Himachal Pradesh University

Dr. A.P.J. Abdul Kalam Bhawan, H. P. University, Shimla-171005

(NAAC accredited “A-Grade” University)

Centre
for
Green Energy and Nanotechnology

Course Syllabus

For

Master of Technology

in

Energy Science and Engineering

Semester I-IV

(Effective for the Batch 2026 and onwards)

Vision and Mission

Vision of University:

The vision of the University is to disseminate and advance knowledge, wisdom and understanding by teaching and research, and by the example and influence of its corporate life.

Mission of University:

To work towards its vision, the University is committed to its mission to:

1. Advance learning and knowledge by teaching and research and by extension programs so as to enable a student to obtain advantages of university education.
2. Provide the right kind of leadership in all walks of life
3. Promote in the students and teachers an awareness and understanding of the social needs of the country and prepare them for fulfilling such needs
4. Take appropriate measures for promoting inter-disciplinary studies in the University
5. Foster the composite culture of India and establish such departments or institutions as may be required for the study and development of the languages, arts and culture of India
6. Make such provision for integrated courses in Humanities, Sciences and Technology in the educational programs of the University.

Vision of School:

To advance sustainable and resilient energy systems through innovation, research, and collaboration in renewable energy and nanotechnology

Mission of School:

1. To support Himachal Pradesh's transition to clean energy.
2. To build research excellence in solar energy, green hydrogen, and electric mobility.
3. To promote indigenous technology development and sustainable rural energy models.

Program's Mission:

To prepare skilled renewable-energy professionals capable of designing, analyzing, and managing advanced solar, wind, hydro, bioenergy, hydrogen, storage, and smart-grid systems through rigorous technical education, research-driven learning, ethical scientific practice, and hands-on laboratory and field training that contribute to sustainable national energy development.

Vision and Mission

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The vision of the University is to disseminate and advance knowledge, wisdom and understanding by teaching and research, and by the example and influence of its corporate life.

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To work towards its vision, the University is committed to its mission to:

1. Advance learning and knowledge by teaching and research and by extension programs to enable a student to obtain advantages of university education.
2. Provide the right kind of leadership in all walks of life.
3. Promote in the students and teachers an awareness and understanding of the social needs of the country and prepare them for fulfilling such needs.
4. Take appropriate measures for promoting inter-disciplinary studies in the University.
5. Foster the composite culture of India and establish such departments or institutions as may be required for the study and development of the languages, arts and culture of India.
6. Make such provision for integrated courses in Humanities, Sciences and Technology in the educational programs of the University.

Vision of Centre:

To advance sustainable and resilient energy systems through innovation, research, and collaboration in renewable energy and nanotechnology

Mission of Centre:

1. To support Himachal Pradesh's transition to clean energy.
2. To build research excellence in solar energy, green hydrogen, and electric mobility.
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Program's Mission:

To prepare skilled renewable-energy professionals capable of designing, analyzing, and managing advanced solar, wind, hydro, bioenergy, hydrogen, storage, and smart-grid systems through rigorous technical education, research-driven learning, ethical scientific practice, and hands-on laboratory and field training that contribute to sustainable national energy development.

Course Structure & Scheme

Course Scheme

M.Tech. (Energy Science and Engineering)

First Semester

S. No.	Course No.	Course Name	L	T	P	C	Semester End Marks	
							External	Internal
1.	MESE-1001	Energy Systems and Sustainability	3	1	0	4	100	50
2.	MESE-1002	Hybrid Energy Systems	3	1	0	4	100	50
3.	MESE-1003	Solar Energy Engineering	3	1	0	4	100	50
4.	MESE-1004	Energy Storage Systems	3	1	0	4	100	50
5.	MESE-E0XX	Elective-I	3	0	0	3	100	50
6.	MESE-1005	Energy Laboratory-I	0	0	3	3	100	50
7.	MAC-1001	Audit Course-I	0	0	0	0		
Total			15	4	3	22	600	300
							Total: 900	

Second Semester

S. No.	Course No.	Course Name	L	T	P	C	Semester End Marks	
							External	Internal
1.	MESE-2001	Hydrogen Energy Systems	3	1	0	4	100	50
2.	MESE-2002	Energy Management and Audit	3	1	0	4	100	50
3.	MESE-2003	Energy Economics, Markets and Policies	3	0	0	3	100	50
4.	MESE-E0XX	Elective-II	3	0	0	3	100	50
5.	MESE-E0XX	Elective-III	3	0	0	3	100	50
6.	MESE-2004	Design & Innovation Laboratory-II	0	0	3	3	100	50
7.	MAC-2001	Audit Course-II	0	0	0	0		
Total			15	2	3	20	600	300
							Total: 900	

Third Semester

S. No.	Course No.	Course Name	L	T	P	C	Semester End Marks	
							External	Internal
1.	MESE-3001	Dissertation Phase-I	-	-	-	20	250	100
Total			-	-	-	**20**	**Total: 350**	

Fourth Semester

S. No.	Course No.	Course Name	L	T	P	C	Semester End Marks	
							External	Internal
1.	MESE-4001	Dissertation Phase-II	-	-	-	20	250	100
Total			-	-	-	**20**	**Total: 350**	

Total Credits: 82

List of Electives

S. No.	Course No.	Course Name	L	T	P	C
1.	MESE-E001	Hydro Energy Systems	3	0	0	3
2.	MESE-E002	Wind Energy Engineering	3	0	0	3
3.	MESE-E003	Electric Vehicle Technology	3	0	0	3
4.	MESE-E004	Bio Energy Engineering	3	0	0	3
5.	MESE-E005	Smart and Micro grid systems	3	0	0	3
6.	MESE-E006	Advanced Solar Photovoltaic Systems	3	0	0	3
7.	MESE-E007	Sustainable Buildings Systems	3	0	0	3
8.	MESE-E008	Solar Passive Heating and Cooling	3	0	0	3
9.	MESE-E009	Biofuels	3	0	0	3
10.	MESE-E010	Modelling and Optimization of Energy Systems	3	0	0	3
11.	MESE-E011	Circular Economy and Sustainability	3	0	0	3
12.	MESE-E012	Life Cycle Assessment	3	0	0	3
13.	MESE-E013	Environmental Impact Assessment	3	0	0	3
14.	MESE-E014	Energy Materials and Devices	3	0	0	3
15.	MESE-E015	Waste to Energy	3	0	0	3
16.	MESE-E016	Power Electronics for Renewable Energy	3	0	0	3
17.	MESE-E017	Instrumentation and Control in Energy System	3	0	0	3
18.	MESE-E018	AI applications in Energy	3	0	0	3
19.	MESE-E019	Alternative Fuels	3	0	0	3
20.	MESE-E020	Energy Policy and Planning	3	0	0	3
21.	MESE-E021	Renewable Energy Integration and Power Systems	3	0	0	3
22.	MESE-E022	Carbon Capture and Storage	3	0	0	3
23.	MESE-E023	Climate Change and Mitigation	3	0	0	3
24.	MESE-E024	Energy System Dynamics	3	0	0	3
25.	MESE-E025	Cyber Security for Energy Systems	3	0	0	3
26.	MESE-E026	Solar PV System Design	3	0	0	3

List of Audit Courses

Audit Course - I

Sr. No.	Course Name
1.	English for Research Paper Writing
2.	Disaster Management
3.	Sanskrit for Technical Knowledge
4.	Value Education
5.	Online Courses (SWAYAM / MOOC &NPTEL)

Audit Course - II

Sr. No.	Course Name
1.	Constitution of India
2.	Pedagogy Studies
3.	Stress Management by Yoga
4.	Personality Development through Life Enlightenment Skills.
5.	Online Courses (SWAYAM / MOOC &NPTEL)

Legend:

L - Number of lecture hours per week

T - Number of tutorial hours per week

P - Number of practical hours per week

C- Total no. of credits

DETAILED SYLLABUS

SEMESTER-I

<table>
<tr><td>Name of the Course</td><td colspan="3">Energy Systems and Sustainability</td></tr>
<tr><td>Course Code</td><td>MESE-1001</td><td>Credits-4</td><td>L-3, T-1, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">52 (1 Hour Each) (L=39, T=13 for each semester)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
This course provides an overview of global energy systems, sustainability principles, and major renewable and non-renewable energy sources. It examines their environmental and social impacts, key climate policies, and the role of emerging technologies and energy transitions in shaping a sustainable future.</td></tr>
<tr><td colspan="4">Course Objectives:
To provide an understanding of different energy sources, global energy use patterns, and their links to sustainability.
To examine renewable and non-renewable energy technologies along with their environmental, social, and policy dimensions.
To analyze climate change frameworks, energy transition drivers, and economic factors shaping sustainable energy development.</td></tr>
</table>

Units	Course Content
Unit 1	Overview of energy systems, types of energy sources (renewable vs. non-renewable), global energy demand and consumption patterns; principles of sustainability: definition and pillars of sustainability (environmental, social, economic), Sustainable Development Goals (SDGs); role of renewable energy in sustainable development, Introduction to renewable energy sources: photovoltaic and solar thermal systems: applications, and case studies; wind energy; hydropower: environmental and social considerations; biomass and bioenergy, geothermal energy; marine energy (wave, tidal)
Unit 2	Non-renewable energy sources and their impact; fossil fuels: extraction, utilization, environmental impacts, economic and geopolitical implications, nuclear fission and fusion technologies; safety, waste management, public perception, role of nuclear energy in low-carbon future.
Unit 3	Environmental impacts and climate change; energy and the environment: impact of energy production and consumption on pollution, lifecycle assessment of energy systems; carbon and water footprint, International Legal and Policy Framework for Climate Change, Origin of concepts of sustainable development and sustainability, Kyoto Protocol, Clean development mechanism (CDM), Joint implementation, Emissions Trading System (ETS), Climate targets, CSR and sustainability, Role of UN, IPCC, UNFCC, COP, Paris Agreement on climate change, Climate change changing the focus of energy policy, International Environmental Policy Practices, UNFCCC, NAPCC, INDC

Unit 4	Energy transition; key drivers of the energy transition: environmental concerns, technological advancements in renewables; national and international policies driving transition; socio-economic aspects of energy transition; job creation and workforce transition; social acceptance and stakeholder engagement; scenarios for global energy transition and achieving net-zero targets, Economics of sustainable energy: cost analysis of different energy sources; economic benefits of sustainable energy transitions.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-1001-1: *Explain* global energy systems and compare renewable and non-renewable energy sources.

MESE-1001-2: *Describe* sustainability principles and relate them to global energy use and development goals.

MESE-1001-3: *Evaluate* major renewable and non-renewable energy technologies and their environmental and social impacts.

MESE-1001-4: *Summarize* international and national climate policies that guide sustainable energy planning.

MESE-1001-5: *Analyze* the drivers, challenges, and economic aspects of the global transition toward sustainable energy.

Reference Books:

1. Dutta B. K. (2000). Heat Transfer Principal and Applications. PHI Learning Publishers
2. Holman J. and Bhattacharyya S. (2017). Heat Transfer, 10th edition, McGraw Hill Education
3. White F. M. and Xue H. (2022). Fluid Mechanics, 9th edition, McGraw Hill Education
4. Fox R.W., McDonald A. T., Mitchell J. W. (2020). Introduction to Fluid Mechanics. 10th edition, Wiley
5. Bergman T. L., Lavine A. S., Incropera F. P., Dewitt D. P. (2018). Fundamentals of Heat and
6. Mass Transfer. 8th edition, Wiley

Further Readings:

1. R. A. Dunlap, Energy, Climate, and Sustainability: An Integrated Approach. Sustainable Publishers, 2020.
2. R. T. Wright, &, D. Boorse, Environmental Science: Toward a Sustainable Future, 2020.
3. W. J. Burroughs, Climate Change: A Multidisciplinary Approach. Cambridge University Press, 2019.

<table>
<tr><td>Name of the Course</td><td colspan="3">Hybrid Energy System</td></tr>
<tr><td>Course Code</td><td>MESE-1002</td><td>Credits-4</td><td>L-3, T-1, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">52 (1 Hour Each) (L=39, T=13 for each semester)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
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<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
This course introduces major renewable energy sources and their combination in hybrid systems. It covers hybrid system design, sizing, storage options, simulation using software tools, and the economic, environmental, and practical considerations involved in deploying hybrid energy solutions for both stand-alone and grid-connected applications.</td></tr>
<tr><td colspan="4">Course Objectives:
• To explain the principles, types, and components of hybrid energy systems.
• To develop skills for designing, sizing, and evaluating hybrid systems for different applications.
• To use software tools for modelling, assessing performance, and analyzing the costs of hybrid energy systems.</td></tr>
</table>

Units	Course Content
Unit 1	Overview of renewable energy sources including Solar, Wind, Hydro, Biomass, Hydrogen and emerging alternatives, Advantages and limitations of renewable sources, Need and evolution of hybrid energy systems, Definition and principles of hybrid systems, Classification of hybrid systems, Integration of multiple energy sources, Hybrid system components and configurations, Overview of hybrid combinations: Solar–Wind, Solar–Diesel, Wind–Hydro, Micro-Hydel–PV, Biomass–Diesel–Fuel-Cell, Systems with pumped hydro storage, Systems with battery and alternative storage technologies, Applications of hybrid renewable systems in stand-alone and grid-connected models.
Unit 2	Site assessment and renewable resource mapping, Load profile analysis for remote villages, Energy demand profiling for domestic, agricultural and livelihood improvement applications, Hybrid system design techniques, System sizing and load matching, Integration strategies for maximum efficiency and reliability, Cost-effective hybrid configuration planning, Battery storage technologies including Li-ion and Lead-acid, Pumped hydro energy storage, Thermal energy storage, Hybrid configurations combining other renewable and non-renewable energy sources.
Unit 3	Software-based hybrid system simulation using HOMER or RETScreen, Steps for modelling hybrid energy systems including data input, sizing, optimization and result interpretation, Techno-economic assessment of hybrid systems, Cost-benefit evaluation, Levelized Cost of Energy (LCOE) calculation, Net Present Cost (NPC) computation,

	Payback period analysis, Environmental and sustainability impact evaluation, Grid integration issues and operational constraints in hybrid systems.
Unit 4	Case studies of hybrid renewable energy implementation in remote communities and grid-connected systems, technical challenges in integrating hybrid resources, Grid compatibility and stability considerations, Environmental and social impact of hybrid energy deployment, Design and development of hybrid energy systems based on resource availability and cost criteria, Modelling and detailed performance analysis of user-specific hybrid system configurations.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-1002-1: *Describe* major renewable sources and their suitability for hybrid energy combinations.

MESE-1002-2: *Analyze* site conditions, load profiles, and resource availability for hybrid system planning.

MESE-1002-3: *Design* and size hybrid systems with appropriate storage and component selection.

MESE-1002-4: *Use* software tools to model, optimize, and assess hybrid system performance and cost.

MESE-1002-5: *Evaluate* technical, economic, environmental, and practical aspects of hybrid energy projects.

