assignment problems and dynamic programming problems and achieve optimal solutions.	BL3	1.1, 1.3, 2.1, 2.3	1.1, 1.2, 1.3, 1.4, 2.3
NP40.01.4	Apply PERT and CPM to control and monitor projects effectively.	BL3	1.1, 1.3, 2.1, 2.3	1.1, 1.2, 1.3, 1.4, 2.3
NP40.01.5	Solve nonlinear programming problems using Lagrange's method, K-T conditions and numerical methods like the Steepest descent method and conjugate gradient method.	BL3	1.1, 1.3, 2.1, 2.3	1.1, 1.2, 1.3, 1.4, 2.3

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
NP40.01.1	2	2	-	2	1
NP40.01.2	2	2	-	2	1
NP40.01.3	2	2	-	2	1
NP40.01.4	2	2	-	2	1
NP40.01.5	2	2	-	2	1

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Renewable Technology Lab	**Course Code**: MEPP130	**Credit**: : 02
Max Marks: 100	**CIE:** 60	**SEE:** 40
End Term Exam Time: 04 hours	**Teaching Scheme:** 0L+0T+4P	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	4
2	Study of Conventional & Non-conventional energy systems.	8
3	Calculate the energy density of newly produced waste biomass briquettes and compare it with that of coal and diesel.	8
4	Study of a biomass gasifier, biogas digester and biogas appliances.	8
5	Estimation of solar radiation with the help of Pyranometer and Pyrheliometer and to check the variation with location and season.	8
6	To observe the variations in voltage and current and draw I-V and P-V characteristics for a single solar panel.	8
7	To draw I-V and P-V characteristics with series and parallel connections of two solar panels.	8
8	Measurement of wind speed and wind direction using an anemometer and wind vane.	4
9	Study on wind energy experimental setup.	4
	Total	**60**

Text Books:

1. G. D. Rai, “Non-Conventional Sources of Energy”, Khanna Publishers.
2. D. P. Kothari, K. C. Singhal, and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies” Prentice Hall India Pvt., Limited
3. S. P. Sukhatme and J. K. Nayak, “Solar Energy: Principles of Thermal Collection and Storage” TMH.

Reference Books:

1. Godfrey Boyle, “Renewable Energy” Oxford University Press.
2. G. D. Rai, “Solar Energy Utilization” Khanna Publishers.

Prerequisite:

1. Engineering Thermodynamics
2. Heat and mass transfer

Course Outcomes:

After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPP130.1	Demonstrate various renewable energy techniques.	BL3	1.1, 1.2, 2.2, 2.3, 2.4, 3.2, 3.3	1.1, 1.2, 1.6, 2.3, 2.6
MEPP130.2	Demonstration of various biomass utilization techniques and comparison with conventional fuels.	BL3	1.1, 1.2, 2.1, 2.3, 2.4, 3.2	1.1, 1.3, 1.5, 2.3, 2.5, 2.7
MEPP130.3	Measure direct and diffused solar radiations and effect of variation in season.	BL3	1.1, 1.2, 2.1, 2.3, 2.4, 3.2, 3.3	1.1, 1.3, 1.5, 2.1, 2.3, 2.5, 2.7
MEPP130.4	Characterization of solar PV panels.	BL4	1.2, 2.2, 2.3, 2.4, 3.2, 3.3	1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 2.5, 2.6, 2.7
MEPP130.5	Measure the speed and power generation capacity of the wind.	BL3	1.2, 2.2, 2.3, 2.4, 3.2, 3.3	1.2, 1.3, 1.4, 2.1, 2.2, 2.5, 2.6, 2.7

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPP130.1	1	3	3	2	2
MEPP130.2	1	3	3	2	2
MEPP130.3	3	3	3	2	2
MEPP130.4	1	3	3	3	3
MEPP130.5	1	3	3	2	3

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: I
Course Name: Solar Photovoltaic Lab	**Course Code**: MEPP131	**Credit**: : 02
Max Marks: 100	**CIE:** 40	**SEE: 60**
End Term Exam Time: 04 hours	**Teaching Scheme:** 0L+0T+4P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	4
2	Study of solar photovoltaic module. Design a solar photovolatic system for a medium size commercial/residential/organizational buildings.	8
3	To demonstrate the I-V and P-V characteristics of PV Module	4
4	To demonstrate the I-V and P-V characteristics of PV module with varying insolation and temperature level	4
5	Study the effect of 'tilt angle' on the performance of solar photovolatic system in every 3 months.	8
6	To demonstrate the effect of shading on PV module output power.	8
7	Determination of maximum power point and fill factor of a solar photovoltaic module.	8
8	Analysis of the working of solar photovoltaic water pumping system	8
9	Analysis of working of grid-connected rooftop solar photovoltaic power system	4
10	Analysis of working of solar PV-based street lighting system	4
	Total	**60**

