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MAHARAJA INSTITUTE OF TECHNOLOGY MYSORE

Autonomous Institution Affiliated to VTU

Competency Based Syllabus (CBS)

for

Mechanical Engineering

(Under Outcome Based Education (OBE) and
Choice-Based Credit System (CBCS))

Offered from 3rd to 4th Semesters of Study

in

Partial Fulfillment for the Award of Master's Degree in

Thermal Power Engineering

2023 Scheme

Scheme Effective from the academic year 2023-24

General Contents of Competency Based Syllabus Document

Index	Description
1	Prerequisites
2	Competencies
3	Syllabus
4	Syllabus Timeline
5	Teaching-Learning Process Strategies
6	Assessment Details
7	Learning Objectives
8	Course Outcomes and Mapping with POs/ PSOs
9	Assessment Plan
10	Future with this Subject

3rd Semester	Professional Core Course (PC) DESIGN OF HEAT TRANSFER EQUIPMENT'S	M23MTP301

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Thermodynamics	To excel in Design of Heat Transfer Equipment's, students need to understand thermodynamic systems and properties, including open, closed, and isolated systems, as well as state properties like pressure, volume, temperature, and specific heats. They should be able to apply laws of thermodynamics, encompassing concepts of internal energy, work, heat, and energy conservation, covering entropy, irreversibility, and the Carnot cycle. Additionally, proficiency in analyzing thermodynamic processes (isothermal, adiabatic, isobaric, and isochoric) and fundamental cycles such as Carnot and Rankine is essential.
2.	Heat transfer	Students should have fundamental knowledge of conduction, convection, and radiation, Knowledge of heat transfer equations and their applications. Principles of heat exchanger design, types of heat exchangers (e.g., shell-and-tube, plate, and finned-tube), and analysis of heat exchanger performance. Principles and applications of fins in enhancing heat transfer, types of fins, and performance analysis.
3.	Fluid Mechanics	Basic principles of fluid mechanics, including fluid properties, fluid statics, and fluid dynamics. Knowledge of flow through pipes and channels, as well as boundary layer concepts.
4.	Understanding of Physical Quantities and Units	Students should be comfortable with concepts like mass, length, time, temperature, pressure, and be able to work with different unit systems (SI units are preferred).
5.	Mathematical Problem Solving	Familiarity with differentiation and integration will be advantageous. Calculus helps understand how properties change with respect to other variables.
6.	Problem-Solving Skills	The ability to use learned concepts and equations to solve numerical problems by applying their knowledge to various scenarios.
7.	Physics Fundamentals	Students need a strong grasp of Newtonian mechanics, including the concepts of force, motion, and energy. They should understand the principles of work and energy, as well as power and efficiency. A basic understanding of heat transfer, temperature scales, and the properties of matter is an added advantage.
8.	Chemistry Fundamentals	Students should be familiar with the basic structure of atoms, molecules, and ions. They must understand chemical reactions, including stoichiometry and conservation of mass. Knowledge of the ideal gas law and other gas laws, as well as phase changes and basic thermodynamic quantities such as enthalpy and entropy, is an added advantage.

2. Competencies

S/L	Competency	KSA Description
1.	Classification of Heat Exchangers	**Knowledge:** Understanding the various types of heat exchangers, including shell-and-tube, plate, finned-tube, air-cooled, and double-pipe heat exchangers. **Skills:** Analyze and compare the performance characteristics of different types of heat exchangers and select the appropriate type for specific applications. **Attitudes:** Appreciation for the critical role of heat exchangers in various industrial and engineering applications.
2.	Double Pipe Heat Exchanger Shell & Tube Heat Exchangers	**Knowledge:** Understand the design and operation of double pipe heat exchangers, including counter flow and parallel flow configurations. **Skills:** Analyze heat transfer and pressure drop in double pipe heat exchangers. And Calculate thermal efficiency and design parameters for specific applications.