Reference Books:

1. Twidell, J., & Weir, T. (2006). *Renewable Energy Resources* (2nd ed.). Cambridge University Press.
2. Sukhatme, S. P., & Nayak, J. K. (2017). *Solar Energy: Principles of Thermal Collection and Storage* (4th ed.). Tata McGraw-Hill Education, New Delhi.
3. Kreith, F., & Kreider, J. F. (1978). *Principles of Solar Engineering*. McGraw-Hill Book Company.
4. Soo, S. L. (1968). *Direct Energy Conversion*. Prentice-Hall.

Further Readings:

1. Larminie, J., & Dicks, A. (2003). *Fuel Cell Systems Explained* (2nd ed.). John Wiley & Sons Ltd.
2. Manwell, J. F., McGowan, J. G., & Rogers, A. L. (2009). *Wind Energy Explained: Theory, Design and Application* (2nd ed.). John Wiley & Sons Ltd.
3. Womack, E. J. (1986). *Power Generation: Engineering Aspects*. Chapman and Hall.
4. Rai, G. D. (2011). *Non-Conventional Energy Sources* (5th ed.). Khanna Publishers, New Delhi.
5. Lai, L. L., & Chan, T. F. (2007). *Distributed Generation: Induction and Permanent Magnet Generators*. IEEE Press & John Wiley & Sons Ltd., England.

Name of the Course	**Solar Energy Engineering**		
Course Code	**MESE-1003**	**Credits-4**	**L-3, T-1, P-0**
Total Lectures	**52 (1 Hour Each) (L=39, T=13 for each semester)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A combined study of solar photovoltaic and solar thermal engineering, covering solar radiation fundamentals, device principles, system components, design, performance assessment, and emerging solar technologies.

Course Objectives:
- To provide foundational knowledge of solar PV and thermal conversion.
- To develop analytical capabilities for evaluating solar system performance.
- To enable design and assessment of solar photovoltaic and thermal applications**.**

Units	Course Content
Unit 1	Solar spectrum and geometry, direct–diffuse–global radiation on horizontal and tilted planes, measurement instruments, empirical estimation and sun-path interpretation. Semiconductor energy bands, PN-junction behavior, photovoltaic conversion principles, IV characteristics, and comparative scope of first to third-generation PV technologies.
Unit 2	PV modules and arrays, mounting structures, electrical configuration with MPPT, inverters, charge controllers, battery storage, grounding, cabling, monitoring, and data acquisition. System sizing for off-grid, hybrid, and grid-connected configurations, loss identification and mitigation, performance analysis tools, and fundamentals of DPR development.
Unit 3	Flat-plate and evacuated tube collectors with optical-thermal analysis, heat transfer and efficiency parameters, concentrating collector types, tracking mechanisms, material-design considerations, and solar cooking systems. Thermal applications including water and air heating, industrial process heat and storage (sensible, latent, thermochemical), supported by simulation and optimization methodologies.
Unit 4	Solar resource assessment, output estimation, efficiency and performance ratios, system-level loss analysis, testing and reliability under degradation and preventive maintenance regimes. Standards and certification (PV and thermal), high-temperature and concentrator systems including reflector and lens configurations, emerging applications such as floating PV, Agro-PV, BIPV, and financial-technical evaluation in Indian climatic conditions.

Course Outcomes (COs):
At the end of the course students will be able to:

MESE -1003-1: *Explain* solar radiation, photovoltaic, and thermal fundamentals.
MESE-1003-2: *Analyze* performance characteristics of PV and thermal systems.
MESE-1003-3: *Evaluate* losses, efficiencies, and operational parameters.
MESE-1003-4: *Design* solar PV and solar thermal systems.
MESE -1003-5: *Assess* advancements, standards, and hybrid technologies.

Reference Books:

1. Solanki, C. S. (2015). *Solar Photovoltaics: Fundamentals, Technologies and Applications* (3rd ed.). PHI Learning.
2. Duffie, J. A., & Beckman, W. A. (2013). *Solar Engineering of Thermal Processes* (4th ed.). Wiley.

Further Readings:

1. Luque, A., & Hegedus, S. (Eds.). (2011). *Handbook of Photovoltaic Science and Engineering* (2nd ed.). Wiley.
2. Tao, M. (Ed.). (2014). *Terawatt Solar Photovoltaics: Roadblocks and Opportunities*. Springer.
3. Goswami, D. Y., Kreith, F., & Kreider, J. F. (2000). *Principles of Solar Engineering* (2nd ed.). Taylor & Francis.

Name of the Course	**Energy Storage Systems**		
Course Code	**MESE-1004**	**Credits-4**	**L-3, T-1, P-0**
Total Lectures	**52 (1 Hour Each) (L=39, T=13 for each semester)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive course covering principles, classification, design, operation, and applications of energy storage technologies including electrochemical, mechanical, thermal, and chemical systems, along with grid integration, safety, and emerging trends.

Course Objectives:
- To introduce fundamental concepts and classifications of energy storage systems.
- To analyze performance characteristics of various storage technologies.
- To understand applications, integration, and future trends in energy storage.

Units	Course Content
Unit 1	Role and principles of energy storage in renewable systems, classification and applications, performance metrics including energy and power density, round-trip efficiency, charge–discharge behavior, and basic storage-release mechanisms. Historical development, performance indicators, response characteristics, lifecycle and degradation considerations, cycle life, and core storage system components.
Unit 2	Electrochemical storage including lead-acid, lithium-ion, NiMH, sodium-sulfur and flow batteries, chemistry and reactions, construction, performance and safety, SOC–SOH estimation, thermal management, and battery management systems. Fuel cells and hydrogen storage, metal hydrides, chemical storage media, supercapacitors and hybrid storage technologies, charge–discharge dynamics, degradation factors, and operational safety requirements.
Unit 3	Mechanical and gravitational storage including pumped hydro, CAES, flywheels and gravity-based systems, performance characteristics, storage dynamics and efficiencies, and system design parameters. Sensible, latent and thermochemical thermal storage, phase-change materials, thermal applications in solar systems, material selection, building-integrated storage, and performance evaluation methodologies.
Unit 4	Grid-scale and hybrid renewable-storage applications, microgrids, electric mobility, frequency regulation, peak shaving and load levelling, economic evaluation and techno-economic assessment of storage deployment. Lifecycle analysis, degradation mechanisms, safety standards and codes, hybrid storage configurations, advanced materials and emerging technologies, and trends across global industrial and grid implementations.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-1004-1: *Explain* principles, types, and characteristics of major energy storage systems.
MESE-1004-2: *Analyze* performance parameters and operational behavior of electrochemical, mechanical, thermal, and chemical storage technologies.
MESE-1004-3: *Evaluate* energy storage selection, sizing, efficiency, and life-cycle considerations.
MESE-1004-4: *Assess* integration of storage systems with renewable energy and electrical grids.
MESE-1004-5: *Interpret* advancements, safety protocols, and future developments in energy storage technologies.

Reference Books:

1. Ter-Gazarian, A. G. (1994). *Energy Storage for Power Systems*. IET (Institution of Engineering and Technology).
2. Dincer, I., & Rosen, M. A. (2011). *Thermal Energy Storage: Systems and Applications* (2nd ed.). Wiley.

Further Readings:

1. IEC & IEEE. *Standards for Battery Systems*.
2. IRENA. (2017). *Electricity Storage and Renewables: Costs and Markets to 2030*. International Renewable Energy Agency.
3. Chen, H., Cong, T. N., Yang, W., Tan, C., Li, Y., & Ding, Y. (2009). "Progress in Energy Storage Systems: A Review." *Journal of Progress in Natural Science*, 19(3), 291–312.

<table>
<tr><td>Name of the Course</td><td colspan="3">Energy Laboratory - I</td></tr>
<tr><td>Course Code</td><td>MESE-1005</td><td>Credits-3</td><td>L-0, T-0, P-3</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
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<tr><td colspan="4">Course Description:
Energy Lab–I provides practical exposure to renewable-energy experimentation, focusing on measurement techniques, instrumentation, and safety procedures. Students conduct hands-on experiments on solar, wind, bioenergy, and storage systems to collect data, analyze performance, and generate technical laboratory reports. The course emphasizes experimental accuracy, system evaluation, and the interpretation of operational characteristics of energy devices.</td></tr>
<tr><td colspan="4">Course Objectives:
• Provide practical exposure to energy-system measurements, instrumentation, and testing procedures.
• Enable students to perform performance evaluation of renewable energy devices and analyze experimental data.
• Develop skills in documentation, interpretation, and presentation of laboratory results.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">• Solar cooker
• Solar Thermal Training Kit
• Thermal energy storage</td></tr>
<tr><td>Unit 2</td><td colspan="3">• Heat recovery wheel
• PV system characterization and performance analysis
• Hybrid Smart Grid Solution</td></tr>
<tr><td>Unit 3</td><td colspan="3">• Solar PV Grid tied Training System
• Wind energy training system</td></tr>
<tr><td>Unit 4</td><td colspan="3">• Biogas production
• Battery testing</td></tr>
<tr><td colspan="4">Course Outcomes (COs):
At the end of the course students will be able to:
MESE-1005-1: Identify laboratory instruments, measurement procedures, and safety protocols used in renewable-energy experimentation.
MESE-1005-2: Explain operating principles and performance parameters of basic solar, wind, and bioenergy systems.
MESE-1005-3: Apply experimental procedures to collect reliable data from renewable-energy laboratory setups.</td></tr>
</table>

MESE-1005-4: *Analyze* measured data to determine efficiency, characteristic curves, and operating behavior of energy systems.
MESE-1005-5: *Evaluate* performance outcomes and prepare structured laboratory reports supported by data and observations.

Reference Books:

1. Bureau of Energy Efficiency (BEE). (2015). *Energy Manager & Energy Auditor Training Manuals* (Vols. I–IV). Ministry of Power, Government of India.
2. ASHRAE. (2021). *ASHRAE Handbook – Fundamentals* (Relevant Measurement and Instrumentation Sections). American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Further Readings:

1. Sukhatme, S. P., & Nayak, J. K. (2017). *Solar Energy: Principles of Thermal Collection and Storage* (4th ed.). McGraw-Hill Education.
2. Solanki, C. S. (2015). *Solar Photovoltaics: Fundamentals, Technologies and Applications* (3rd ed.). PHI Learning.
3. Nelson, V. (2013). *Wind Energy: Renewable Energy and the Environment* (2nd ed.). CRC Press.

SEMESTER – II

<table>
<tr><td>Name of the Course</td><td colspan="3">Hydrogen Energy Systems</td></tr>
<tr><td>Course Code</td><td>MESE-2001</td><td>Credits-4</td><td>L-3, T-1, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">52 (1 Hour Each) (L=39, T=13 for each semester)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of hydrogen production, storage, transport, and utilization technologies, covering fuel cells, thermochemical and electrochemical processes, system integration, techno-economic assessment, safety considerations, and emerging developments in the hydrogen economy.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce hydrogen production pathways, properties, and energy relevance
• To analyze hydrogen storage, transport, and fuel cell technologies.
• To evaluate integration, safety, and economic aspects of hydrogen energy systems.</td></tr>
</table>

Units	Course Content
Unit 1	Hydrogen properties and role in energy transition, color classification, thermochemical production including SMR, partial and autothermal reforming, coal and biomass gasification, and comparative efficiency and emissions of production routes. Electrolysis methods such as alkaline, PEM, SOE, photolysis and biological pathways, along with core characteristics like energy density, behavior, and fundamental performance indicators.
Unit 2	Photo-electrochemical and renewable-powered electrolysis, advanced and hybrid production pathways, thermochemical extensions, pyrolysis routes, and CO_2 capture considerations supporting low-carbon hydrogen generation. Physical and chemical storage include compressed and liquefied hydrogen, cryogenic handling, metal and chemical hydrides, LOHCs, pipelines and tankers, distribution logistics, refueling infrastructure, leak detection, and safety codes and standards.
Unit 3	Electrochemistry fundamentals, electrode kinetics and thermodynamics, fuel cell types such as PEMFC, SOFC, PAFC, MCFC and AFC, with stack components including membranes, catalysts, bipolar plates and gas-diffusion layers. Auxiliary systems for humidification, cooling, air supply and fuel processing, performance curves, degradation mechanisms, design considerations, and evaluation of operational efficiency.
Unit 4	System design and balance of plant, hydrogen-fueled IC engines, CHP and trigeneration, hybrid systems with batteries or supercapacitors, fuel cell vehicles, and grid-connected hydrogen applications with modelling and simulation approaches. Lifecycle and cost analysis, environmental impacts, emerging hydrogen-economy trends, metering and instrumentation, safety of gaseous and liquefied hydrogen, hazard characteristics, regulatory frameworks, and storage-facility standards.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-2001-1: *Explain* hydrogen properties, production methods, and classification schemes.
MESE-2001-2: *Analyze* electrochemical and thermochemical hydrogen generation processes.
MESE-2001-3: *Evaluate* hydrogen storage, transport, and distribution technologies.
MESE-2001-4: *Assess* fuel cell systems, performance characteristics, and operational behaviour.
MESE-2001-5: *Interpret* safety standards, techno-economic factors, and emerging applications in hydrogen systems.

Reference Books:

1. Sørensen, B. (2012). *Hydrogen and Fuel Cells: Emerging Technologies and Applications* (2nd ed.). Academic Press.
2. Gupta, R. B. (2008). *Hydrogen Fuel: Production, Transport, and Storage*. CRC Press.

Further Readings:

1. IEA. (2023). *Global Hydrogen Review*. International Energy Agency.
2. NREL. *Hydrogen Energy Reports*. National Renewable Energy Laboratory.
3. Ohta, T. (1979). *Solar-Hydrogen Energy Systems: Science and Technology for the Hydrogen Economy*. Pergamon Press.

Name of the Course	**Energy Management and Audit**		
Course Code	**MESE-2002**	**Credits-4**	**L-3, T-1, P-0**
Total Lectures	**52 (1 Hour Each) (L=39, T=13 for each semester)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive course covering energy management principles, audit methodologies, system efficiency assessment, and conservation opportunities in industrial, commercial, and utility sectors. The course focuses on energy monitoring, instrumentation, financial evaluation, and formulation of energy-efficient strategies aligned with national policies and standards.

Course Objectives:

- To introduce key concepts of energy management, auditing, and conservation
- To develop technical competence in energy data analysis, instrumentation, and performance assessment.
- To enable students to identify, evaluate, and recommend energy-efficiency measures and operational improvements.

Units	**Course Content**
Unit 1	Energy scenario and consumption patterns, forms of energy, Energy Conservation Act and policies, energy management principles, accounting, benchmarking, intensity indicators, cost of energy, and material–energy balance. Energy manager responsibilities, monitoring and targeting, audit planning, performance contracts, load and demand-side management, power factor control, and energy management system practices.
Unit 2	Audit types and methodologies, preliminary and detailed procedures, data collection and measurement planning, process flow analysis, identification of loss areas, and selection and accuracy of measuring instruments. Use of power analyzers, data loggers, combustion analysis tools, flow and temperature measurement, and integration of diagnostic instruments into audit execution and reporting.
Unit 3	Electrical systems including motors, VSDs, pumps, fans, compressors, lighting, power factors, harmonics and load analysis, along with electrical efficiency measures, building energy audits, and metering practices. Thermal systems covering boilers, furnaces, steam systems, insulation and refractory evaluation, waste heat recovery, heat exchangers, HVAC and refrigeration performance assessment, and improvement strategies with measurement tools.
Unit 4	Energy conservation opportunities, operational control, maintenance for efficiency, utility optimization, renewable-energy interventions, financial analysis including payback, NPV, IRR, LCC, and audit-based decision frameworks.