Text Books:

1. S. P. Sukhatme and J. K. Nayak, "Solar Energy: Principles of Thermal Collection and Storage" TMH.

Reference Books:

1. G. D. Rai, "Solar Energy Utilization" Khanna Publishers**.**

Prerequisite:

1. Engineering Thermodynamics
2. Heat and Mass Transfer

Course Outcomes:

After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPP131.1	Study and design a solar PV system for a medium size building.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6
MEPP131.2	Demonstrate the I-V, P-V characteristics and effect of various factors on the performance of a PV module.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6
MEPP131.3	Determine the maximum power point and fill factor of a solar photovoltaic module.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.6
MEPP131.4	Analyze the working of solar photovoltaic water pumping system and solar PV-based street lighting system.	BL4	1.1, 1.2, 2.1, 2.2, 2.3, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3
MEPP131.5	Analyze the working of grid-connected rooftop solar photovoltaic power system.	BL4	1.1, 1.2, 2.1, 2.2, 2.3, 3.1, 3.2	1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPP131.1	3	3	3	3	3
MEPP131.2	3	3	3	3	3
MEPP131.3	3	3	3	3	3
MEPP131.4	3	3	3	3	2
MEPP131.5	3	3	3	3	2

Teaching and Examination Scheme
I Year II Semester: M.Tech. (RET)

S. No.	Course Code	Course Name	Category	Teaching Scheme				Marks			Credit
				L	T	P	Exam Hrs	CIE	SEE	Total	
1	MEPL201	Wind Energy Technology	PCC	3	0	0	3	40	60	**100**	**3**
2	MEPL202	Fuel Cell Technology	PCC	3	0	0	3	40	60	**100**	**3**
		Elective-III:									
3	MEPL211 MEPL212 MEPL213	a. Analysis of Power Plants b. Green Buildings c. Advanced Photovoltaic Technology	PEC	3	0	0	3	40	60	**100**	**3**
		Elective-IV:									
4	MEPL214 MEPL215 MEPL216	a. Solar Thermal Energy b. Electric Vehicle Technology c. Numerical Methods	PEC	3	0	0	3	40	60	**100**	**3**
5	NP99.XX	AUDIT COURSE	MCC	MCC	-	-	-	3	40	60	**100**
6	MEPP230	Building Energy Simulation Lab	PCC	0	0	4	4	60	40	**100**	**2**
7	MEPP231	Solar Energy Simulation Lab	PCC	0	0	4	4	60	40	**100**	**2**
8	MEPD250	Mini Project with Seminar	REW	0	0	2	4	60	40	**100**	**2**
9	MEPA200	Social Outreach, Discipline & Extra Curricular Activities (SODECA)	SODECA							**100**	**1**
Total Credit											**19**

Syllabus

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Wind Energy Technology	**Course Code**: MEPL201	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Wind Resource Assessment:** Introduction to wind energy, Classifications of wind turbines and their construction. Wind characteristics and resources: General characteristics of wind resource, Wind data analysis and resource estimation, Wind measurements and instrumentations, Present status of wind energy in Rajasthan, India and the world.	8
3	**Aerodynamics of Horizontal-Axis Wind Turbines:** Mechanics of wind motion, Available power in the wind, One-dimensional momentum theory and Betz limit, Ideal horizontal axis wind turbine with wake rotation, Airfoils and general concepts of Aerodynamics: lift, drag, lift versus drag machines. Momentum theory and Blade Element Theory.	9
4	**Electrical Aspects of Wind Turbines:** Basic concepts of electrical power, Classification of generators, Synchronous generators, Induction generators, Variable speed generators, Power transformers, Power converters, Control systems, Embedded (dispersed) wind generation.	9
5	**Wind Turbine Siting, System Design, and Integration:** Wind turbine siting. Installation and operation issues. Wind farms. Design of wind farm and its integration with electrical grids. Offshore wind farms. Hybrid wind systems.	9
6	**Environmental and Financial Aspects of Wind Energy:** Environmental concern: Avian interaction with wind turbines, Visual impact of wind turbines, Wind turbine noise, Electromagnetic interference effects, Land-use environmental impacts, and Other environmental considerations. Financial aspects: Annual Energy Output (AEO), Time value of money, Capital recovery factor, Depreciation, Life cycle cost.	9
	Total	**45**

Text Books:

1. D. P. Kothari, “Wind Energy Systems and Applications”, Narosa Publishing House
2. Siraj Ahmed, “Wind Energy: Theory and Practice”, Prentice Hall India Learning Private Limited.