		Attitudes: Recognise the effectiveness of double pipe heat exchangers in various applications.
3.	Condensation of Single Vapours	**Knowledge:** Understand the mechanisms of film wise and drop wise condensation and their respective heat transfer characteristics. **Skills:** Analyze and optimize condensation processes in various industrial applications and Calculate the heat transfer coefficients for film wise and drop wise condensation. **Attitudes:** Appreciate the importance of effective condensation processes in heat transfer applications.
4.	Vaporizers, Evaporators and Re-boilers	**Knowledge:** Understand the principles and operation of vaporizers, evaporators, and re-boilers in heat transfer applications. **Skills:** Calculate heat transfer coefficients, area requirements, and energy consumption for these equipment. **Attitudes:** Appreciate the critical role of vaporizers, evaporators, and re-boilers in various industries, including chemical processing, HVAC systems, and power generation.
5.	Direct Contact Heat Exchanger	**Knowledge:** Familiarize with the applications and advantages of direct contact heat exchangers in industrial processes. **Skills:** Calculate heat transfer rates and efficiencies based on fluid properties and operational parameters. **Attitudes:** Recognize the importance of optimizing design and operation to achieve desired heat transfer outcomes efficiently and sustainably.

3. Syllabus

DESIGN OF HEAT TRANSFER EQUIPMENT'S
SEMESTER – III

Course Code	M23MTP301	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	04	Exam Hours	**03**

Course objectives: This course will enable students to:

- To provide the sufficient knowledge of concept, applications, importance of thermal design of Heat exchanger.
- To familiarize the students about the heat exchanger design and its applications in real life situations.
- To carry out a computer simulation of heat exchanger design.

Module -1

CLASSIFICATION OF HEAT EXCHANGERS: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, extended surface heat exchanger, Plate fin and Tabular fin. Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multi pass, cross flow heat exchanger design calculations.	L1, L2, L3

Module -2

DOUBLE PIPE HEAT EXCHANGER: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements. **Shell & Tube Heat Exchangers:** Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction	L1, L2, L3

factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.	
Module -3	
CONDENSATION OF SINGLE VAPOURS: Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.	L1, L2, L3
Module -4	
VAPORIZERS, EVAPORATORS AND REBOILERS: Vaporizing processes, forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a re-boiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.	L1, L2, L3
Module -5	
DIRECT CONTACT HEAT EXCHANGER: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.	L1, L2, L3

Text Books:

1. James R. Couper; W. Roy Penney, James R. Fair, Stanley M. Walas, Chemical Process Equipment:selection and design, Elsevier Inc., 2nd ed. 2005.
2. Process heat transfer- Donald Q. Kern, Tata McGraw Hill Publishing Company Ltd.
3. Heat Exchangers Selection, Rating and Thermal Design- SadikKakac and Hongtan Liu, CRC Press.
4. Process Heat Transfer- Sarit K.Das, Narosa Publishing House Pvt. Ltd.

Reference Books:

1. Cengel, Y. A. (2014). Heat transfer. In Encyclopedia of Energy Engineering and Technology-Four Volume Set (Print) (pp. 846-853). CRC Press.
2. J P Holman, Souvik Bhattacharyya, 10th Edition, McGraw Hill Education Private Ltd

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/103/105/103105210/
- https://archive.nptel.ac.in/courses/103/107/103107207/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Classification of Heat Exchangers	Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, extended surface heat exchanger, Plate fin and Tabular fin. Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multi pass, cross flow heat exchanger design calculations.
2	Week 3-4: Double Pipe Heat Exchanger	Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Doublepipe exchangers in series parallel arrangements.
3	Week 5-6: Shell & Tube Heat Exchangers	Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.
4	Week 7-8: Condensation of Single Vapours	Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal

		Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.
5	Week 9-10: Vaporizers, Evaporators and Reboilers	Vaporizing processes, forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a re-boiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.
6	Week 11-12: Direct Contact Heat Exchanger	Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Basic Design Methods of Heat Exchanger	To provide the sufficient knowledge of concept, applications, importance of thermal design of Heat exchanger.
2	Designing of shell & tube heat exchangers, boilers, evaporators and direct contact heat exchangers	To familiarize the students about the heat exchanger design and its applications in real life situations.
3	Simulation	To carry out a computer simulation of heat exchanger design