	Energy standards and codes, ISO 50001 and implementation barriers, sector-specific case studies (steel, cement, pulp and paper, textiles, fertilizer, commercial buildings), and national policy alignment with emerging best practices.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-2002-1: *Explain* principles of energy management, audit processes, and energy accounting.
MESE-2002-2: *Analyze* energy use patterns, performance indicators, and efficiency metrics in various systems.
MESE-2002-3: *Apply* audit methods and measurement techniques to identify losses and conservation opportunities.
MESE-2002-4: *Evaluate* techno-economic feasibility of energy-efficiency interventions and conservation strategies.
MESE-2002-5: *Assess* standards, policies, and best practices guiding energy management and sustainable operation.

Reference Books:

1. Bureau of Energy Efficiency (BEE). (2015). *Energy Manager & Energy Auditor Guidebooks* (Vols. I–IV). Ministry of Power, Government of India.
2. Turner, W. C. (2006). *Energy Management Handbook* (6th ed.). The Fairmont Press.

Further Readings:

1. IEA. (2023). *Energy Efficiency Reports*. International Energy Agency.
2. Capehart, B. L., Turner, W. C., & Kennedy, W. J. (2020). *Guide to Energy Management* (9th ed.). CRC Press.
3. ASHRAE. (2019). *ASHRAE Handbook – HVAC Applications: Energy Efficiency and Applied Systems*. American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Name of the Course	**Energy Economics, Markets and Policies**		
Course Code	**MESE-2003**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive study of economic principles, policy frameworks, market mechanisms, pricing structures, and regulatory instruments governing energy systems, with emphasis on renewable integration, financial evaluation, and global–national energy policies.

Course Objectives:

- To introduce core concepts of energy economics and financial evaluation.
- To explain structures of energy markets, pricing, and regulatory mechanisms.
- To enable students to analyze policies, market operations, and regulatory impacts on the energy sector.

Units	**Course Content**
Unit 1	Energy demand–supply frameworks, resource classification, consumption and sectoral use patterns, economic principles, price elasticity, cost curves, and structures of competitive, regulated, and hybrid energy systems. Cost components and economic effects of renewable integration, forecasting in power economics, local and aggregated system impacts, weather-driven wind/PV ramps, and investment and financing considerations.
Unit 2	Market structures and RE integration challenges, organization of pool-based markets, short- and long-term impacts of renewables, planning requirements, flexibility resources, capacity and intraday mechanisms, and price discovery models. Feed-in tariffs and competitive bidding, ancillary and balancing markets with multi-level cost allocation, energy trading platforms, peer-to-peer and local transactions, and redesign of network charging frameworks.
Unit 3	Energy policy instruments and national frameworks including taxes, subsidies, FITs, RPOs, carbon pricing, Electricity Act provisions, energy security, integrated planning, and institutional roles of MNRE, CERC, BEE, and national missions. International agreements (UNFCCC, Kyoto, Paris, NDCs), global renewable and carbon market mechanisms, energy governance bodies, geopolitical influences, and dynamics of global oil and gas markets.
Unit 4	Financial evaluation methods include NPV, IRR, cost-benefit analysis, LCOE, risk and uncertainty assessment, policy evaluation approaches, and comparative case studies across major global regions. Low-carbon transition pathways, diversification strategies, economic modelling of transitions, green hydrogen economy, environmental economics, and trends in global

	markets, regulations, and emerging renewable sectors.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-2003-1: *Explain* fundamental concepts of energy economics and market structures.
MESE-2003-2: *Analyze* pricing mechanisms, tariff structures, and cost components in energy systems.
MESE-2003-3: *Evaluate* regulatory frameworks, policy instruments, and market operations.
MESE-2003-4: *Assess* economic feasibility and financial performance of energy projects.
MESE-2003-5: *Interpret* national and global energy policies, market reforms, and regulatory trends.

Reference Books:

1. Bhattacharyya, S. C. (2011). *Energy Economics: Concepts, Issues, Markets and Governance*. Springer.
2. Smil, V. (2017). *Energy and Civilization: A History*. MIT Press.

Further Readings:

1. IEA. (2023). *World Energy Outlook*. International Energy Agency.
2. Sterling, A., & Platchkov, L. (2011). *Energy Market Reform: Lessons for Policymakers*. International Energy Agency.
3. UN, IRENA, & World Bank. *Global Energy Policy Reports*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Design & Innovation Laboratory-II</td></tr>
<tr><td>Course Code</td><td>MESE-2004</td><td>Credits-3</td><td>L-0, T-0, P-3</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
Energy Laboratory–II provides advanced practical training in energy auditing, thermal–electrical system diagnostics, renewable-energy performance evaluation, and instrument-based data acquisition. The laboratory emphasizes real-time measurement methods, efficiency assessment, loss analysis, and applied interpretation of operational data. Students develop competencies in audit instrumentation, system evaluation techniques, and preparation of professional technical reports based on field-relevant datasets.</td></tr>
<tr><td colspan="4">Course Objectives:
• Provide practical exposure to advanced measurement techniques for energy auditing and system diagnostics.
• Enable students to assess performance of electrical, thermal, and renewable-energy systems using field-relevant instruments.
• Build the ability to process, analyze, and report data with professional accuracy and technical clarity.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">• Performance evaluation of boilers or steam systems (if available)
• Heat exchanger effectiveness measurement
• Refrigeration and HVAC system performance analysis (COP, EER)
• Thermal insulation assessment and heat-loss measurement
• Flue gas analysis for combustion efficiency</td></tr>
<tr><td>Unit 2</td><td colspan="3">• Performance evaluation of boilers or steam systems (if available)
• Heat exchanger effectiveness measurement
• Refrigeration and HVAC system performance analysis (COP, EER)
• Thermal insulation assessment and heat-loss measurement
• Flue gas analysis for combustion efficiency</td></tr>
<tr><td>Unit 3</td><td colspan="3">• Performance assessment of a grid-tied or standalone PV system
• Inverter efficiency testing and MPPT behaviour analysis
• Data logging and monitoring of small wind/solar hybrid systems
• Energy-output comparison under varying environmental conditions
• Storage system performance: charge/discharge cycle evaluation</td></tr>
<tr><td>Unit 4</td><td colspan="3">• Conduct of a mock energy audit for an assigned laboratory area
• Data acquisition using portable audit instruments</td></tr>
</table>

	• Spreadsheet-based data analysis and loss estimation • Preparation of a complete audit report with recommendations • Critical review and presentation of findings

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-2004-1: *Identify* advanced audit instruments, diagnostic tools, and measurement procedures used in energy systems.
MESE-2004-2: *Explain* operational characteristics and performance indicators of thermal, electrical, and hybrid energy systems.
MESE-2004-3: *Apply* field-level audit techniques to measure system parameters and collect performance data.
MESE-2004-4: *Analyze* losses, efficiency trends, and operational deviations using measured datasets.
MESE-2004-5: *Evaluate* system performance and prepare detailed technical reports with corrective recommendations.

Reference Books:

1. ASHRAE. (2019). *ASHRAE Handbook – HVAC Applications* (Relevant Measurement and Performance Sections). American Society of Heating, Refrigerating and Air-Conditioning Engineers.
2. IEEE. *Recommended Practices for Electrical Measurements and Testing*. Institute of Electrical and Electronics Engineers.

Further Readings:

1. Bureau of Energy Efficiency (BEE). (2015). Energy Manager & Energy Auditor Manuals (Vols. I–IV). Ministry of Power, Government of India.
2. Capehart, B. L., Turner, W. C., & Kennedy, W. J. (2020). Guide to Energy Management (9th ed.). CRC Press.
3. Thumann, A., & Younger, W. J. (2010). *Handbook of Energy Audits* (8th ed.). CRC Press.

ELECTIVES

<table>
<tr><td>Name of the Course</td><td colspan="3">Hydro Energy Systems</td></tr>
<tr><td>Course Code</td><td>MESE-E001</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of hydropower resources, hydraulic principles, turbine technologies, and hydro-mechanical systems used for electricity generation. The course covers site assessment, flow measurement, turbine selection, system design, small-hydro development, environmental considerations, and modern trends in hydro energy conversion and grid integration.</td></tr>
<tr><td colspan="4">Course Objectives:
To introduce hydropower resources, assessment methods, and hydraulic fundamentals.
To analyze turbine performance, hydro-mechanical systems, and design considerations.
To evaluate hydropower project planning, environmental impacts, and integration issues.</td></tr>
</table>

Units	Course Content
Unit 1	Hydropower fundamentals including water cycle, global and Indian status, plant classification, advantages and limitations, hydro potential and small/mini/micro projects, major plants, operational terminology and legal requirements, Reservoir management and challenges, Pumped Storage Hydropower (PSH), Principles of operation and energy storage, Applications, benefits, and limitations of PSH, Energy consumption context, exploitation trends, and policy–regulatory considerations shaping development and deployment.
Unit 2	Turbine types such as Pelton, Francis, Kaplan, Bulb and impulse vs reaction machines, performance parameters and efficiency curves, site selection, fluid-mechanics basics, and single or multi-reservoir and cascaded plant configurations. Structural components including dams, spillways, surge chambers, stilling basins, penstocks, spiral casings, pressure pipes, caverns, tailraces and auxiliary systems with location and design principles.
Unit 3	Hydro-electrical equipment including AC generators, sizing and specification of single and three-phase units, power-factor correction, excitation systems, electromechanical and digital governors, electronic load controllers, relays, contactors and control schemes. SCADA and integrated control, switchyard equipment, transformers, circuit breakers, busbars, protection schemes for generators and transformers, and auxiliary and grounding system design for hydro stations.
Unit 4	Classification and working principles of impulse and reaction turbines, design concepts, pump-as-turbine and non-conventional machines, characteristic curves, geometric similarity, hill diagrams and governing systems including mechanical and electronic controls.

	Environmental and social impacts, reservoir sedimentation, fish passages, regulatory approval processes, selection of turbines, gates and valves, model and performance testing, cavitation and silt erosion effects, and erection, commissioning, operation and maintenance practices.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E001-1: *Explain* hydropower resources, hydraulic fundamentals, and system components.
MESE-E001-2: *Analyze* flow characteristics, turbine performance, and selection criteria.
MESE-E001-3: *Evaluate* hydropower system design, efficiency, and operational parameters.
MESE-E001-4: *Assess* small-hydro development, site assessment, and techno-economic factors.
MESE-E001-5: *Interpret* environmental, regulatory, and grid-integration aspects of hydro systems.

Reference Books:

1. Varma, H. L. (2011). *Hydropower Engineering*.
2. Mosonyi, E. (1991). *Waterpower Development: Low-Head Hydropower*. Akademiai Kiado.

Further Readings:

1. Paish, O. (2002). *Small Hydropower Resources and Technologies*.
2. International Energy Agency (IEA). *Hydropower Technology Reports*.
3. United States Bureau of Reclamation (USBR). *Hydraulic Turbines and System Design Manuals*.

Name of the Course	Wind Energy Engineering		
Course Code	MESE-E002	Credits-3	L-3, T-0, P-0
Total Lectures	39 (1 Hour Each)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A technical study of wind resources, turbine aerodynamics, mechanical and electrical subsystems, performance evaluation, and integration of wind energy into power networks. The course covers site assessment, power curve analysis, control strategies, reliability considerations, and recent advances in wind technology.

Course Objectives:

- To introduce wind resource characteristics and assessment techniques.
- To analyze aerodynamics, turbine components, and system performance.
- To evaluate integration, control, and technological developments in wind systems.

Units	Course Content
Unit 1	Wind energy fundamentals, types of converters, advantages and limitations, evolution of modern systems, wind characteristics and atmospheric boundary layer effects, local terrain influences and micro-sitting considerations. Site selection using roughness length, wind shear and speed variability, Weibull and Rayleigh distributions, wind-resource estimation, and measurement and instrumentation for resource assessment.
Unit 2	Small, micro and hybrid wind turbines, sitting in complex and offshore environments, operational challenges, one-dimensional momentum theory, Betz limit, wake rotation, blade-element theory and aerodynamic performance factors. Airfoil behavior, lift and drag, turbine performance coefficients, rotor and nacelle design, gearbox and generator systems, and power-curve interpretation for performance evaluation.
Unit 3	Mechanical dynamics, electrical systems, power-electronics interfaces, load analysis, condition monitoring and component selection including blades, gearboxes, generators, towers and auxiliary systems. Wind-farm design and topologies, simulation and testing standards, design loads, safety and component testing, SCADA and control strategies, reliability assessment, failure modes and maintenance planning.
Unit 4	Wind-farm layout design, terrain effects, wake losses, energy-yield estimation and cost–performance evaluation, operational control including pitch, stall, yaw, grid connectivity and reactive-power management. Environmental and social impacts such as noise, visual and electromagnetic effects, forecasting and hybrid renewable integration, emerging wind technologies and

	requirements for grid-connected operation.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E002-1: *Explain* wind resource characteristics, assessment methods, and turbine aerodynamics.

MESE-E002-2: *Analyze* turbine components, power curves, and performance behavior.

MESE-E002-3: *Evaluate* mechanical, electrical, and control subsystems of wind turbines.

MESE-E002-4: *Assess* wind farm planning, layout design, and grid-integration aspects.

MESE-E002-5: *Interpret* reliability, maintenance strategies, and emerging wind-energy technologies.

Reference Books:

1. Hau, E. (2013). *Wind Turbines: Fundamentals, Technologies, Application, Economics* (3rd ed.). Springer.
2. Manwell, J. F., McGowan, J. G., & Rogers, A. L. (2009). *Wind Energy Explained: Theory, Design and Application* (2nd ed.). Wiley.

Further Readings:

1. International Energy Agency (IEA). *IEA Wind Annual Reports*.
2. Burton, T., Jenkins, N., Sharpe, D., & Bossanyi, E. (2011). *Wind Energy Handbook* (2nd ed.). Wiley.

<table>
<tr><td>Name of the Course</td><td colspan="3">Electric Vehicle Technology</td></tr>
<tr><td>Course Code</td><td>MESE-E003</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
</table>

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive study of electric vehicle (EV) architectures, energy storage systems, electric drives, power electronics, charging infrastructure, and control strategies. The course covers modelling, performance analysis, safety considerations, and technological developments shaping modern electric mobility.

Course Objectives:

- To introduce EV configurations, propulsion systems, and energy storage fundamentals.
- To analyze EV power electronics, drives, and charging technologies.
- To evaluate EV performance, safety, control, and technological trends.