Reference Books:

1. E. Hau, “Wind Turbines: Fundamentals, Technologies, Application, Economics”, Springer Berlin
2. J. F. Manwell, J. G. McGowan, and A. L. Rogers, “Wind energy explained: Theory, Design and Application”, Wiley.

Prerequisite:

1. Fluid Mechanics
2. Basic Electrical Engineering

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL201.1	Characterization of wind energy and wind data analysis, estimation, and measurement.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL201.2	Apply the aerodynamic theories on wind machines and analyze the airfoil design.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL201.3	Describe the various electrical aspects used in the windmill.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL201.4	Analyze the different factors for site selection for windmill installation.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL201.5	Explain the various environmental and financial concerns of windmill installation.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL201.1	3	2	2	-	2
MEPL201.2	3	2	2	-	2
MEPL201.3	3	2	2	-	2
MEPL201.4	3	2	2	-	2
MEPL201.5	3	2	2	-	2

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Fuel Cell Technology	**Course Code**: MEPL202	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Fuel Cells:** Fuel cells basics, relevance and importance. Stack design, gas supply, and cooling, classification of fuel cells. Electrochemistry basis of fuel cells. Efficiency and open circuit voltage. Influence of pressure and gas concentration: Nernst Equation, hydrogen partial pressure. Voltage-current behavior of fuel cell, Fuel-cell irreversibility. Applications of small, medium and large size fuel cell technology	8
3	**Alkaline Fuel Cell (AFC):** Description, working principle, components, general performance characteristics, operating temperature and pressure. Ammonia as AFC fuel	9
4	**Phosphoric Acid Fuel Cell (PAFC):** System design: Fuel processing, fuel utilization. Principles of Operation: electrolyte, electrode, catalyst, stack construction, stack cooling & manifold. Performance: operating pressure & temperature, effects of carbon monoxide and Sulphur.	9
5	**High-Temperature Fuel Cells:** Solid Oxide Fuel Cell (SOFC): History, benefits and limitations, cell components, Cathode and Anode materials, fuel, configuration and performance. Environmental impact of SOFC. Application and future of SOFC. Molten Carbonate Fuel Cell (MCFC): General principle, cell components, mechanisms of electrode reactions, Influence of pressure & temperature, status of MCFC	9
6	**Proton-Exchange Membrane Fuel Cell (PEMFC):** Principles of operation, Electrodes & electrodes structure, components. Water management, cooling and air supply. Introduction to Direct Methanol Fuel Cell (DMFC).	9
	Total	**45**

Text Books:

1. B. Viswanathan and M. Aulice Scibioh, “Fuel Cells: Principles and Applications”, Universities Press.

Reference Books:

1. Suddhasatwa Basu, “Recent Trends in Fuel Cell Science and Technology”, Springer.
2. Ewa Rudnik, “Direct Methanol Fuel Cell Technology”, Elsevier.

Prerequisite:

1. Thermodynamics

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL202.1	Describe the basics of fuel cell technology, classification, and its efficiency.	BL2	2.1	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL202.2	Describe the components and working principles of an Alkaline Fuel Cell.	BL2	2.1	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL202.3	Describe the components and working principles of Phosphoric Acid Fuel Cell.	BL2	2.1	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL202.4	Compare the construction and working of a Solid Oxide fuel cell and a Molten Carbonate fuel cell.	BL2	2.1	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL202.5	Describe the components and working principles of the Proton-Exchange Membrane fuel cell.	BL2	2.1	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL202.1	-	1	-	3	1
MEPL202.2	-	1	-	3	1
MEPL202.3	-	1	-	3	1
MEPL202.4	-	1	-	3	1
MEPL202.5	-	1	-	3	1