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP301.1	Understand the physics and the mathematical treatment of typical heat exchangers and employ LMTD and Effectiveness methods in the design of heat exchangers
M23MTP301.2	Design, analyze and examine the performance of double-pipe counter flow (hair-pin) and shell and tube heat exchanger
M23MTP301.3	Understand the fundamental, physical and mathematical aspects of and condensation.
M23MTP301.4	Demonstrate the importance of Vaporizers, Evaporators and Reboilers as heat exchangers
M23MTP301.5	Classify cooling towers and explain their technical features.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP301.1	3		
M23MTP301.2			3
M23MTP301.3			3
M23MTP301.4			3
M23MTP301.5			3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The "Design of Heat Transfer Equipment's "course in the third semester of the M.Tech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Thermal Engineering. Here are some notable contributions:

- **Heat Exchanger Design and Optimization:** The course equips students with the skills necessary to design and optimize various types of heat exchangers, such as shell-and-tube, plate, and finned-tube heat exchangers. Mastery in this area is essential for applications in industries like power generation, chemical processing, and HVAC systems.

- **Enhanced Heat Transfer Techniques:** Students learn about advanced techniques to enhance heat transfer, including the use of fins, extended surfaces, and innovative materials. These skills are crucial for improving the efficiency of thermal systems in various engineering applications.

- **Energy Efficiency:** Understanding and designing efficient heat transfer equipment are key to reducing energy consumption and minimizing environmental impact in industrial processes. This aligns with global efforts towards sustainability and energy conservation.

- **Project Work and Research:** The course prepares students for research roles where they can contribute to the development of new technologies in heat transfer. This includes exploring novel materials, nanotechnology, and advanced computational methods for heat transfer analysis.

- **Industry Applications:** Graduates can engage in innovative projects that push the boundaries of current thermal engineering practices, leading to breakthroughs in areas such as micro-scale heat transfer and electronic cooling systems.

3rd Semester	Professional Elective Course (PE) ALTERNATIVE FUELS FOR IC ENGINES	M23MTP321

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Theory of IC engines	Basic knowledge of internal combustion engine operation and performance metrics. Familiarity with fuel properties and their impact on engine efficiency and emissions.
2.	Thermodynamics	To excel in Alternative fuels for IC engines, students need to understand thermodynamic systems and properties, including open, closed, and isolated systems, as well as state properties like pressure, volume, temperature, and specific heats. They should be able to apply laws of thermodynamics, encompassing concepts of internal energy, work, heat, and energy conservation, covering entropy, irreversibility, and the Carnot cycle. Additionally, proficiency in analyzing thermodynamic processes (isothermal, adiabatic, isobaric, and isochoric) is essential.
3.	Heat transfer	Students should have fundamental knowledge of conduction, convection, and radiation, Knowledge of heat transfer equations and their applications.
4.	Understanding of Physical Quantities and Units	Students should be comfortable with concepts like mass, length, time, temperature, pressure, and be able to work with different unit systems (SI units are preferred).
5.	Physics Fundamentals	Students need a strong grasp of Newtonian mechanics, including the concepts of force, motion, and energy. They should understand the principles of work and energy, as well as power and efficiency. A basic understanding of heat transfer, temperature scales, and the properties of matter is an added advantage.
6.	Chemistry Fundamentals	Students should be familiar with the basic structure of atoms, molecules, and ions. They must understand chemical reactions, including stoichiometry and conservation of mass. Knowledge of the ideal gas law and other gas laws, as well as phase changes and basic thermodynamic quantities such as enthalpy and entropy, is an added advantage.