Units	Course Content
Unit 1	Evolution and architecture of electric vehicles, component overview, layouts and classification, comparison with internal-combustion systems, advantages and limitations, and vehicle-resistance forces including rolling, grading and aerodynamic drag. Performance calculations covering acceleration, maximum speed, tractive-effort and wheel-torque requirements, transmission elements such as differential, clutch and gearbox, braking performance and thermal considerations in EV operation.
Unit 2	Battery technologies including Li-ion, NiMH and solid-state systems, battery modelling, SOC–SOH estimation, BMS functions, and power-electronic interfaces including DC-DC converters, inverters, motor controllers and protection circuits. Hybrid-electric vehicle history, components and layouts, comparison with EVs, advantages and disadvantages, and charging-side interfaces supporting propulsion and energy management.
Unit 3	Electric machines including induction, PMSM, BLDC and DC motors, torque–speed characteristics, efficiency mapping, comparison across motor types, and four-quadrant power-converter operation with driver circuits and AC/DC conversion. Charging architectures and levels, onboard and offboard chargers, fast and wireless charging, grid-to-vehicle and vehicle-to-grid concepts, along with powertrain and hybrid-architecture sizing for EV and HEV systems.
Unit 4	Vehicle control and energy-optimization strategies, thermal management, fault diagnosis, reliability and system-level supervision for propulsion and safety-critical operation. EV standards and safety codes, crash and fire protection, metering and protection requirements, and emerging technologies shaping future mobility and electrified transport.

Course Outcomes (COs):

At the end of the course students will be able to:
MESE-E003-1: *Explain* EV architecture, components, and propulsion principles.
MESE-E003-2: *Analyze* battery systems, electric drives, and power electronics used in EVs.
MESE-E003-3: *Evaluate* EV charging methods, infrastructure requirements, and grid interaction.
MESE-E003-4: *Assess* EV performance parameters, control strategies, and operational characteristics.
MESE-E003-5: *Interpret* safety protocols, standards, and emerging EV technologies.

Reference Books:

1. Larminie, J., & Lowry, J. (2012). *Electric Vehicle Technology Explained* (2nd ed.). Wiley.
2. Husain, I. (2010). *Electric and Hybrid Vehicles: Design Fundamentals* (2nd ed.). CRC Press**.**

Further Readings:

1. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. (2018). *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles* (3rd ed.). CRC Press.
2. International Energy Agency (IEA). *Global EV Outlook*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Bio Energy Engineering</td></tr>
<tr><td>Course Code</td><td>MESE-E004</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A study of biomass resources, conversion pathways, biogas and biofuel technologies, biochemical and thermochemical processes, and system design considerations. The course examines feedstock characteristics, reactor operation, energy yields, environmental impacts, and emerging developments in modern bioenergy systems.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce biomass resources, feedstock properties, and bioenergy fundamentals.
• To analyze biochemical and thermochemical conversion technologies.
• To evaluate bioenergy systems, performance factors, and sustainability considerations.</td></tr>
</table>

Units	**Course Content**
Unit 1	Biomass types and availability, feedstock properties and lignocellulosic composition, production and supply-chain considerations, physical and chemical characteristics, energy plantations and environmental–food security implications. Proximate and ultimate analysis including moisture, calorific value and ash content, along with biomass assessment and resource-evaluation methods.
Unit 2	Combustion pathways including direct combustion, cofiring and incineration, gasification principles, gasifier types and design parameters, syngas quality, pyrolysis modes, reactor configurations and bio-oil and char production. Torrefaction, biomass boilers, waste-to-energy thermal routes, IGCC configurations, process modelling and performance evaluation across thermal conversion systems.
Unit 3	Anaerobic digestion fundamentals, reactor types, kinetics, biogas purification and upgrading, ethanol via fermentation, pre-treatment approaches and enzymatic hydrolysis processes. Biodiesel production and transesterification, catalysts, biorefineries, algal biofuels, hydrogen production pathways and quality standards for liquid and gaseous biofuels.
Unit 4	Biogas upgrading and CHP applications, sizing of bioenergy systems, hybrid biomass configurations, environmental impacts, lifecycle assessment, GHG-mitigation potential and regulatory frameworks. Economic feasibility, costing and financing, and applications in rural energy, industrial boilers and transportation fuels, along with innovations in next-generation biofuels.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E004-1: *Explain* biomass resources, feedstock characteristics, and bioenergy fundamentals.

MESE-E004-2: *Analyze* biochemical processes including anaerobic digestion and fermentation.
MESE-E004-3: *Evaluate* thermochemical methods such as gasification, pyrolysis, and combustion.
MESE-E004-4: *Assess* design parameters, operating factors, and performance indicators of bioenergy systems.
MESE-E004-5: *Interpret* sustainability, environmental impacts, and advancements in bioenergy technologies.

Reference Books:

1. Bhattacharya, S. C. (2013). *Biomass Energy in Developing Countries*. Taylor & Francis.
2. Demirbas, A. (2009). *Bioenergy: Global Change, Health, and the Environment*. Springer.

Further Readings:

1. Sridhar, K. (2011). *Biomass Conversion Technologies*.
2. Drapcho, C. M., Nhuan, N. P., & Walker, T. H. (2008). *Biofuels Engineering Process Technology*. McGraw-Hill.

Name of the Course	**Smart and Micro Grid Systems**		
Course Code	**MESE-E005**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A detailed study of smart grid architecture, communication technologies, control strategies, micro grid design, and renewable-energy integration. The course covers sensing, automation, protection, energy management, power electronics interfaces, and emerging cyber-physical advancements essential for modern grid modernization.

Course Objectives:
- To introduce smart grid concepts, components, and communication technologies.
- To analyse micro grid structures, control strategies, and renewable integration.
- To evaluate system performance, protection, stability, and emerging smart-grid technologies.

Units	**Course Content**
Unit 1	Indian smart-grid policy, definition and evolution of electrical grids, functional requirements, layered and reference architectures, characteristics such as flexibility, reliability and demand response, and enabling technologies for modernization. Smart-grid technologies, DER and microgrid integration, demand-side management, smart appliances, performance parameters, advantages and challenges of deployment in current power systems.
Unit 2	Microgrid concepts and classifications (AC, DC, hybrid), sources, structure and configuration, autonomous and grid-connected operation, sizing methods, multi-DG integration, power-electronics interfaces and communication infrastructure. Smart-metering and data acquisition including AMI, PMU technologies, energy monitoring, data management, and implementation trends in Indian and international contexts.
Unit 3	Renewable-integration challenges, grid codes, automated substations, feeder automation, FLISR, state estimation, outage management, voltage and frequency regulation and economic dispatch strategies. Power-quality issues (harmonics, flicker, sag/swell), distributed protection schemes, cybersecurity considerations, demand-side management and FACTS concepts including reactive-power compensation and series/shunt control approaches.
Unit 4	Power-injection principles, active/reactive power control, integration of multiple renewable sources through AC, DC and HFAC links, islanding and interconnection, forecasting, storage integration, V2G and B2G, LVDC and hybrid energy systems. Smart-grid protection strategies, regulatory policies and standards, techno-economic evaluation, emerging technologies, IoT, AI and ML applications, electric-vehicle

	integration and future smart-grid developments.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E005-1: *Explain* smart grid concepts, architecture, and key enabling technologies.

MESE-E005-2: *Analyze* microgrid configurations, control layers, and operational strategies.

MESE-E005-3: *Evaluate* renewable-energy integration, power electronics interfaces, and load-management techniques.

MESE-E005-4: *Assess* protection schemes, reliability, stability, and power-quality issues in smart and microgrid systems.

MESE-E005-5: *Interpret* emerging trends in automation, communication, and cyber-physical aspects of smart grids.

Reference Books:

1. Momoh, J. A. (2012). *Smart Grid: Fundamentals of Design and Analysis*. Wiley-IEEE Press.
2. Chowdhury, S., Chowdhury, S. P., & Crossley, P. (2009). *Microgrids and Active Distribution Networks*. The Institution of Engineering and Technology (IET).

Further Readings:

1. Lasseter, R. H. *Microgrid Concepts and Applications*.
2. International Energy Agency (IEA). *Reports on Grid Modernization*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Advanced Solar Photovoltaic Systems</td></tr>
<tr><td>Course Code</td><td>MESE-E006</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
</table>

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
An advanced study of photovoltaic (PV) materials, device physics, module technologies, PV system design, power electronics, performance evaluation, and emerging innovations. The course covers modelling, characterization, degradation mechanisms, and integration of PV systems into modern power networks.

Course Objectives:

- To explain advanced PV materials, device structures, and conversion mechanisms.
- To analyze PV module technologies, characterization techniques, and performance behaviour.
- To evaluate system design, power electronics, integration, and emerging PV technologies.

Units	Course Content
Unit 1	Semiconductor materials and device physics include band-gap engineering, carrier transport, recombination, quantum efficiency, thin-film (CdTe, CIGS), high-efficiency silicon (PERC, bifacial, HJT, TOPCon), perovskite and organic PV, tandem and multijunction architectures, concentrator PV and optical enhancement. Light-management and encapsulation materials, characterization instruments, certification standards, advanced cell modelling and recycling of commercial PV panels with reliability and sustainability considerations.
Unit 2	Module technologies and fabrication, encapsulation, interconnection methods, bypass and blocking diodes, shading and mismatch effects, ageing and thermal derating, IV curve measurement, flash testing under STC/NOCT and degradation mechanisms with reliability testing and standards. Inverters and power-electronics including MPPT techniques, grid-tied and micro-inverters, power conditioning, DC/AC protection, thermal management and module-level performance and safety.
Unit 3	PV array sizing, tilt and orientation, shading analysis, system layout, loss estimation, IV modelling, array configuration and anti-islanding compliance with power-quality considerations such as harmonics and voltage fluctuations. Performance-ratio analysis, monitoring and fault detection, hybrid PV–storage systems, optimization under variable load and climate, MPPT algorithms, DC-DC converters, grid-code adherence and system-level diagnostics.
Unit 4	Distributed and grid-interactive PV integration, smart inverters, forecasting and variability management, hybrid configurations, BIPV, floating and Agro-PV deployment and solar-resource modelling for operational planning.

	IEC standards for modules and inverters, degradation pathways including LID and LeTID, lifecycle assessment, techno-economic evaluation and next-generation developments shaping future PV deployment.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E006-1: *Explain* advanced PV materials, device physics, and conversion mechanisms.
MESE-E006-2: *Analyze* PV module technologies, I–V characteristics, and degradation behavior.
MESE-E006-3: *Evaluate* PV system design parameters, power electronics interfaces, and operational performance.
MESE-E006-4: *Assess* grid integration, system monitoring, and reliability considerations.
MESE-E006-5: *Interpret* emerging trends, advanced PV concepts, and innovative applications.

Reference Books:
1. Solanki, C. S. (2015). *Solar Photovoltaics: Fundamentals, Technologies and Applications* (3rd ed.). PHI Learning.
2. Green, M. A. (2005). *Third Generation Photovoltaics*. Springer.

Further Readings:
1. International Energy Agency (IEA). *Photovoltaic Power Systems (PVPS) Reports*.
2. Luque, A., & Hegedus, S. (Eds.). (2011). *Handbook of Photovoltaic Science and Engineering* (2nd ed.). Wiley.
3. National Renewable Energy Laboratory (NREL). *PV Research Publications*.

Name of the Course	Sustainable Buildings Systems		
Course Code	MESE-E007	Credits-3	L-3, T-0, P-0
Total Lectures	39 (1 Hour Each)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A study of sustainable building design principles, energy-efficient systems, building materials, thermal comfort, and performance assessment. The course covers passive and active building strategies, HVAC efficiency, lighting design, green-rating frameworks, and integration of renewable energy in buildings.

Course Objectives:
1. To introduce sustainable building principles, materials, and performance concepts.
2. To analyze building energy use, HVAC systems, lighting, and passive design strategies.
3. To evaluate green-building rating systems, renewable-energy integration, and sustainability metrics.

Units	Course Content
Unit 1	Sustainable design concepts, building energy flows, heat transfer mechanisms (conduction, convection, radiation), thermal mass, infiltration and ventilation, climate analysis, psychrometry and factors influencing building energy demand. Thermal-comfort metrics (PMV, PPD), material properties, low-impact and green-material selection, embodied-energy considerations, insulation and moisture control, and building-envelope performance.
Unit 2	Passive-design strategies include orientation, shading, glazing, walls and roofs, insulation materials, solar-heat-gain control, daylighting methods and climate-responsive design for reduced operational loads. Envelope-performance indices (U-value, SHGC), ventilation and indoor-environment strategies, moisture control and core principles of green-building approaches.
Unit 3	HVAC system components and types, load-calculation basics, efficiency indicators, ventilation systems, heat-recovery units and indoor-air-quality considerations. Lighting-design principles, efficient technologies (LED and controls), daylight integration, electrical-system efficiency and building energy-use profiles.
Unit 4	Green-rating frameworks (LEED, GRIHA, IGBC), certification metrics, benchmarking and compliance with ECBC, ASHRAE and ISO standards, along with energy-modelling and audit applications. Building-integrated renewables (solar thermal and PV), energy-management systems, retrofitting strategies, smart-building technologies, cost–benefit evaluation and case studies of high-performance buildings.

Course Outcomes (COs):

At the end of the course students will be able to:
MESE-E007-1: *Explain* principles of sustainable building design, materials, and performance factors.
MESE-E007-2: *Analyze* thermal comfort parameters, passive design strategies, and building envelope behaviour.
MESE-E007-3: *Evaluate* HVAC efficiency, lighting systems, and energy-use patterns in buildings.
MESE-E007-4: *Assess* green-building frameworks, certification criteria, and sustainability indicators.
MESE-E007-5: *Interpret* renewable-energy integration options and emerging sustainable building technologies.

Reference Books:

1. Kwok, A. G., & Grondzik, W. T. (2018). *Environmental Control Systems: Heating, Cooling, Lighting* (3rd ed.). Wiley.
2. Mazria, E. (1979). *The Passive Solar Energy Book*. Rodale Press.

Further Readings:

1. Santamouris, M. (2001). *Energy and Climate in the Urban Built Environment*. Routledge.
2. ASHRAE. *Energy-Efficient Building Standards*. American Society of Heating, Refrigerating and Air-Conditioning Engineers.