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Analysis of Power Plants	**Course Code**: MEPL211	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Introduction:** Power and energy, sources of energy, review of thermodynamic cycles related to power plant. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant units. Power plant economics and selection	8
3	**Steam Power Plant:** General layout of steam power plant, Power plant boilers including critical and super-critical boilers. Fluidized bed boilers, Different systems such as coal handling system, pulverisers and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power plant. A case study to realize above concepts.	9
4	**Hydroelectric and Non-Conventional Power Plants:** Hydroelectric power plants, classification, typical layout and components, Types of turbine- Pelton, Francis, Kaplan, Propeller, Deriaz and Bulb turbines. Performance of turbines and comparison. A case study to realize above concepts.	9
5	**Diesel and Gas Turbine Power Plants:** General layout of Diesel and Gas Turbine power plants, Performance of Diesel and Gas Turbine power plants, comparison with other types of power plants	9
6	**Nuclear power plant:** Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas-cooled and liquid metal cooled reactors, safety measures for nuclear power plants.	9
	Total	**45**

Text Books:

1. P.K. Nag, “Power Plant Engineering”, McGraw Hill.

Reference Books:

1. P.K. Das, A.K. Das, “An Introduction to Thermal Power Plant Engineering and Operation”, Notion Press.
2. G. D. Rai, “Non-Conventional Sources of Energy”, Khanna Publishers.
3. M. M. El Wakil, “Power Plant Technology”, McGraw Hill.
4. R. K. Rajput, “A Textbook of Power Plant Engineering”, Laxmi Publications.

Prerequisite:

1. Engineering Thermodynamics
2. Steam Engineering
3. Renewable Energy

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL211.1	Calculate the performance parameters and plot load duration curves of a power plant.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 2.3,	1.1, 1.2, 1.3
MEPL211.2	Describe the components of a steam generation power plant and associated systems.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 2.3,	1.1, 1.2, 1.3
MEPL211.3	Analyze the performance of hydro-electric power plant under various operating and geographical conditions.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3,	1.1, 1.2, 1.3
MEPL211.4	Analyze the performance of diesel and gas power plants, and compare with the other power plants.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 2.3,	1.1, 1.2, 1.3
MEPL211.5	Describe the layout and subsystems of a nuclear power plant.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 2.3,	1.1, 1.2, 1.3

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL211.1	3	3	-	2	-
MEPL211.2	3	3	-	2	-
MEPL211.3	3	3	-	2	-
MEPL211.4	3	3	-	2	-
MEPL211.5	3	3	-	2	-

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Green Buildings	**Course Code**: MEPL212	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Introduction**: Definition, Environmental implications of buildings energy, carbon emissions, water use, waste disposal; Building materials, environmental implications. Embodied Energy in Building Materials: Transportation Energy for Building Materials; Energy requirement for Buildings Maintenance	8
3	**Comforts in Building**: Thermal Comfort in Buildings-Issues; Heat Transfer Characteristic of Building Materials. Incidence of Solar Heat on Buildings-Implications of Geographical Locations. Utility of Solar energy in buildings: Concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings	8
4	**Green Building Techniques:** Concepts of Green Composites. Water Utilisation in Buildings, Low Energy Approaches to Water Management. Management of Solid Wastes. Management of Sewage. Urban Environment and Green Buildings. Green Cover and Built Environment. Rain Water Harvesting, Solar PV systems, Solar Water Heaters	10
5	**Green Building Rating Systems**: Features of green building rating systems in India: Indian Green Building Council (IGBC) standards, Green Rating for Integrated Habitat Assessment (GRIHA), & LEED (Leadership in Energy and Environmental Design), ASHRAE standards etc. Sustainable site, water, energy, material, and indoor environment issues for green buildings; Intent and documentation for credits/points for green rating systems; Difference in evaluation and documentation for new construction and existing buildings. Green home rating, green factory rating, green neighborhood concept	10
6	**Concept of Net Zero Energy Building**: Costs of green buildings. Energy Conservation Building Code: requirements of code, applicability, compliance options: prescriptive, trade-off, whole building performance routes for compliance. A case study to realize above concepts.	8
	Total	**45**

Text Books:

1. Green construction project management and cost oversight by Sam Kubba.
2. Introduction to green buildings and built environment by Indian green building council.

Reference Books:

1. Handbook of Green Building Design and Construction Author: Sam Kubba.
2. Handbook of Green Building Design and Construction LEED, BREEAM, and Green Globes.
3. Life-Cycle Cost Models for Green Buildings with Optimal Green Star Credits.
4. Green Building: Principles & Practices by Dr. Adv. Harshul Savla.