2. Competencies

S/L	Competency	KSA Description
1.	Conventional Fuels, Properties of petroleum products	**Knowledge:** Understand the types and sources of conventional fuels, including coal, natural gas, and crude oil. **Skills:** Analyze the properties and characteristics of different conventional fuels. **Attitudes:** Appreciate the role of conventional fuels in meeting global energy demands.
2.	Alternative fuels for I.C. engines, Single Fuel Engines	**Knowledge:** Understand the different types of alternative fuels for internal combustion (IC) engines, such as biofuels (e.g., ethanol, biodiesel), natural gas (CNG, LNG), hydrogen, and synthetic fuels. **Skills:** Analyze the feasibility and performance implications of using alternative fuels in IC engines. **Attitudes:** Appreciate the environmental benefits and challenges associated with alternative fuels for IC engines.
3.	Dual fuel Engine:	**Knowledge:** Understand the concept of dual fuel engines, which operate on a combination of two fuels, typically diesel or natural gas paired with a gaseous or liquid alternative fuel **Skills:** Analyze the performance and efficiency of dual fuel engines under different operating conditions. **Attitudes:** Recognize the environmental advantages, such as lower emissions and

		compliance with stringent emission regulations, associated with dual fuel engine technologies.
4.	Biodiesels and their availability	**Knowledge:** Understand biodiesel as a renewable fuel derived from vegetable oils, animal fats, or recycled cooking oils. **Skills:** Analyze the production processes and technological advancements in biodiesel production. **Attitudes:** Appreciate the environmental benefits of biodiesel, including reduced greenhouse gas emissions and decreased dependency on fossil fuels.
5.	Environmental pollution	**Knowledge:** Understand environmental pollution as the introduction of harmful contaminants into the natural environment, impacting air, water, soil, and ecosystems. **Skills:** Evaluate the effectiveness of pollution control measures and mitigation strategies to reduce environmental impacts. **Attitudes:** Recognize the role of individuals, industries, and governments in protecting natural resources for future generation

3. Syllabus

ALTERNATIVE FUELS FOR IC ENGINES
SEMESTER – III

Course Code	M23MTP321	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	03	Exam Hours	**03**

Course objectives: This course will enable students to:
- To Understand the need of alternative fuels, environment impact, types of alternative fuels, preparation of alternative fuels
- To familiarize the students about engine alteration to use alternative fuels
- To understand the current status of alternative fuels

Module	
Module -1	
Conventional Fuels: Introduction, Current fuel scenario and consumption, per capita consumption Indian scenario, Structure of petroleum, refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels. **Properties of petroleum products**: Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloud point, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.	L1, L2
Module -2	
Alternative fuels for I.C. engines: Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing. **Single Fuel Engines**: Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation.	L1, L2
Module -3	
Dual fuel Engine: Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.	L1, L2
Module -4	
Biodiesels: What are biodiesels Need of biodiesels, Properties of bio-diesels v/s Petro-diesel, Performance and emission characteristics of bio-diesels v/s Petro diesel operation. **Availability:** Suitability & Future prospects of these gaseous fuels in Indian context.	L1, L2
Module -5	
Environmental pollution: with conventional and alternate fuels, Pollution control methods and	L1,

packages. Euro norms, Engine missions, Emission control methods, EPA. Air quality emission standards	L2

Text Books:

1. A Course in Internal Combustion Engines - R.P Sharma & M.L. Mathur, Danpat Rai & Sons
2. Elements of Fuels, Furnaces & Refractories - O.P. Gupta, Khanna Publishers.
3. Internal Combustion Engines -Domkundwar V.M., I Edition, DhanpatRai& Sons.
4. Internal Combustion Engines Fundamentals - John B. Heywood, McGraw Hill International Edition

Reference Books:

1. Present and Future Automotive Fuels - Osamu Hirao& Richard Pefley, Wiley Inter Science Publications.
2. Internal Combustion Engines - V. Ganesan, Tata McGraw-Hill Publications.
3. M.K. Gajendra Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013.
4. Richard L. Bechfold, Alternative Fuels Guidebook - SAE International Warrendale 1997.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=ZEEVENZKkGM&list=PLjI7n73QrhzSPo_xrKmBLaz9DIL3XP2f6