<table>
<tr><td>Name of the Course</td><td colspan="3">Solar Passive Heating and Cooling</td></tr>
<tr><td>Course Code</td><td>MESE-E008</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A focused study of passive solar heating and cooling strategies for buildings, emphasizing thermal comfort, climate-responsive design, heat-transfer mechanisms, and architectural integration. The course explores passive system configurations, simulation principles, material selection, and performance evaluation for energy-efficient built environments.</td></tr>
<tr><td colspan="4">Course Objectives:
1. To introduce passive solar design principles and climate-responsive building strategies.
2. To analyze passive heating, passive cooling, and thermal storage techniques.
3. To evaluate performance, material choices, and simulations for passive building systems.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">Climate-responsive design, solar geometry and sun-path interpretation, climatic zones, building orientation and site planning, thermal comfort indices and psychometrics, and building–climate interaction.
Passive-design criteria, envelope functions and solar heat-gain characteristics, heat-transfer principles, material and design constraints, and integration of natural elements.</td></tr>
<tr><td>Unit 2</td><td colspan="3">Direct, indirect and isolated-gain systems including Trombe walls, sunspaces and attached greenhouses, solar chimneys, glazing options and thermal-mass integration with material selection.
Thermal-storage and insulation strategies, heat-retention methods, seasonal-performance considerations, and design calculations for passive-solar heating systems.</td></tr>
<tr><td>Unit 3</td><td colspan="3">Natural-ventilation approaches include cross and stack effects, wind-assisted and night cooling, wind towers and earth-air heat exchangers for passive air movement.
Shading devices, courtyard design, cool roofs, evaporative and radiative cooling, airflow modelling and performance factors for cooling-dominant climates.</td></tr>
<tr><td>Unit 4</td><td colspan="3">Daylighting principles, fenestration design, daylight factor and glare control, energy-efficient lighting integration and simulation-tool applications.
Building envelope interactions, performance measurement, economic and environmental evaluation, and documented case studies of passive-building performance.</td></tr>
<tr><td colspan="4">Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E008-1: Explain passive solar design principles, heat-transfer mechanisms, and climate considerations.
MESE-E008-2: Analyze passive heating techniques, thermal storage methods, and envelope design.</td></tr>
</table>

MESE-E008-3: *Evaluate* passive cooling strategies, ventilation approaches, and shading systems.
MESE-E008-4: *Assess* performance indicators, simulation-based analysis, and energy-saving potential of passive systems.
MESE-E008-5: *Interpret* material choices, architectural applications, and emerging trends in passive building design.

Reference Books:

1. Mazria, E. (1979). *The Passive Solar Energy Book*. Rodale Press.
2. Givoni, B. (1998). *Man, Climate and Architecture* (2nd ed.). Elsevier.
3. Santamouris, M. (Ed.). (2007). *Passive Cooling of Buildings*. Routledge.

Further Readings:

1. Indian Plumbing Code (IPC) & Bureau of Energy Efficiency (BEE). *Manuals on Thermal Comfort*.
2. ASHRAE. *Thermal Environmental Standards*. American Society of Heating, Refrigerating and Air-Conditioning Engineers.

<table>
<tr><td>Name of the Course</td><td colspan="3">Biofuels</td></tr>
<tr><td>Course Code</td><td>MESE-E009</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of biofuel resources, production pathways, conversion technologies, and fuel properties. The course examines biodiesel, bioethanol, biogas, advanced biofuels, and algal fuels, along with process design considerations, environmental impacts, and sustainability aspects in modern biofuel systems.</td></tr>
<tr><td colspan="4">Course Objectives:
1. To introduce biofuel resources, production fundamentals, and fuel-quality parameters.
2. To analyze biochemical and thermochemical conversion pathways for liquid and gaseous biofuels.
3. To evaluate performance, environmental impacts, and future prospects of advanced biofuels.</td></tr>
</table>

Units	Course Content
Unit 1	Feedstock categories including oil-bearing crops, sugar and starch materials, lignocellulosic and algal resources, biomass composition, physicochemical properties and logistics, sustainability and availability assessments. Fuel properties such as calorific value, viscosity and combustion behavior, biofuel classifications, resource-potential evaluation and pretreatment relevance for downstream conversion pathways.
Unit 2	Biodiesel production via transesterification with catalysts and kinetics, by-product utilization, bioethanol fermentation with pretreatment, enzymatic hydrolysis, distillation and lignocellulosic ethanol fundamentals. Thermochemical routes including fast/slow/catalytic pyrolysis, hydrothermal liquefaction, torrefaction, gasification and syngas cleaning, Fischer–Tropsch synthesis, reactor types, design factors, process efficiency and product distribution.
Unit 3	Anaerobic digestion and biogas production, digester types, operating conditions, upgrading and biomethane applications, microbial pathways and bioreactors, and cross-linked ethanol and biodiesel processes. Advanced fuels including algal biofuels, biobutanol, bio-oil upgrading, Fischer–Tropsch fuels and hydrogen from biomass, along with emerging next-generation conversion pathways.
Unit 4	Lifecycle-assessment fundamentals, carbon footprint, environmental impacts, energy balance, water-energy considerations, waste valorization and hybrid process integration. Biofuel quality standards, policy and blending mandates, techno-economic evaluation, case studies and future trends in advanced and commercial biofuel technologies.

Course Outcomes (COs): At the end of the course students will be able to: **MESE-E009-1:** *Explain* biofuel resources, feedstock characteristics, and fuel properties. **MESE-E009-2:** *Analyze* production pathways for biodiesel, bioethanol, and biogas. **MESE-E009-3:** *Evaluate* process parameters, reaction mechanisms, and energy yields in biofuel systems. **MESE-E009-4:** *Assess* environmental impacts, sustainability indicators, and lifecycle considerations of biofuels. **MESE-E009-5:** *Interpret* emerging trends, advanced biofuel technologies, and policy frameworks.
Reference Books: 1. Demirbas, A. (2009). *Biofuels: Securing the Planet's Future Energy Needs*. Springer. 2. Wyman, C. E. (1996). *Handbook on Bioethanol: Production and Utilization*. CRC Press. **Further Readings:** 1. Bozell, J. J., & Petersen, G. R. (2010). *Biomass Conversion Pathways*. 2. Griffiths, M. J. (Ed.). (2013). *Algal Biofuels Handbook*. CRC Press.

<table>
<tr><td>Name of the Course</td><td colspan="3">Modelling and Optimization of Energy Systems</td></tr>
<tr><td>Course Code</td><td>MESE-E010</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A detailed study of mathematical modelling techniques, simulation tools, and optimization methods applied to energy systems. The course covers system representation, performance modelling, numerical methods, optimization algorithms, and decision-making strategies for efficient energy planning and operation.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce modelling principles, mathematical foundations, and system representation techniques for energy systems.
• To analyze simulation approaches, numerical methods, and computational tools used in energy modelling.
• To evaluate optimization methods for design, planning, and operational improvement of energy systems.</td></tr>
</table>

Units	Course Content
Unit 1	System representation and mathematical-modelling concepts, model classification (deterministic and stochastic), input–output relationships, assumptions, data requirements, curve-fitting and regression, and solution approaches for algebraic and differential systems. Model development steps including boundary definition, calibration and validation, simplifications, accuracy and performance metrics, and introductory sensitivity-analysis principles.
Unit 2	Steady-state and dynamic modelling, numerical and iterative methods with convergence and error analysis, simulation workflows, time-series handling, scenario modelling and case-study applications using computational tools. Static and dynamic energy-system examples, modelling errors and validation techniques, and software-based implementation across standard energy-modelling platforms.
Unit 3	Linear and nonlinear programming, mixed-integer and constrained optimization, formulation of objective functions, feasibility analysis and input-output–based econometric modelling for energy budgeting. Metaheuristic approaches including genetic algorithms, particle-swarm and multi-objective optimization, along with sensitivity-analysis methods and solution-evaluation criteria.
Unit 4	Renewable-energy system optimization, storage sizing and load-management strategies,

	integrated resource planning, risk and uncertainty modelling and policy-driven optimization frameworks. Cost–benefit and techno-economic evaluation, practical optimization case studies, linear-programming applications to energy systems and emerging trends in modelling and decision support.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E010-1: *Explain* modelling principles, system representation methods, and mathematical foundations.

MESE-E010-2: *Analyze* simulation approaches, numerical techniques, and computational tools for energy systems.

MESE-E010-3: *Evaluate* optimization methods, constraints, and performance metrics in energy applications.

MESE-E010-4: *Assess* multi-objective decision-making, sensitivity analysis, and scenario evaluation.

MESE-E010-5: *Interpret* modelling results, optimization outputs, and their implications for energy system design and planning.

Reference Books:

1. Kehlhofer, J. (2009). *Applied Modeling in Energy Systems*.
2. Stoecker, W. F. (1989). *Design of Thermal Systems* (3rd ed.). McGraw-Hill.

Further Readings:

1. Belegundu, A. D., & Chandrupatla, T. R. (2011). *Optimization Concepts and Applications in Engineering* (2nd ed.). Cambridge University Press.
2. Yang, X.-S. (2010). *Computational Optimization for Energy Systems*.

Name of the Course	**Circular Economy and Sustainability**		
Course Code	**MESE-E011**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive study of circular economy principles, sustainable resource management, lifecycle thinking, and environmental performance frameworks. The course explores waste minimization, material circularity strategies, industrial symbiosis, sustainability indicators, and policy mechanisms supporting circular transition.

Course Objectives:

- To introduce circular economy concepts, material-flow principles, and sustainability frameworks.
- To analyze lifecycle thinking, resource-efficiency strategies, and waste valorisation pathways.
- To evaluate circular models, sustainability metrics, and policy frameworks enabling circular transition.

Units	**Course Content**
Unit 1	Concepts of circular economy, linear vs circular models, material loops, waste hierarchy, resource efficiency, sustainability principles, India's environmental and resource challenges, national priorities and SDG alignment. Systems thinking, material-flow analysis, industrial metabolism, environmental linkages, building-energy and material-use foundations, and core assumptions supporting circular transitions.
Unit 2	Environmental and social-impact assessment in the Indian regulatory context, life-cycle thinking and evaluation tools for identifying circular opportunities. Assessment of environmental and socio-economic implications of circular transitions, screening and decision-support considerations for implementation feasibility.
Unit 3	Lifecycle thinking, carbon and resource foot printing, environmental-performance evaluation and LCA linkage to circularity, strategies and best-practice models. Indian policies and regulatory frameworks, sectoral applications across manufacturing, agriculture, waste, construction, energy and mobility, industrial symbiosis, circular business models, sharing economy, reverse logistics and case studies.
Unit 4	Eco-design and design for disassembly, circular value chains and industrial collaboration, technology and innovation drivers, implementation pathways for organizations and public systems, communication and stakeholder engagement. Sustainability indicators, environmental KPIs, circularity metrics, performance monitoring, decision-support tools, international standards and frameworks, corporate-

	sustainability practices and future circular-economy trends.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E011-1: *Explain* circular economic principles, material loops, and sustainability concepts.

MESE-E011-2: *Analyze* resource flow patterns, waste minimization strategies, and material-efficiency approaches.

MESE-E011-3: *Evaluate* lifecycle thinking, circular business models, and industrial symbiosis opportunities.

MESE-E011-4: *Assess* sustainability metrics, environmental indicators, and performance evaluation tools.

MESE-E011-5: *Interpret* policy frameworks, global practices, and emerging trends in circular and sustainable systems.

Reference Books:

1. Kirchherr, J., Reike, D., & Hekkert, M. (2017). *Circular Economy: Concepts and Strategies*.
2. Murray, A., Skene, K., & Haynes, K. (2017). *The Circular Economy: A Wealth of Flows*. Routledge.

Further Readings:

1. United Nations Environment Programme (UNEP). *Sustainability and Resource Efficiency Reports*.
2. Organisation for Economic Co-operation and Development (OECD). *Circular Economy Policy Papers*.

Name of the Course	**Life Cycle Assessment**		
Course Code	**MESE-E012**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive study of Life Cycle Assessment (LCA) methodologies, environmental impact modelling, inventory analysis, and interpretation techniques. The course covers ISO standards, data collection, impact-assessment frameworks, software tools, uncertainty analysis, and applications of LCA in energy, environment, and sustainability decision-making.

Course Objectives:
1. To introduce LCA principles, system boundaries, and ISO framework requirements.
2. To analyze inventory development, impact-assessment methods, and modelling tools.
3. To evaluate LCA interpretation, sensitivity analysis, and applications in sustainability planning.

Units	**Course Content**
Unit 1	Definition and importance of LCA for renewable-energy systems, types and methodological approaches, full assessment procedure, design and development phases, strategy formulation, evaluation and comparison of methods, cost–benefit analysis and uncertainty handling. Indicators of financial performance, life-cycle costing economics, cost-model selection and estimation methods, along with assumptions, simplifications and performance considerations.
Unit 2	Inventory-development steps including data collection, mass and energy balances, quality indicators, LCI data sources and background–foreground system handling, process-chain and input–output methods. Life-cycle energy analysis covering embodied energy, cumulative energy demand, energy yield ratio, payback metrics, specific emissions and case studies across wind, bioenergy and solar systems, with modelling flows, process mapping and basic OpenLCA/SimaPro use.
Unit 3	Impact-assessment categories using midpoint and endpoint approaches (CML, TRACI, ReCiPe), normalization and weighting, environmental-performance analysis, GHG calculations, carbon foot printing, offsetting and emissions trading for renewable-energy systems. Resource-depletion and ecotoxicity metrics, cumulative emissions, decarbonization-pathway concepts, sensitivity and variability analysis, and linkage between circularity and environmental indicators.
Unit 4	Alternative sustainability-assessment approaches, LCA software tools and databases,

	structural requirements, interpretation and reporting of results, and evaluation of tool outputs and limitations. ISO standards including 14040, 14044, 14067 and 14020/14021/14024/14025/14026 for environmental labels, LCA-based certification programs, future developments and decision-support relevance for policy and industry.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E012-1: *Explain* LCA principles, phases, functional units, and ISO standards.
MESE-E012-2: *Analyze* goal definition, scope development, and system boundary selection.
MESE-E012-3: *Evaluate* life-cycle inventory (LCI) processes, data collection, and modelling tools.
MESE-E012-4: *Assess* impact-assessment approaches, uncertainty analysis, and interpretation methods.
MESE-E012-5: *Interpret* LCA outcomes for environmental decision-making and sustainability planning.

Reference Books:

1. Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (Eds.). (2018). *Life Cycle Assessment: Theory and Practice*. Springer.
2. Guinée, J. B. (Ed.). (2002). *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards*. Kluwer Academic Publishers.