Prerequisite:

1. Refrigeration & Air Conditioning.
2. Energy Management.

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL212.1	Describe concepts and techniques related to energy efficiency in green buildings practices.	BL2		1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL212.2	Analyze various factors affecting the comfort in buildings.	BL4	1.2, 2.1, 2.2, 2.3, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL212.3	Select appropriate green building materials and techniques.	BL3	1.2, 2.1, 2.2, 2.3, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL212.4	Assess green buildings and rate them as per IGBC and other standards.	BL4	1.2, 2.1, 2.2, 2.3, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPL212.5	Describe concepts and techniques related to net zero energy building.	BL2	1.2, 2.1, 2.2, 2.3, 3.2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL212.1	-	-	-	3	1
MEPL212.2	1	3	1	3	1
MEPL212.3	1	3	1	3	1
MEPL212.4	1	3	1	3	1
MEPL212.5	1	3	1	3	1

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Advanced Photovoltaic Technology	**Course Code**: MEPL213	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	Overview of different types of solar cells/panels. Photovoltaic industries in India and the World. International certification of solar panels and Indian scenario	8
3	Wafer-based silicon solar cells and its market trend. Cost breakup of wafer-based solar panels, future trends. Concentrator solar cells, reflector and lens-based versions. Performance in Indian climatic conditions. Low, medium and high concentration, combined thermal and concentration PV system	9
4	Semi-transparent solar cells and related materials, applications in buildings (BIPV), thin film and wafer-based versions, appearance and structure of thin film solar cells, Flexible solar cells	9
5	Multi-junction solar cells, its working principles. Hetero-junction with an intrinsic thin layer (HIT) solar cells, structure and working principle, comparison with conventional bulk solar cells, bi-facial solar cells	9
6	Polymer, organic, dye-sensitized, and quantum dot solar cells, structure, working principle, present applications, near-future trends. New SPV materials availability, Efficiency and cost estimation. Cooling and cleaning of SPV Panels. Daily and weekly tracking. Shading of solar panels	9
	Total	**45**

Text Books:

1. Solar Photovoltaics: Fundamentals, Technologies and Application, Chetan Singh Solanki, PHI Learning, 3rd Edition, 2015.
2. Solar Cell Technology and Applications, A.R .Jha, CRC Press, 1st Edition, 2009.

Reference Books:

1. John Balfour, Michael Shaw, and Sharlene Jarosek, “Introduction to Photovoltaics”, Jones and Bartlett Publishers.
2. Antonio Luque and Viacheslav Andreev, “Concentrator Photovoltaic”, Springer.

Prerequisite:

1. Engineering Thermodynamics
2. Engineering Mechanics
3. Engineering Chemistry
4. Solar photovoltaic

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL213.1	Explore the advancement in photovoltaic technology and global potential.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	1.1, 1.2, 1.3, 1.4
MEPL213.2	Describe concentrated solar cells and integration of PV technology with solar thermal.	BL2	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.6
MEPL213.3	Utilize thin film technology in building integrated photovoltaic solar panels.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	1.1, 1.2, 1.3, 1.4
MEPL213.4	Compare multi junction and hetero junction solar cells with conventional solar cells.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	1.1, 1.2, 1.3, 1.4
MEPL213.5	Discover the latest advancement in solar cell materials and future trends.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	1.1, 1.2, 1.3, 1.4, 1.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL213.1	3	3	3	3	-
MEPL213.2	3	3	3	3	-
MEPL213.3	3	3	3	3	-
MEPL213.4	3	3	3	3	-
MEPL213.5	3	3	3	3	-

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Solar Thermal Energy	**Course Code**: MEPL214	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Solar Radiation:** Solar radiation outside the Earth's atmosphere and at the Earth's surface. Solar Radiation Geometry, sunrise, sunset, day length, Local Apparent Time. Empirical equations for predicting the availability of solar radiation: Monthly average daily global radiation, monthly average daily diffuse radiation, monthly average hourly global radiation, and monthly average hourly diffuse radiation. Hourly global, beam, and diffuse radiation under cloudless skies. Solar radiation on tilted surfaces	9
3	**Liquid Flat-Plate Collectors (FPC):** Introduction of FPC, Performance analysis, Transmissivity of the cover system: Transmissivity based on reflection, refraction, absorption, and diffuse radiation. Transmissivity - Absorptivity product. Overall loss coefficient. Effects of various parameters on performance (Selective surfaces, Number of covers, Spacing, Effect of shading, collector tilt, Fluid inlet temperature, Cover transmissivity, Dust on the top cover). Alternatives to FPC (Evacuated Tube Collectors), Solar water heaters	9
4	**Solar Air Heaters:** Introduction, various types of solar air heaters, Matrix air heater. Plastic air heater. Inflatable-tunnel plastic solar heater, Solar dryer, Solar Cookers	9
5	**Concentrating Collectors:** Concentrating collectors for medium and high-temperature applications. Line-focusing and point-focusing concentrators: Cylindrical parabolic collector, compound parabolic collector (CPC), paraboloid dish collector, Central Receiver Collector (heliostat field with central receiver), Linear Fresnel lens collector, Circular Fresnel lens concentration	8
6	**Thermal Energy Storage:** Introduction to three basic methods for storing thermal energy. Sensible heat storage in liquids & solids, Thermal Stratification. Latent Heat Storage. Thermochemical Storage. Solar pond, its principle of working, and solar pond electric-power plant.	9
	Total	**45**