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Conventional Fuels	Introduction, Current fuel scenario and consumption, per capita consumption. Indian scenario, Structure of petroleum, refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels
2	Week 3-4: Properties of petroleum products	Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloud point, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.
3	Week 5-6: Alternative fuels for I.C. engines	Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing
4	Week 7-8: Single Fuel Engines	Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation. Vertical reflux type condenser. Condensation of steam.
5	Week 9-10: Dual fuel Engine	Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.
6	Week 11-12: Biodiesels and Environmental pollution:	What are biodiesels Need of biodiesels, Properties of bio-diesels v/s Petro-diesel, Performance and emission characteristics of bio-diesels v/s Petro diesel operation. **Availability:** Suitability & Future prospects of these gaseous fuels in Indian context. Pollution control methods and packages. Euro norms, Engine missions, Emission control methods, EPA. Air quality emission standards

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.

5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Need for alternate fuels	To Understand the need of alternative fuels, environment impact, types of alternative fuels, preparation of alternative fuels
2	Conventional engine design and required alteration	To familiarize the students about engine alteration to use alternative fuels
3	Present scenario of alternate fuels	To understand the current status of alternative fuels

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP321.1	Explain about the availability and usage of conventional fuels for IC engines.
M23MTP321.2	Identify possible alternative fuels for IC engines
M23MTP321.3	Demonstrate the use of alternative fuels for different types of engines
M23MTP321.4	Assess the environmental impact standards and procedures of using alternate fuels.
M23MTP321.5	Describe and analyze Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen and their manufacturing procedure.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP321.1	3		
M23MTP321.2	3		
M23MTP321.3	3		
M23MTP321.4	3		
M23MTP321.5	3		

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The "**Alternative Fuels for IC Engines"** course in the third semester of the M.Tech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Thermal Engineering. Here are some notable contributions:

- **Environmental Impact:** By studying alternative fuels, students will develop a deep understanding of their role in reducing carbon emissions and mitigating environmental pollution. They will be equipped to advocate for and implement sustainable practices in transportation and energy sectors, aligning with global environmental goals.

- **Availability and optimization:** They will develop skills in engine calibration, emissions control, and combustion optimization specific to different types of alternative fuels, considering their availability and regional variations.

- **Project Work and Research:** Students will engage in research projects aimed at improving the efficiency, reliability, and environmental impact of IC engines running on alternative fuels.

- **Industry Applications:** They will contribute to innovations in engine design, fuel blending techniques, and emissions control technologies, shaping the future of sustainable transportation.

3rd Semester	Professional Elective Course (PE) THERMAL POWER STATION	M23MTP322

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Thermodynamics	To excel in Design of Heat Transfer Equipment's, students need to understand thermodynamic systems and properties, including open, closed, and isolated systems, as well as state properties like pressure, volume, temperature, and specific heats. They should be able to apply laws of thermodynamics, encompassing concepts of internal energy, work, heat, and energy conservation, covering entropy, irreversibility, and the Carnot cycle. Additionally, proficiency in analyzing thermodynamic processes (isothermal, adiabatic, isobaric, and isochoric) and fundamental cycles such as Carnot and Rankine is essential.
2.	Heat transfer	Students should have fundamental knowledge of conduction, convection, and radiation, Knowledge of heat transfer equations and their applications. Principles of heat exchanger design, types of heat exchangers.
3.	Fluid Mechanics	Basic principles of fluid mechanics, including fluid properties, fluid statics, and fluid dynamics.
4.	Understanding of Physical Quantities and Units	Students should be comfortable with concepts like mass, length, time, temperature, pressure, and be able to work with different unit systems (SI units are preferred).
5.	Physics Fundamentals	Students need a strong grasp of Newtonian mechanics, including the concepts of force, motion, and energy. They should understand the principles of work and energy, as well as power and efficiency. A basic understanding of heat transfer, temperature scales, and the properties of matter is an added advantage.
6.	Chemistry Fundamentals	Students should be familiar with the basic structure of atoms, molecules, and ions. They must understand chemical reactions, including stoichiometry and conservation of mass. Knowledge of the ideal gas law and other gas laws, as well as phase changes and basic thermodynamic quantities such as enthalpy and entropy, is an added advantage.