Further Readings:

1. International Organization for Standardization (ISO). *ISO 14040 & ISO 14044 Standards for Life Cycle Assessment*.
2. European Commission Joint Research Centre (JRC). *ILCD Handbook: General Guide for Life Cycle Assessment*.
3. United Nations Environment Programme (UNEP). *Life Cycle Initiative Publications*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Environmental Impact Assessment</td></tr>
<tr><td>Course Code</td><td>MESE-E013</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A detailed study of Environmental Impact Assessment (EIA) principles, methods, legal frameworks, and analytical tools used to evaluate environmental consequences of projects and policies. The course covers screening, scoping, baseline studies, impact prediction, mitigation planning, public consultation, and preparation of EIA reports with reference to national and international guidelines.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce EIA concepts, regulatory frameworks, and procedural stages.
• To analyze impact prediction methods, baseline data collection, and evaluation techniques.
• To evaluate mitigation measures, environmental management plans, and reporting standards.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">EIA definitions, objectives, need and importance, process overview, evolution of EIA, rapid vs comprehensive approaches, national and international regulations, Environmental Impact Statement requirements.
Screening and scoping procedures, TOR preparation, stakeholder identification, sustainable-development linkage and regulatory-compliance expectations.</td></tr>
<tr><td>Unit 2</td><td colspan="3">Environmental-baseline components (physical, biological, socio-economic), data-collection tools, monitoring methods, sampling techniques, impact indicators, data-quality and seasonal-variation considerations, GIS applications.
Criteria for selecting EIA methodologies, general assessment framework, site characterization and environmental-risk analysis using matrix, checklist and mathematical-model approaches.</td></tr>
<tr><td>Unit 3</td><td colspan="3">Impact-prediction tools including matrices, checklists and network models, qualitative and quantitative significance assessment, air-water-soil-noise modelling, cumulative-impact analysis and uncertainty evaluation.
Public participation, fault-tree and consequence analysis, socio-economic impact assessment and effectiveness measurement of pollution-control measures.</td></tr>
<tr><td>Unit 4</td><td colspan="3">Mitigation hierarchy, pollution-control strategies, Environmental Management Plan structure, monitoring and auditing, public consultation, documentation and review processes, decision-making criteria and emerging EIA trends.
Environmental legislation, Environmental Management Systems, environmental-statement procedures, environmental auditing and cost–benefit analysis for project evaluation.</td></tr>
<tr><td colspan="4">Course Outcomes (COs):</td></tr>
</table>

At the end of the course students will be able to:
MESE-E013-1: *Explain* EIA principles, legal frameworks, and procedural stages.
MESE-E013-2: *Analyze* screening, scoping, and baseline environmental study requirements.
MESE-E013-3: *Evaluate* impact prediction methods, assessment tools, and significance criteria.
MESE-E013-4: *Assess* mitigation strategies, environmental management plans, and monitoring frameworks.
MESE-E013-5: *Interpret* EIA reports, public consultation outcomes, and compliance requirements.

Reference Books:

1. Canter, L. W. (1996). *Environmental Impact Assessment* (2nd ed.). McGraw-Hill.
2. Petts, J. (Ed.). (1999). *Handbook of Environmental Impact Assessment*. Blackwell Science.

Further Readings:

1. Ministry of Environment, Forest and Climate Change (MOEFCC). *Guidelines on Environmental Impact Assessment*.
2. Glasson, J., Therivel, R., & Chadwick, A. (2013). *Introduction to Environmental Impact Assessment* (4th ed.). Routledge.

<table>
<tr><td>Name of the Course</td><td colspan="3">Energy Materials and Devices</td></tr>
<tr><td>Course Code</td><td>MESE-E014</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of functional materials used in energy conversion and storage devices. The course covers materials for batteries, fuel cells, supercapacitors, solar cells, thermoelectric, and hydrogen systems, along with device fabrication, characterization techniques, performance evaluation, and emerging material innovations.</td></tr>
<tr><td colspan="4">Course Objectives:
To introduce functional materials used in modern energy technologies.
To analyze material properties, fabrication techniques, and characterization methods.
To evaluate performance, device integration, and emerging trends in energy materials and devices.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">Silicon, thin-film, dye-sensitized, quantum-dot, perovskite and tandem photovoltaic technologies, including emerging and flexible PV materials and multi-junction architectures.
Spectral response, device-physics fundamentals and characterization basics for advanced solar-energy materials and next-generation cell structures.</td></tr>
<tr><td>Unit 2</td><td colspan="3">Thermoelectric materials and generators, principles of thermal-to-electric conversion and performance parameters for high-efficiency thermoelectric systems.
Thermionic energy-conversion concepts, associated device materials and design considerations for advanced heat-harvesting platforms.</td></tr>
<tr><td>Unit 3</td><td colspan="3">Materials for capacitors and supercapacitors, chemical and ion-based battery systems, electrode and electrolyte compositions and CNT-based storage composites.
Fuel-cell membrane and component materials with fundamentals of PEM and alkaline devices supporting electrochemical-energy conversion.</td></tr>
<tr><td>Unit 4</td><td colspan="3">Materials for fuel-cell technologies, PEC water-splitting devices and hydrogen-production pathways with associated material requirements.
Advanced energy-conversion systems and relevant characterization techniques (SEM, TEM, XRD, Raman, AFM) for evaluation and development of next-generation devices.</td></tr>
<tr><td colspan="4">Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E014-1: Explain material classes, functional properties, and relevance to energy devices.
MESE-E014-2: Analyze fabrication methods, structural properties, and characterization techniques.
MESE-E014-3: Evaluate material–device interfaces, performance indicators, and degradation</td></tr>
</table>

behavior.
MESE-E014-4: *Assess* device operation principles for photovoltaics, batteries, fuel cells, and storage systems.
MESE-E014-5: *Interpret* emerging materials, nanostructured systems, and advanced energy-device applications.

Reference Books:

1. Bhadeshia, H. K. D. H. (2014). *Materials for Energy Systems*.
2. Daniel, C., & Besenhard, J. O. (Eds.). (2011). *Handbook of Battery Materials* (2nd ed.). Wiley-VCH.

Further Readings:

1. Goodenough, J. B., & Park, K. S. (2013). *Energy Storage Materials*. Springer.
2. Ozin, G. A., & Arsenault, A. C. (2005). *Nanochemistry: Concepts and Applications*. Royal Society of Chemistry.

<table>
<tr><td>Name of the Course</td><td colspan="3">Waste to Energy</td></tr>
<tr><td>Course Code</td><td>MESE-E015</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of waste-to-energy (WTE) technologies, covering waste characterization, thermal and biochemical conversion processes, system design, emissions control, and energy recovery. The course examines municipal solid waste (MSW) management, process optimization, environmental impacts, and techno-economic evaluation of WTE systems.</td></tr>
<tr><td colspan="4">Course Objectives:
1. To introduce waste characterization, MSW management practices, and resource recovery concepts.
2. To analyze thermal, biochemical, and emerging waste-to-energy conversion technologies.
3. To evaluate system performance, environmental impacts, and techno-economic feasibility of WTE projects.</td></tr>
</table>

Units	Course Content
Unit 1	Principles of waste management and utilization, waste-management hierarchy and 3R concepts, waste as a resource and alternate-energy source, types and classification of waste across sectors, MSW composition and physicochemical characteristics. Collection, segregation and preprocessing, material-recovery facilities, landfill basics, resource-recovery criteria and regulatory frameworks governing waste-to-energy applications.
Unit 2	Combustion and mass-burn incineration systems, grate technologies, RDF and AFR production, heat-recovery configurations and characterization of waste for energy utilization. Thermochemical routes include gasification, pyrolysis and plasma-gasification, reactor designs, syngas quality and cleaning requirements for conversion efficiency.
Unit 3	Anaerobic-digestion processes, digester types, operating conditions, biogas upgrading, digestate utilization and co-digestion strategies with energy-yield estimation. Biochemical pathways include fermentation, biohydrogen from waste, landfill-gas recovery, waste-to-fuel conversion, process integration, benchmarking and standardization practices.
Unit 4	Emission-control technologies, air-pollution-control devices, environmental and lifecycle considerations, centralized vs decentralized WTE configurations, siting and infrastructure requirements. Techno-economic evaluation including capital and O&M costs, policy incentives, sustainability assessment and emerging waste-to-energy technologies and deployment

	models.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E015-1: *Explain* waste characteristics, MSW composition, and waste-management fundamentals.
MESE-E015-2: *Analyze* waste-to-energy conversion processes, including thermal and biochemical routes.
MESE-E015-3: *Evaluate* process parameters, system efficiencies, and energy yields of WTE technologies.
MESE-E015-4: *Assess* environmental impacts, emissions control strategies, and regulatory requirements.
MESE-E015-5: *Interpret* techno-economic feasibility, system design considerations, and future WTE trends.

Reference Books:
1. Manahan, S. E. (2017). *Environmental Chemistry and Waste-to-Energy*. CRC Press.
2. Niessen, W. R. (2010). *Combustion and Incineration Processes: Applications in Environmental Engineering* (4th ed.). CRC Press.

Further Readings:
1. International Energy Agency (IEA) Bioenergy. *Waste-to-Energy (WTE) Reports*.
2. United Nations Environment Programme (UNEP). *Solid Waste Management Guides*.
3. Klass, D. L. (1998). *Biomass for Renewable Energy and Fuels*. Academic Press.

Name of the Course	**Power Electronics for Renewable Energy**		
Course Code	**MESE-E016**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A detailed study of power electronic devices, converters, control strategies, and interfaces used in renewable-energy systems. The course covers DC–DC, DC–AC, and AC–DC converters, grid integration, MPPT techniques, inverter control, harmonics, and protection aspects essential for solar, wind, and hybrid energy applications.

Course Objectives:
- To introduce power electronic devices, converter fundamentals, and switching characteristics.
- To analyze power converter topologies and their control for renewable-energy systems.
- To evaluate inverter operation, MPPT methods, and grid-integration requirements.

Units	**Course Content**
Unit 1	Global energy trends, resource availability and the need for emerging renewable technologies, qualitative overview of solar, wind, ocean, biomass, fuel-cell and hydrogen systems, and hybrid renewable configurations. Power-semiconductor fundamentals including MOSFET and IGBT characteristics, switching behavior, losses, thermal management, converter basics, PWM and switching strategies, gate-drive and protection circuits.
Unit 2	Photovoltaic-energy conversion principles, system components, MPPT operation, factors influencing output, PV system design and DC/AC power-conditioning interfaces. Grid-synchronized operation using line-commutated inverters and power-electronics topologies for PV integration in distributed and grid-connected applications.
Unit 3	Wind-energy conversion principles, wind characteristics and Indian resource context, WECS components, induction and PMSG-based systems, classification and converters for variable-speed turbines including matrix and multilevel platforms. Inverter control, PLL and synchronization, modulation strategies, MPPT algorithms (P&O, INC, fuzzy, ANN), converter–PV interface design and control-loop stability considerations.
Unit 4	Fuel-cell working principles, distributed-generation applications, power-conditioning topologies, EMS considerations and auxiliary storage requirements for stationary systems. Hybrid renewable-system types and optimization, power-quality issues, other renewable sources (biogas, biomass, etc.) and power-electronics control for microgrids and smart-grid integration.

Course Outcomes (COs):

At the end of the course students will be able to:
MESE-E016-1: *Explain* power electronic devices, converter principles, and switching behavior.
MESE-E016-2: *Analyze* DC–DC, DC–AC, and AC–DC converter topologies used in renewable systems.
MESE-E016-3: *Evaluate* inverter control, MPPT algorithms, and operational performance.
MESE-E016-4: *Assess* power-quality issues, protection requirements, and standards for renewable integration.
MESE-E016-5: *Interpret* emerging converter technologies and advanced control strategies.

Reference Books:

1. Rashid, M. H. (2013). *Power Electronics: Circuits, Devices, and Applications* (4th ed.). Pearson.
2. Bose, B. K. (2002). *Modern Power Electronics and AC Drives*. Prentice Hall.

Further Readings:

1. Singh, B., & Chandra, A. (2015). *Power Quality in Power Systems and Electrical Machines* (2nd ed.). Academic Press.
2. National Renewable Energy Laboratory (NREL). *Reports on Inverter-Based Resources*.
3. IEEE. *Power Electronics Standards and Technical Papers*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Instrumentation and Control in Energy Systems</td></tr>
<tr><td>Course Code</td><td>MESE-E017</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A detailed study of instrumentation principles, sensors, measurement techniques, control strategies, and data acquisition systems used in renewable and conventional energy systems. The course covers transducers, signal conditioning, controllers, automation, and monitoring approaches essential for efficient operation and performance optimization of energy systems.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce instrumentation fundamentals, sensors, and measurement techniques used in energy systems.
• To analyze control strategies, signal conditioning, and data acquisition methods.
• To evaluate automation, monitoring, and control applications in renewable-energy systems.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">Principles of measurement systems, classification of instruments, measurement errors, static and dynamic characteristics, input–output configurations and system behavior.
Mechanical and electrical transducers, modern sensor principles, and instruments for temperature, pressure, flow, velocity, heat flux, liquid level, concentration, combustor characterization and flue/exhaust-gas analysis.</td></tr>
<tr><td>Unit 2</td><td colspan="3">Electrical transducers include strain gauges and LVDTs, solar-radiation and meteorological measurements, energy-auditing instruments and humidity-measurement requirements.
Introduction to control systems, components and configurations, feedback and non-feedback applications and measurement integration within energy-system monitoring.</td></tr>
<tr><td>Unit 3</td><td colspan="3">Feedback-control principles, transfer functions, block-diagram representation and reduction, signal-conditioning using operational amplifiers and standard application circuits.
ADC/DAC techniques, PLC fundamentals, SCADA systems, control algorithms, real-time monitoring and system-response analysis.</td></tr>
<tr><td>Unit 4</td><td colspan="3">Microprocessor and microcontroller basics, architecture and device selection, compiler use for acquisition, processing and display functions.
Typical microcontroller applications for monitoring and control of electrical and non-electrical parameters and process-level integration in energy systems.</td></tr>
<tr><td colspan="4">Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E017-1: Explain instrumentation principles, sensing elements, and measurement techniques.</td></tr>
</table>

MESE-E017-2: *Analyze* transducers, signal conditioning circuits, and data acquisition systems.
MESE-E017-3: *Evaluate* control strategies, controller tuning, and system response characteristics.
MESE-E017-4: *Assess* instrumentation requirements, monitoring tools, and automation in energy systems.
MESE-E017-5: *Interpret* advanced sensing technologies, communication interfaces, and smart energy-control applications.

Reference Books:

1. Doebelin, E. O. (2003). *Measurement Systems: Application and Design* (5th ed.). McGraw-Hill.
2. Jain, R. (2013). *Control Systems and Instrumentation*.

Further Readings:

1. National Renewable Energy Laboratory (NREL). *Monitoring and Control Reports*.
2. Johnson, C. D. (2006). *Process Control Instrumentation Technology* (8th ed.). Pearson.

<table>
<tr><td>Name of the Course</td><td colspan="3">AI Applications in Energy</td></tr>
<tr><td>Course Code</td><td>MESE-E018</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A study of artificial intelligence (AI) and machine-learning (ML) techniques applied to energy systems, including forecasting, optimization, diagnostics, and control. The course covers data-driven modelling, neural networks, predictive maintenance, renewable-energy forecasting, smart-grid applications, and intelligent energy management.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce AI, ML, and data-driven modelling concepts relevant to energy systems.
• To analyze ML algorithms for forecasting, optimization, diagnostics, and control.
• To evaluate AI-enabled applications in renewable energy, smart grids, storage, and energy management.</td></tr>
</table>

Units	Course Content
Unit 1	Overview of AI applications in the energy sector, challenges in modern power systems, enabling technologies including machine learning, IoT and big-data platforms, and benefits for efficiency, reliability and resource management. Foundational context for digital transformation in energy with traditional system-performance expectations and emerging operational constraints.
Unit 2	AI-based predictive analytics for energy demand, time-series forecasting, load balancing, peak management, smart-grid applications, real-time monitoring and decentralized-intelligence algorithms. Supervised and unsupervised methods including regression, decisions of trees, SVMs, ensembles, neural-network basics, clustering, dimensional-reduction, reinforcement-learning fundamentals, model tuning and cross-validation.
Unit 3	Load and renewable-energy forecasting, energy-price prediction and weather-linked models, optimization using AI, metaheuristics, anomaly detection, fault diagnosis and condition monitoring across grid and plant assets. Applications in solar and wind forecasting, optimization of renewable-integration and storage systems, predictive-maintenance strategies and operational-efficiency enhancement.
Unit 4	AI in smart grids for demand response, control optimization, energy-storage management and microgrid automation, including predictive-maintenance and digital-twin deployment. AI-enabled energy-efficiency strategies, smart metering and building optimization, data-privacy and security considerations, ethical and regulatory issues, environmental-impact

	assessment and future AI trends in energy systems.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E018-1: *Explain* AI and ML fundamentals, data types, and modelling principles in energy systems.