Text Books:

1. H. P. Garg and J. Prakash, “Solar Energy: Fundamentals and applications” McGraw-Hill Education.
2. Sukhatme & Nayak, “Solar Energy: Principles of thermal collection & storage” TMH.
3. G. D. Rai, “Solar Energy Utilization” Khanna Publishers.

Reference Books:

1. John A. Duffie and William A. Beckman, “Solar Engineering of Thermal Processes” Pearson
2. G. D. Rai, “Non-Conventional Sources of Energy”, Khanna Publishers.

Prerequisite:

1. Engineering Thermodynamics
2. Heat and Mass transfer
3. Renewable Energy

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL214.1	Analyze various sun-earth geometrical parameters that affect solar radiation.	BL4	3.1	1.1, 1.2, 1.3,1.4, 1.6
MEPL214.2	Analyze the performance parameters of flat plate collectors.	BL4	3.1	1.1, 1.2, 1.3,1.4, 1.6
MEPL214.3	Explain the construction and application of solar air heater and its applications.	BL2		1.1, 1.2, 1.3,1.4, 1.6
MEPL214.4	Design concentrating solar collectors for high-temperature applications.	BL4	3.1	1.1, 1.2, 1.3,1.4, 1.6, 2.3, 2.4
MEPL214.5	Categorize the different solar thermal energy storage techniques and other solar thermal applications.	BL4		1.1, 1.2, 1.3,1.4, 1.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL214.1	-	-	1	3	-
MEPL214.2	-	-	1	3	-
MEPL214.3	-	-	-	3	-
MEPL214.4	-	-	1	3	1
MEPL214.5	-	-	-	3	-

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Electric Vehicle Technology	**Course Code**: MEPL215	**Credit**: 3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 hrs.	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Components of Electric Vehicle:** Comparison of EV with conventional petrol/diesel/CNG vehicle on performance, fuel consumption, life cycle, cost and environment aspects, Components of a conventional vehicle and propulsion load; power train of HEV and EV; efficiency considerations for a conventional vehicle, HEV and EV; multi-motor in-wheel EVs; impact and benefits of EV on utility grid	7
3	**On-board Chargers:** Semiconductor devices; turn-on and turn-off characteristics; loss computation in semiconductor devices; basics of non-isolated/isolated DC-DC and grid-connected converters; classification of EV chargers; modeling and control of bi-directional DC-DC converters; discussions on V2X applications	9
4	**Induction Motor Drives:** Basics of induction motor; open-loop V/f control; basics of DC-AC power converters; basic pulse width modulation techniques; vector control of IM drives; advanced control techniques	9
5	**Battery Management:** Types of batteries, Effects of Current Density on Battery Formation, Effects of Heat on Battery Cycle Life, Battery Storage, Lithium-ion Battery, Traction Battery Pack Design, Battery Capacity, capacity-tests, effect of temperature on Battery Capacity, Recovery of Capacity, Energy Balances for the Electric Vehicle, Discharge Characteristics of Li-ion Battery and Battery Pack, Effect of cold weather on battery capacity and discharging, Environment issues with battery disposal.	10
6	**Fuel Cells for Electric vehicles:** Fuel cell – Introduction, Technologies & Types, Obstacles. Operation principles, Potential and I-V curve, Fuel and Oxidation Consumption, Power design of fuel Cell Vehicle and freeze capacity. The lifetime cost of Fuel Cell Vehicle – System, components, maintenance. Comparison with battery EV	9
	Total	**45**

Text Books:

1. J. Larminie and J. Lowry, “Electric vehicle technology explained”, 2nd edition, Wiley, 2012.

Reference Books:

1. Ali Emadi, “Advanced Electric Drive Vehicles”, CRC Press 2015
2. Iqbal Husain, “Electric and Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press.2011
3. R Krishnan, “Permanent Magnet Synchronous and Brushless DC Motor Drives”, CRC Press 2010.
4. Jack Erjavec and Jeff Arias, “Hybrid, Electric and Fuel Cell Vehicles”, Cengage Learning, 2012.
5. Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes Publishing, 2002.