2. Competencies

S/L	Competency	KSA Description
1.	Steam Generator and Auxiliaries	**Knowledge:** Understand steam generation processes, boiler types, heat transfer mechanisms, and steam cycle configurations like Rankine cycle. **Skills:** Select steam generators based on operational requirements and performance criteria. **Attitudes:** Appreciate the critical role of steam generators in power station, and commit to optimizing efficiency, reliability, and safety in their operation
2.	Dust Extraction Equipment	**Knowledge:** Understand the principles and operation of dust extraction systems, including types of dust collectors **Skills:** Ability to design and evaluate dust extraction systems based on industrial needs, calculate airflow rates, pressure drops, and select appropriate filtration media **Attitudes:** Appreciate the importance of effective dust extraction systems in maintaining workplace safety, health standards, and environmental regulations.
3.	Feed Water system	**Knowledge:** Understand the components and operation of feed water systems in steam power plants, including feedwater heaters, deaerators, pumps, and control systems. **Skills:**

		Ability to analyze and optimize feed water systems for efficient steam generation. **Attitudes:** Appreciate the critical role of feed water systems in maintaining steam plant efficiency, reliability, and safety.
4.	Performance of power plant equipment	**Knowledge:** Understand the operational principles, design features, and maintenance requirements of key power plant equipment such as turbines, boilers, condensers, and generators. **Skills:** Ability to analyze and evaluate the performance metrics of power plant equipment including efficiency, reliability, availability, and heat rate calculations. **Attitudes:** Appreciate the significance of maintaining optimal performance in power plant equipment to ensure continuous and reliable electricity generation.
5.	Miscellaneous of steam power plant	**Knowledge:** Understanding operational strategies, layout considerations, and configurations essential for optimizing power plant performance. **Skills:** Ability to accurately estimate costs and conduct comparative analyses to evaluate the feasibility and efficiency of different power plant technologies. **Attitudes:** Prioritizing safety measures and sustainable practices to ensure safe operations and minimize environmental impact.

3. Syllabus

THERMAL POWER STATION SEMESTER – III			
Course Code	M23MTP322	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	03	Exam Hours	**03**

Course objectives: This course will enable students to:

- To understand merits and demerits of various power plant and Criteria for selection of power plant and economics.
- To understand various safety devices and controlling devices for power plant Comparison of various power plants on efficiencies, working performance, and characteristics.
- To plan and design the experimental investigations efficiently and effectively.
- To practice statistical software to achieve robust design of experiments.

Module -1	
Steam Generator and Auxiliaries: High pressure boilers, classification, schemes¸ circulation, nature of fuels and its influence on design, furnaces, PF burners, PF milling plant, oil and gas burner types and location, arrangement of oil handling plant. Waste heat recovery systems. Operation and Maintenance of Steam Generators and auxiliaries: Pre commissioning activities, Boiler start up and shut down procedures, emergencies in boiler operation, Maintenance of Steam generator and auxiliaries.	L1, L2
Module -2	
Dust Extraction Equipment: Bag house, electrostatic precipitator, draught systems, FD, ID and PA fans, chimneys, flue and ducts, dampers, thermal insulation, and line tracing, FBC boilers and types., waste heat recovery boilers.	L1, L2
Module -3	
Feed Water system: Impurities in water and its effects, feed and boiler water corrosion, quality of feed water, boiler drum water treatment and steam purity, water treatment, clarification, demineralization, evaporation, and reverse osmosis plant. Circulating water system: Introduction, System classification, The circulation system, Wet-Cooling towers, Wet-cooling tower calculations, Dry cooling towers, Dry-cooling towers and plant efficiency and economics, wet-dry cooling towers, cooling-tower icing, Cooling lakes and ponds, Spray ponds and canals.	L1, L2
Module -4	