MESE-E018-2: *Analyze* supervised, unsupervised, and reinforcement learning algorithms for energy applications.

MESE-E018-3: *Evaluate* AI-driven forecasting, optimization, and anomaly detection techniques.

MESE-E018-4: *Assess* intelligent control, predictive maintenance, and smart-grid automation approaches.

MESE-E018-5: *Interpret* emerging AI trends, computational tools, and ethical considerations in energy applications.

Reference Books:

1. Kröse, B., & van der Smagt, P. (1996). *An Introduction to Neural Networks*. University of Amsterdam.
2. Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.

Further Readings:

1. IEEE Transactions on Smart Grid. *AI-Focused Research Papers*.
2. International Energy Agency (IEA). *Digitalization and Energy Reports*.
3. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.

Name of the Course	Alternative Fuels		
Course Code	MESE-E019	Credits-3	L-3, T-0, P-0
Total Lectures	39 (1 Hour Each)		
Semester End Examination	Max Marks: 100	Min. Pass Marks: 40	Max. Time: 3 Hrs.
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			Max Marks: 50

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive study of alternative fuels for transportation and stationary applications, including gaseous, liquid, synthetic, and renewable fuels. The course covers fuel properties, production pathways, combustion behaviour, engine performance, emission characteristics, environmental impacts, and future trends in clean-fuel technologies.

Course Objectives:
- To introduce alternative-fuel classifications, properties, and production methods.
- To analyze combustion characteristics, engine performance, and emission profiles of various alternative fuels.
- To evaluate techno-economic, environmental, and operational aspects of emerging clean fuels.

Units	Course Content
Unit 1	Types and availability of energy sources, need for alternative and non-conventional options, classification of alternative fuels and drivetrains, global auto-fuel scenario, oil-reserve context and fuel-quality implications for emissions. Technological upgradation and business drivers, implementation barriers, stakeholder roles and national road-mapping for alternative-fuel deployment and transition planning.
Unit 2	Biogas history, properties, production and plant classifications, storage and dispensing systems, advantages, hazards and emissions, and suitability for combustion applications. Production, properties, engine-performance characteristics, advantages and limitations of methanol, ethanol, butanol, straight vegetable oil and biodiesel for IC-engine use.
Unit 3	Hydrogen properties, production and storage, advantages and disadvantages, combustion behavior in SI and CI engines, emission characteristics, safety systems and operational hazards. Gaseous-fuel options include CNG, LNG, ANG, LPG and LFG with production, properties and engine-performance considerations, plus reformulated fuels such as coal-water slurry, RFG, emulsified fuels and hydrogen-enriched gasoline.
Unit 4	Future alternative fuels including PMF, ammonia, liquid nitrogen, boron, compressed air and water-based concepts with production, properties, engine-performance and associated advantages and drawbacks. Alternative powertrains covering EV components, batteries, chargers, drives, transmission and power devices, hybrid-EV drivetrain elements and dual-fuel technologies with operational characteristics, applications and performance trade-offs.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E019-1: *Explain* classifications, production pathways, and properties of alternative fuels.
MESE-E019-2: *Analyze* combustion behavior, thermochemical characteristics, and performance parameters.
MESE-E019-3: *Evaluate* engine-fuel compatibility, storage requirements, and operational impacts.
MESE-E019-4: *Assess* emission characteristics, environmental impacts, and sustainability indicators.
MESE-E019-5: *Interpret* technological developments, policies, and future prospects of alternative fuels.

Reference Books:
1. Bechtold, R. L. (1997). *Alternative Fuels Guidebook*. SAE International.
2. Callahan, T. J. (2007). *Alternative Transportation Fuels: Utilization in Combustion Engines*.

Further Readings:
1. International Energy Agency (IEA). *Alternative Fuels Reports*.
2. Demirbas, A. (2007). *Methanol, Hydrogen, and Biofuels*. Springer.
3. SAE International. *Technical Papers on Alternative Fuels*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Energy Policy and Planning</td></tr>
<tr><td>Course Code</td><td>MESE-E020</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of energy policies, planning frameworks, regulatory mechanisms, and strategic decision-making for sustainable energy transitions. The course covers policy instruments, energy economics, national and global energy governance, forecasting, integrated resource planning, and evaluation of renewable-energy policies.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce energy-policy frameworks, planning methodologies, and regulatory structures.
• To analyze policy instruments, economic drivers, and governance mechanisms.
• To evaluate planning models, energy forecasting, and sustainability-driven policy strategies.</td></tr>
</table>

Units	Course Content
Unit 1	Energy-policy concepts, governance structures, regulatory frameworks, national strategies and sustainable-development linkages, including institutional roles and policy-driven energy transitions. Financial and economic feasibility of energy systems, engineering-economics foundations, technology evaluation, social cost–benefit analysis and techno-economic case studies for conservation and renewable-energy options.
Unit 2	Energy-demand forecasting, supply assessment and demand–supply balancing using planning tools, energy–economy interactions, investment planning, project formulation and pricing strategies. Energy-planning models and software, CDM mechanisms, technology transfer and financing, carbon credits and trading opportunities, and policy implications of energy–environment linkages.
Unit 3	National energy and power policies, tariffs and subsidies, utility interfaces, private-sector participation, fiscal instruments and regulatory acts governing the sector. Role of modelling in policy analysis, energy databases, balances and flow diagrams, reference-energy-system construction, demand analysis using trend, econometric, elasticity, input–output and simulation approaches, and supply-side evaluation.
Unit 4	National renewable-energy policies, international frameworks, SDG alignment, climate-policy interactions, transition pathways and economics of depletable and renewable resource utilization including scarcity rent and global supply dynamics. Energy-economy and environment interaction, pricing and investment considerations, sustainability indicators, strategic-impact analysis, just-transition principles and future policy trends with institutional best practices.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E020-1: *Explain* energy-policy frameworks, governance structures, and regulatory mechanisms.
MESE-E020-2: *Analyze* policy instruments, market mechanisms, and economic drivers influencing energy systems.
MESE-E020-3: *Evaluate* planning methodologies, forecasting tools, and integrated resource planning.
MESE-E020-4: *Assess* national and global renewable-energy policies, sustainability indicators, and strategic development pathways.
MESE-E020-5: *Interpret* policy impacts, stakeholder roles, and future trends in energy planning.

Reference Books:

1. Jefferson, M., & Sovacool, B. K. (2017). *Energy Policy: Concepts, Issues, and Futures*.
2. Bhattacharyya, S. C. (2011). *Energy Economics: Concepts, Issues, Markets and Governance*. Springer.

Further Readings:

1. International Energy Agency (IEA). *Global Energy Policy Reports*.
2. United Nations Environment Programme (UNEP) & United Nations Framework Convention on Climate Change (UNFCCC). *Energy Policy Documents*.
3. Intergovernmental Panel on Climate Change (IPCC). *Mitigation and Policy Chapters*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Renewable Energy Integration and Power Systems</td></tr>
<tr><td>Course Code</td><td>MESE-E021</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of integrating renewable-energy sources into modern power systems, covering grid stability, variability management, forecasting, power electronics interfaces, and operational challenges. The course examines standards, protection, flexibility solutions, and system-level planning for reliable and resilient renewable-rich power networks.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce power-system fundamentals relevant to renewable-energy integration.
• To analyze impacts of renewable variability on grid stability, protection, and operation.
• To evaluate technologies, strategies, and planning approaches for large-scale renewable integration.</td></tr>
</table>

Units	Course Content
Unit 1	Power-system architecture, transmission and distribution fundamentals, load profiles, grid codes, voltage and frequency regulation, system inertia and reserve requirements, and hybrid-grid operation with nano/micro/mini-grid concepts. Integration of large-scale renewables and rooftop systems, renewable-penetration impacts, VPP concepts, and challenges in utilizing power from variable sources.
Unit 2	Resource variability and forecasting methods, short- and long-term prediction, data requirements, forecasting tools and stability considerations for transient, voltage and frequency behavior in low-inertia grids. Synchronous-generator synchronization and load sharing, induction-generator stability, and power-electronics equipment including converters, inverters, choppers, AC regulators and cyclo-converters for AC/DC interfacing.
Unit 3	Inverter-control fundamentals, grid-following and grid-forming modes, MPPT behavior, harmonics, reactive-power control, fault ride-through, synthetic inertia, hybrid inverters and storage integration for microgrid operation. Power-quality issues (THD, voltage sag/swell, frequency deviations), system protection, grid codes, scheduling and dispatch, operating reserves, EV integration, ancillary-services requirements and CERC/CEA technical standards.
Unit 4	Principles of power injection, active/reactive-power control, integration of multiple renewable sources via AC, DC and HFAC links, islanding and interconnection, relay coordination, anti-islanding and mitigation of power-quality disturbances. Flexibility options including demand response, storage-based balancing, transmission planning, future-grid trends and evolving regulatory frameworks for high-renewable

	penetration.

Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E021-1: *Explain* renewable-integration challenges, power-system characteristics, and operational impacts.
MESE-E021-2: *Analyze* forecasting, variability management, and stability considerations in renewable-rich grids.
MESE-E021-3: *Evaluate* inverter-based resources, power electronics interfaces, and grid-support functions.
MESE-E021-4: *Assess* protection, power quality, and flexibility solutions for modern power systems.
MESE-E021-5: *Interpret* planning strategies, regulatory requirements, and future trends in renewable integration.

Reference Books:

1. Jenkins, N., Allan, R., Crossley, P., Kirschen, D., & Strbac, G. (2000). *Embedded Generation*. IET (Institution of Engineering and Technology).
2. Kundur, P. (1994). *Power System Stability and Control*. McGraw-Hill.

Further Readings:

1. IEEE. *Standards for Renewable Interconnection*.
2. International Energy Agency (IEA). *Grid Integration Reports*.
3. National Renewable Energy Laboratory (NREL). *Publications on Inverter-Based Resources*.

Name of the Course	**Carbon Capture and Storage**		
Course Code	**MESE-E022**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A detailed study of carbon capture, transport, and storage (CCS) technologies aimed at reducing greenhouse-gas emissions from energy and industrial systems. The course covers capture methods, separation processes, geological storage, monitoring techniques, risk assessment, techno-economics, and emerging carbon-utilization pathways.

Course Objectives:
- To introduce the principles, need, and role of CCS in climate mitigation.
- To analyze carbon-capture technologies, separation mechanisms, and transport systems.
- To evaluate geological storage, monitoring, safety considerations, and CCS techno-economics.

Units	**Course Content**
Unit 1	Global CO_2-emission trends, industrial and energy-sector sources, climate-policy and regulatory interventions, CCS role in mitigation pathways and national–international deployment status. CCS framework including system boundaries, CO_2 properties and the capture–transport–storage chain with current global progress and implementation context.
Unit 2	CO_2-capture technologies from power plants including post-combustion, pre-combustion, oxy-fuel, chemical-looping and calcium-looping processes, solvent and sorbent systems and capture-efficiency considerations. Chemical absorption, adsorption, membrane and cryogenic separation, ionic liquids and MOFs, process integration and operational requirements for large-scale capture.
Unit 3	CO_2-storage and sequestration options including geological formations, saline aquifers, depleted reservoirs and biomimetic pathways, pipeline and ship transport, compression, material selection and safety constraints. Utilization pathways such as CO_2-derived fuels, polymers, solvents and oxygenated organics, conversion to higher-carbon fuels, logistics, leakage risks, monitoring and purity specifications.
Unit 4	Storage mechanisms, mineral carbonation, integrity and long-term monitoring, risk assessment, techno-economic evaluation and emerging CCS and CCU deployment trends. Environmental assessment needs, green-chemistry tools, life-cycle assessment methodology, ISO 14040/14044/14067 alignment and standardized certification approaches for CO_2 capture and utilization.

Course Outcomes (COs):

At the end of the course students will be able to:
MESE-E022-1: *Explain* CCS fundamentals, emission sources, and the role of CCS in mitigation.
MESE-E022-2: *Analyze* carbon-capture processes, separation techniques, and system configurations.
MESE-E022-3: *Evaluate* transport options, pipeline design requirements, and safety considerations.
MESE-E022-4: *Assess* geological storage mechanisms, monitoring methods, and risk assessment approaches.
MESE-E022-5: *Interpret* techno-economic factors, environmental impacts, and emerging carbon-utilization technologies.

Reference Books:

1. Maroto-Valer, M. M. (Ed.). (2010). *Carbon Capture and Storage*. Wiley.
2. Intergovernmental Panel on Climate Change (IPCC). (2005). *Special Report on Carbon Capture and Storage*. Cambridge University Press.

Further Readings:

1. International Energy Agency (IEA). *CCS Technology Reports*.
2. National Energy Technology Laboratory (NETL). *Carbon Storage Publications*.
3. Global CCS Institute. *Technical Reports on Carbon Capture and Storage*.

Name of the Course	**Climate Change and Mitigation**		
Course Code	**MESE-E023**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A comprehensive study of climate-change science, greenhouse-gas emissions, climate modelling, vulnerability assessment, and mitigation strategies. The course covers global warming mechanisms, policy frameworks, renewable-energy roles, carbon management, and adaptation–mitigation linkages essential for sustainable development pathways.

Course Objectives:
- To introduce climate-change science, emission sources, and global environmental impacts.
- To analyze climate modelling, vulnerability assessment, and impact-evaluation methods.
- To evaluate mitigation strategies, low-carbon technologies, and policy frameworks for climate action.

Units	**Course Content**
Unit 1	Climate-change response measures, evolution of mitigation concepts, stabilization scenarios, regional and national characteristics, long- and short-term mitigation options and mainstreaming into development planning. Greenhouse effect, radiative forcing, climate drives, feedback mechanisms and the carbon cycle as foundations for evaluating mitigation pathways.
Unit 2	Climate-modeling approaches including GCMs, downscaling techniques, climate projections and uncertainty factors, integrated-assessment models and LCA/EIA-based analytical methods. Methodologies for regional GHG inventories and emission computation aligned with IPCC good-practice guidelines and national reporting frameworks.
Unit 3	Mitigation strategies including renewable-energy deployment, energy-efficiency measures, CCS, demand-side management and transport decarbonization. Land-use interventions such as afforestation, circular-economy linkages and sector-specific approaches for power, transport, agriculture, municipal waste, industry and buildings with cross-sector sustainable-development integration.
Unit 4	Global climate-governance frameworks including UNFCCC, Kyoto Protocol, Paris Agreement and NDC processes, national-policy instruments and carbon-pricing mechanisms with adaptation–mitigation linkages. Sustainable-development pathways, market- and regulatory-based mitigation policies, NAPCC missions, flexible and voluntary mechanisms (REC, PAT) and micro-level initiatives such as Panchayati Raj interventions.