Prerequisite:

1. Basic knowledge of vehicles working principles.

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL215.1	Compare conventional vehicles with HEV and EV, evaluating efficiency and grid integration challenges.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL215.2	Classify EV chargers and modeling of bi-directional DC-DC converters for efficient V2X applications.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL215.3	Apply V/f control, pulse width modulation, and vector control techniques for precise motor operation and efficiency.	BL3	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL215.4	Analyze battery management for different EV applications.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6
MEPL215.5	Integrate fuel cell technology in EV application.	BL4	1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.3	2.2, 2.3, 2.4, 2.6

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL215.1	3	2	2	-	2
MEPL215.2	3	2	2	-	2
MEPL215.3	3	2	2	-	2
MEPL215.4	3	2	2	-	2
MEPL215.5	3	2	2	-	2

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Numerical Methods	**Course Code**: MEPL216	**Credit**:3
Max Marks: 100	**CIE:** 40	**SEE:** 60
End Term Exam Time: 3 Hours	**Teaching Scheme:** 3L+0T+0P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Approximations:** Accuracy and precision, definitions of round-off and truncation errors, error propagation	7
3	**Algebraic Equations:** Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss-Siedel), convergence of iteration methods, Eigen values, and Eigen vectors	10
4	**Interpolation Methods:** Newton's divided difference, interpolation polynomials, and Lagrange interpolation polynomials.	9
5	**Differentiation and Integration:** High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature, and integration.	9
6	**Introduction to Optimization Methods:** Local and global minima of one and two variables, constraints optimization, Lagrange's Method, K-T conditions, Steepest descent method, Conjugate gradient method.	9
	Total	**45**

Text Books:

1. S. K. Gupta, "Numerical Methods for Engineers", New Age International Publishers.
2. M. K. Jain, Satteluri R. K. Iyengar, R. K. Jain, "Numerical Methods: Problems & Solutions", New Age International Publishers.

Reference Books:

1. A. Gourdin and M. Boumahrat, "Applied Numerical Methods", PHI.
2. S. S. Rao, "Engineering Optimization: Theory and Practice", New Age International Publishers.
3. P.K. Gupta and D.S. Hira, "Operations Research", S. Chand Publishers.

Prerequisite:

1. Basics of Numerical Methods

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPL216.1	Apply appropriate error-handling techniques in computations.	BL3	1.1, 1.3, 2.1, 2.3	1.3, 1.4
MEPL216.2	Derive Eigen values and Eigen vectors and solutions of linear algebraic equations by using Gauss elimination, LU decomposition, Gauss – Siedel methods	BL3	1.1, 1.3, 2.1, 2.3	1.3, 1.4
MEPL216.3	Employ Newton's and Lagrange's interpolation methods to obtain interpolation polynomials	BL3	1.1, 1.3, 2.1, 2.3	1.3, 1.4
MEPL216.4	Apply interpolation methods for numerical derivatives and Gauss quadrature method for numerical integration	BL3	1.1, 1.3, 2.1, 2.3	1.3, 1.4
MEPL216.5	Implement Lagrange's method & K-T conditions for constrained optimization and steepest descent & conjugate gradient methods for unconstrained optimization	BL3	1.1, 1.3, 2.1, 2.3	1.1, 1.2, 1.3, 1.4, 2.3

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPL216.1	2	2	-	1	
MEPL216.2	2	2	-	1	
MEPL216.3	2	2	-	1	
MEPL216.4	2	2	-	1	
MEPL216.5	2	2	-	2	1

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Building Energy Simulation Lab	**Course Code**: MEPP230	**Credit**: 2
Max Marks: 100	**CIE:** 60	**SEE:** 40
End Term Exam Time: 4 hrs.	**Teaching Scheme:** 0L+0T+4P	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	4
2	Case study on heating and cooling energy calculations of a building	8
3	Modeling and simulation of a building energy consumption.	8
4	Case study on the energy supply system of a building	8
5	Field visit I: Visit of domestic energy efficient/green building and report writing	8
6	Field visit II: Visit of commercial energy efficient building and report writing	8
7	A project on small scale building design, modeling and simulation using different software.	16
	Total	**60**

Text Book:

1. Vishal Garg, “Building Energy Simulation”, CRC Press.

Reference Books:

1. V.S.K.V. Harish, Arun Kumar, “Green Building Energy Simulation and Modeling”, Elsevier Science

Prerequisite:

1. Basic knowledge about the different types of energy loads on the buildings

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPP230.1	Estimate heating and cooling requirements for a building.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP230.2	Apply energy modelling and simulation technologies to analyze the energy performance of buildings.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP230.3	Identify building Heating, Ventilating, and Air-Conditioning (HVAC) systems in a real-time building project.	BL3	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP230.4	Prepare the reports of field visits.	BL2	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP230.5	Develop a model of energy-efficient building.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPP230.1	1	3	3	3	1
MEPP230.2	1	3	3	3	1
MEPP230.3	1	3	3	3	1
MEPP230.4	1	3	3	3	1
MEPP230.5	1	3	3	3	3

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Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Solar Energy Simulation Lab	**Course Code**: MEPP231	**Credit**: 2
Max Marks: 100	**CIE:** 60	**SEE:**40
End Term Exam Time: 4 hrs.	**Teaching Scheme:** 0L+0T+4P	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	4
2	Study and simulation of flat plate collector and evacuated tube collector.	8
3	Study and simulation of a box-type solar cooker and calculation of its thermal efficiency.	8
4	Study and simulation of natural and forced convection-type solar water heaters.	8
5	Study and simulation of natural and forced convection type solar dryers and heaters.	8
6	Simulation of grid-connected 1 MW solar photovoltaic power plant using PVSyst software.	8
7	Field visit I: A case study and report writing on a grid-connected rooftop solar photovoltaic power plant.	6
8	Field visit II: A case study and report writing on a commercial solar power plant.	6
9	Design and Suggest a solar system to meet energy requirements of a family of four people.	4
	Total	**60**

Text Books:

1. Jyoti Prakash Srivastava, “Step by Step Guide to Solar Simulation Software PVsyst - Practical Approach to Solar Simulation” (e-book).

Reference Books:

1. K Sudhakar, Tulika Srivastava, Kavali Janardhan, “MATLAB Modelling and Simulation of Solar Photovoltaic Panel”, Lambert.
2. Laurentiu Fara, Masafumi Yamaguchi, “Advanced Solar Cell Materials, Technology, Modeling, and Simulation (Advances in Chemical and Materials Engineering)”, Idea Group, U.S.
3. Weidong Xiao, “Photovoltaic Power System: Modeling, Design, and Control”, Wiley

Prerequisite:

1. Basic knowledge of thermal systems, thermal engineering, and engineering materials.

Course Outcomes:

After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPP231.1	Modeling and simulation of different solar collectors.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP231.2	Analyze the results provided by the simulation of box-type solar cookers.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP231.3	Analyze the results provided by simulation of solar water heaters and solar dryers.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP231.4	Analyze the performance of grid-connected photovoltaic plant with the help of simulation software.	BL4	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.2
MEPP231.5	Experience the installation of actual solar PV/thermal projects.	BL2	1.2, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPP231.1	1	3	3	3	1
MEPP231.2	1	3	3	3	1
MEPP231.3	1	3	3	3	1
MEPP231.4	1	3	3	3	1
MEPP231.5	1	3	3	3	3

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Renewable Energy Technology	**Year**: I	**Semester**: II
Course Name: Mini Project with Seminar	**Course Code**: MEPD250	**Credit**: 2
Max Marks: 100	**CIE:** 60	**SEE:** 40
End Term Exam Time: 4 hrs.	**Teaching Scheme:** 0L+0T+2P	

Contents:

1. Literature Review
2. Presentation
3. Report writing
4. Publication of papers

Course Outcomes:
After successful completion of course students will be able to

Course Code	Course Outcomes	Bloom's Level	PO Performance Indicators	PSO Performance Indicators
MEPD250.1	Search literature on various cutting-edge technologies and contemporary issues from various databases, books, journals, etc.	BL3	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7
MEPD250.2	Compile the literature to reach a valid conclusion.	BL3	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7
MEPD250.3	Analyse critically the assumptions, hypotheses, and arguments of previous authors.	BL4	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7
MEPD250.4	Describe the collection of evidence to draw conclusions consistent with the relevant text.	BL4	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7
MEPD250.5	Communicate effectively the work done in the form of a report.	BL4	1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7

Mapping of COs with POs-PSOs:

Course Code	PO1	PO2	PO3	PSO1	PSO2
MEPD250.1	1	3	3	3	3
MEPD250.2	1	3	3	3	3
MEPD250.3	1	3	3	3	3
MEPD250.4	1	3	3	3	3
MEPD250.5	1	3	3	3	3

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