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E023-1: *Explain* climate-change science, GHG emission sources, and global warming mechanisms.

MESE-E023-2: *Analyze* climate models, vulnerability assessments, and impact indicators.

MESE-E023-3: *Evaluate* mitigation strategies, low-carbon technologies, and sectoral emission-reduction options.

MESE-E023-4: *Assess* climate policies, international agreements, and national action frameworks.

MESE-E023-5: *Interpret* climate scenarios, risk assessments, and pathways for sustainable development.

Reference Books:

1. Nordhaus, W. D. (2013). *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. Yale University Press.
2. Stern, N. (2006). *The Stern Review on the Economics of Climate Change*. HM Treasury, UK Government.

Further Readings:

1. United Nations Framework Convention on Climate Change (UNFCCC). *Climate Policy Documents*.
2. International Energy Agency (IEA). *Energy and Climate Change Reports*.

Name of the Course	**Energy System Dynamics**		
Course Code	**MESE-E024**	**Credits-3**	**L-3, T-0, P-0**
Total Lectures	**39 (1 Hour Each)**		
Semester End Examination	**Max Marks: 100**	**Min. Pass Marks: 40**	**Max. Time: 3 Hrs.**
Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)			**Max Marks: 50**

Instructions

For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.

For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.

Course Description:
A study of dynamic behaviour, stability, control, and transient analysis of energy systems. The course covers modelling of thermal, electrical, and renewable-energy subsystems, dynamic response characteristics, system interactions, and control strategies for maintaining stable and efficient operation under fluctuating conditions.

Course Objectives:
- To introduce dynamic modelling principles for thermal, electrical, and renewable-energy systems.
- To analyze transient behaviour, stability, and system-response characteristics.
- To evaluate control and coordination strategies for dynamic performance enhancement.

Units	Course Content
Unit 1	Dynamic-modelling foundations, state-space representation, purpose and scope of system dynamics, fundamental modes of dynamic behavior and their interactions, complex-system interpretation and modelling workflow. Causal-diagram notation, guidelines for constructing causal-loop diagrams (CLDs) and conceptualization of system structure using feedback-driven modelling approaches.
Unit 2	Identification and mapping of stocks and flows, first-order system behavior, positive and negative feedback leading to exponential growth or decay, multi-loop interactions and policy resistance. Transient-response characteristics for step, impulse and ramp inputs, overshoot and settling behavior, stability criteria, root-locus and Bode-analysis basics, inertia effects and dynamics of interconnected energy systems.
Unit 3	Nonlinear first-order systems, S-shaped growth patterns, formulation and impact of delays, differentiation between material and information delays and development of rate equations. Use of table functions and interactive elicitation of model relationships for representing real-world nonlinear responses and behavioral complexity.
Unit 4	Model validation and testing principles, decision-modelling guidelines and application of system-dynamics methods to energy-system behavior and planning. Case studies addressing demand growth, renewable-integration dynamics, storage interaction and policy analysis for long-term system performance assessment.

Course Outcomes (COs):
At the end of the course students will be able to:

MESE-E024-1: *Explain* fundamentals of dynamic modelling, system behavior, and response characteristics.
MESE-E024-2: *Analyze* transient behavior, stability concepts, and system interactions in energy systems.
MESE-E024-3: *Evaluate* dynamic models of thermal, electrical, and renewable-energy subsystems.
MESE-E024-4: *Assess* control strategies, feedback mechanisms, and stability enhancement methods.
MESE-E024-5: *Interpret* dynamic simulations, performance metrics, and system-level optimization strategies.

Reference Books:

1. Ogata, K. (2010). *Modern Control Engineering* (5th ed.). Prentice Hall.
2. El-Wakil, M. M. (1984). *Power Plant Technology*. McGraw-Hill.

Further Readings:

1. Dorf, R. C., & Bishop, R. H. (2017). *Modern Control Systems* (13th ed.). Pearson.
2. National Renewable Energy Laboratory (NREL). *Dynamic Modelling Publications*.
3. IEEE Transactions on Energy Conversion. *Studies on Dynamic Behaviour of Energy Systems*.

<table>
<tr><td>Name of the Course</td><td colspan="3">Cyber Security for Energy Systems</td></tr>
<tr><td>Course Code</td><td>MESE-E025</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
A comprehensive study of cyber-security principles, threats, vulnerabilities, and protection strategies related to modern energy systems. The course covers cybersecurity frameworks, communication protocols, cyber-physical systems, SCADA protection, risk assessment, incident response, and resilience strategies essential for secure operation of smart grids and renewable-integrated power networks.</td></tr>
<tr><td colspan="4">Course Objectives:
• To introduce cyber-security fundamentals, threat landscapes, and vulnerabilities in energy systems.
• To analyze communication protocols, cyber-physical interactions, and SCADA/ICS security mechanisms.
• To evaluate risk assessment, incident response, and resilience strategies for energy infrastructures.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td></tr>
<tr><td>Unit 1</td><td colspan="3">Cyber-security concepts, Threat types, Attack surfaces, Vulnerabilities in energy systems, Cyber-physical risks
Security architecture basics, Cryptographic principles, Authentication, Access control models, Defence layers</td></tr>
<tr><td>Unit 2</td><td colspan="3">Communication protocols: Modbus, DNP3, IEC 61850, Wireless communication basics, Protocol vulnerabilities
Cyber-physical systems, Attack detection, Malware behaviour, Network intrusion, Real-time monitoring</td></tr>
<tr><td>Unit 3</td><td colspan="3">SCADA components, Industrial control systems, Data acquisition vulnerabilities, Control-loop security, Remote access risks
Encryption, Firewalls, Intrusion detection systems, Secure control-room practices, Hardening strategies</td></tr>
<tr><td>Unit 4</td><td colspan="3">SCADA components, Industrial control systems, Data acquisition vulnerabilities, Control-loop security, Remote access risks
Encryption, Firewalls, Intrusion detection systems, Secure control-room practices, Hardening strategies</td></tr>
<tr><td colspan="4">Course Outcomes (COs):
At the end of the course students will be able to:
MESE-E025-1: Explain cyber-security fundamentals, threat types, and vulnerabilities in energy</td></tr>
</table>

systems.
MESE-E025-2: *Analyze* cyber-physical interactions, communication protocols, and security breaches.
MESE-E025-3: *Evaluate* authentication, encryption, and protection methods for SCADA/ICS architectures.
MESE-E025-4: *Assess* cyber-risk analysis, incident response frameworks, and resilience strategies.
MESE-E025-5: *Interpret* emerging trends, standards, and security practices in smart and renewable-rich grids.

Reference Books:

1. Knapp, E. D., & Langill, J. T. (2014). *Industrial Network Security: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems* (2nd ed.). Syngress.
2. Bayuk, J., Healey, J., Rohmeyer, P., Sachs, M., Weiss, J., & Wolff, J. (2012). *Cyber Security Policy Guidebook*. Wiley.

Further Readings:

1. National Institute of Standards and Technology (NIST). *Framework for Improving Critical Infrastructure Cybersecurity*.
2. IEEE. *Cybersecurity Standards for Smart Grids*.
3. U.S. Department of Energy (DOE). *Energy Sector Cybersecurity Guidelines*

<table>
<tr><td>Name of the Course</td><td colspan="3">Solar PV System Design</td></tr>
<tr><td>Course Code</td><td>MESE-E026</td><td>Credits-3</td><td>L-3, T-0, P-0</td></tr>
<tr><td>Total Lectures</td><td colspan="3">39 (1 Hour Each)</td></tr>
<tr><td>Semester End Examination</td><td>Max Marks: 100</td><td>Min. Pass Marks: 40</td><td>Max. Time: 3 Hrs.</td></tr>
<tr><td colspan="3">Continuous Assessment (Based on Sessional Tests 50%, Tutorials / Assignments 30%, Quiz/Seminar 15%, Attendance 5%)</td><td>Max Marks: 50</td></tr>
<tr><td colspan="4">Instructions</td></tr>
<tr><td colspan="4">For Paper Setters:
The question paper will consist of five Sections A, B, C, D & E. Section E will be compulsory, it will consist of a single question with 10-20 subparts of short answer type, which will cover the entire syllabus and will carry 20% of the total marks of the semester end examination for the course. Section A, B, C & D will have two questions from the respective sections of the syllabus, and each question will carry 20% of the total marks of the semester end examination for the course.</td></tr>
<tr><td colspan="4">For Candidates:
Candidates are required to attempt five questions in all, selecting one question from each of the Sections A, B, C & D of the question paper and all the subparts of the questions in Section E. Use of non-programmable calculators is allowed.</td></tr>
<tr><td colspan="4">Course Description:
This course covers the principles of solar PV cell operation, module behavior, and system components, along with methods for sizing and designing grid-connected and off-grid PV systems. It includes energy estimation, software-based simulation, financial assessment, and installation practices required for complete PV system design.</td></tr>
<tr><td colspan="4">Course Objectives:
• To explain the working of PV cells, modules, and essential components used in PV system design.
• To develop skills for designing and sizing grid-connected and off-grid solar PV systems.
• To use simulation tools, safety practices, and financial evaluation methods in PV system planning.</td></tr>
</table>

Units	Course Content
Unit 1	Introduction to the structure and working of a PV cell, Characteristics of PV cells and factors affecting output, Series and parallel interconnection of PV modules and their effects on voltage, current, and power, understanding solar energy as a resource and its availability, Methods for estimating incident solar energy for different locations and conditions. NOCT parameters; efficiency, power output, and lifetime of PV modules; module configuration: series and parallel connections. PV system components: inverters: types, selection, and sizing (central, string, micro); charge controllers and their functions in off-grid systems; battery storage systems: types (lead-acid, lithium-ion, sodium-sulfur), design, and management; Balance of System (BOS) components: wiring, combiner boxes, disconnects, protection devices
Unit 2	PV system design: Grid-connected system design: load assessment and energy consumption patterns; sizing PV arrays and inverters based on energy demand and local solar resources; site assessment and tilt/azimuth optimization; islanding protection of inverters, power quality of inverter, inverter sizing, operating modes and related controls in inverters; Off-grid system design: load profiling for autonomous systems; sizing of PV modules, inverters, batteries, and charge controllers; designing hybrid systems with backup generators; integration with other systems such as electrolyzer (H2 generation), System sizing and energy yield estimation: energy demand calculation and matching with system output; PV array sizing based on location and solar resource assessment; system performance metrics: specific yield, performance ratio, capacity factor
Unit 3	Software for PV system design: introduction to industry-standard software: PVsyst,

	HelioScope, SAM, RETScreen, HOMER; performance modeling and optimization using simulation tools; simulation of real-world system performance, Grid connection and net metering: grid-tied PV system requirements and standards; net metering, feed-in tariffs, and power purchase agreements (PPAs); anti-islanding protection, system grounding, and safety requirements
Unit 4	Financial modeling: cost analysis, return on investment, payback period calculations; CAPEX and RESCO model; incentives and policy frameworks (e.g., feed-in tariffs, tax credits); environmental impact and carbon footprint reduction of PV systems, Installation best practices and procedures; system layout, electrical wiring, grounding, and protection; electrical and mechanical layout design; operation and maintenance guidelines; case studies; design and simulation of a complete solar PV system for a specific application,

Course Outcomes (COs):

At the end of the course students will be able to:

MESE-E026-1: *Describe* the operation and characteristics of PV cells and modules used in solar PV system design.

MESE-E026-2: *Estimate* solar energy and size PV arrays, inverters, batteries, and controllers for different system types.

MESE-E026-3: *Select* suitable PV components and assess their performance based on site and load requirements.

MESE-E026-4: *Design* and analyze grid-connected and off-grid PV systems using standard simulation software.

MESE-E026-5: *Evaluate* system cost, payback, and environmental benefits for complete solar PV projects.

Reference Books:

1. Deambi S. (2020). Photovoltaic System Design: Procedures, Tools and Applications. 1st edition, CRC Press
2. Satpathy R. and Pamuru V. (2020). Solar PV Power: Design, Manufacturing and Applications from Sand to Systems. Academic Press
3. Kaushika N. D., Mishra A., Rai A. K. (2018). Solar Photovoltaics: Technology, System Design, Reliability and Viability. Springer

Further Readings:

1. Mariprasath T., Kishore P., Kalyankumar K. (2024). Solar Photovoltaic System Modelling and Analysis Design and Estimation. 1st edition, Routledge
2. Gevorkian P. (2011). Large-Scale Solar Power System Design: An Engineering Guide for Grid-Connected Solar Power Generation. 1st edition, McGraw-Hill

SEMESTER III & IV

Dissertation / Thesis Guidelines

The M.Tech. (Energy Science and Engineering) dissertation is carried out in two stages: Dissertation Phase I (Semester III) and Dissertation Phase II (Semester IV). The dissertation is a major component of the program and represents a student's ability to apply advanced knowledge, research methods, and analytical skills to a problem relevant to energy science and engineering.

1. Purpose of the Dissertation

The dissertation provides an opportunity for students to:

- Apply theoretical and practical knowledge gained during coursework
- Conduct independent and original research
- Develop and evaluate energy technologies, models, simulations, or methodologies
- Demonstrate research planning, data analysis, interpretation, and technical writing skills
- Contribute to the advancement of sustainable and clean energy systems

2. Topic Selection and Approval

- Students must select a dissertation topic during the beginning of Semester III.
- Topics may involve experimental work, modelling, simulation, design, optimization, techno-economic analysis, or policy evaluation.
- Topics should be relevant to renewable energy, energy systems, sustainability, or related interdisciplinary domains.
- The topic must be approved by the Departmental Committee or an equivalent academic body.

3. Faculty Supervision

- Each student will be assigned a primary supervisor from the department.
- Co-supervisors from industry, national laboratories, or other institutions may be approved if the work requires additional expertise.
- Students are expected to meet their supervisors regularly and maintain a research logbook or digital record of progress.

4. Evaluation Structure

The dissertation is evaluated based on:

- Continuous assessment by the supervisor
- Mid-term review presentations
- Quality of research methodology and execution
- Depth of analysis and technical understanding
- Quality of written reports (Phase I and final dissertation)

- Final presentation and oral defence

Marks distribution, internal/external weightage, and evaluation panels are determined by the department and university regulations.

5. **Research Ethics and Plagiarism Policy**
    - All dissertation work must follow ethical research standards.
    - Plagiarism is strictly prohibited and will be checked through approved plagiarism detection software, as per UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations, 2018.
    - Any violation will result in penalties as per university policy.
6. **Industry Collaboration and External Research**

    Students are encouraged to pursue dissertation work in collaboration with:
    - Renewable energy industries
    - Research labs
    - Government agencies
    - National and international institutions

    However, the topic and supervision arrangement must be approved by the department, and the final evaluation will be conducted by the university.
7. **Storage and Record Keeping**

    A soft copy of each final dissertation will be archived in the department library or institutional digital repository for academic reference and accreditation requirements.s