Performance: Boiler efficiency and optimization, coal mill, fans, ESP. EIA study: Pollutants emitted, particulate matter, SOx and NOx and ground level concentration, basic study of stack sizing.	L1, L2
Module -5	
Miscellaneous of steam power plant: Methods of loading, plant selection, arrangements, useful life of plant components, pumps, cost estimation steam power plant, comparison of different power plants, current scenario of thermal power generation in India, Indian boiler act and amendments, case studies.	L1, L2

Text Books:

- Power Plant Engineering - P.K. Nag, Tata McGraw-Hill Publications. 2nd edition
- Power Plant Engineering - M.M. EI-Wakil, McGraw- Hill Publications. 1st edition

Reference Books:

- Power plant engineering –R.K. Rajput,Laxmi Publications 3rd edition
- Drbal, L., Westra, K., & Boston, P. (Eds.). (2012). *Power plant engineering*. Springer Science & Business Media.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/112/107/112107291/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Steam Generator and Auxiliaries:	High pressure boilers, classification, schemes¸ circulation, nature of fuels and its influence on design, furnaces, PF burners, PF milling plant, oil and gas burner types and location, arrangement of oil handling plant. Waste heat recovery systems
2	Week 3-4: Operation and Maintenance of Steam Generators	Pre commissioning activities, Boiler start up and shut down procedures, emergencies in boiler operation, Maintenance of Steam generator and auxiliaries.
3	Week 5-6: Dust Extraction Equipment	Bag house, electrostatic precipitator, draught systems, FD, ID and PA fans, chimneys, flue and ducts, dampers, thermal insulation, and line tracing, FBC boilers and types, waste heat recovery boilers.
4	Week 7-8: Feed Water system	Impurities in water and its effects, feed and boiler water corrosion, quality of feed water, boiler drum water treatment and steam purity, water treatment, clarification, demineralization, evaporation, and reverse osmosis plant.
5	Week 9-10: Cooling towers	Circulating water system: Introduction, System classification, The circulation system, Wet-Cooling towers, Wet-cooling tower calculations, Dry cooling towers, Dry-cooling towers and plant efficiency and economics, wet-dry cooling towers, cooling-tower icing, Cooling lakes and ponds, Spray ponds and canals.
6	Week 11-12: Miscellaneous of steam power plant	**M**ethods of loading, plant selection, arrangements, useful life of plant components, pumps, cost estimation steam power plant, comparison of different power plants, current scenario of thermal power generation in India, Indian boiler act and amendments, case studies.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Selection of power plants	To understand merits and demerits of various power plant and Criteria for selection of power plant and economics.
2	Performance and safety of power station	To understand various safety devices and controlling devices for power plant Comparison of various power plant on efficiencies, working performance, and characteristics.
3	Efficiency of the plant	To plan and design the experimental investigations efficiently and effectively.
4	Design of experiments	To practice statistical software to achieve robust design of experiments.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP322.1	Describe the working principle, operation, and maintenance of a various steam generators.
M23MTP322.2	Identify the arrangements of different flow systems their operation and maintenance.
M23MTP322.3	Illustrate the impact of thermal power plant exhaust on environment.
M23MTP322.4	Estimate the working expenses, current scenario and trends in power generation.
M23MTP322.5	Asses the performance and suitability of thermal power plant

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP322.1	3		
M23MTP322.2	3		
M23MTP322.3	3		
M23MTP322.4	3		
M23MTP322.5	3		

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The "Thermal Power Station" course in the third semester of the M.Tech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Thermal Engineering. Here are some notable contributions:

- **Design and Optimization:** The course equips students with the skills necessary to understand and optimize various auxiliaries associated with thermal power station.
- **Energy Efficiency and Optimization:** The focus will be on optimizing plant performance through advanced control systems, predictive maintenance techniques, and efficient water and energy management practices. This will contribute to reducing operational costs and improving overall plant reliability.
- **Environmental Regulations:** With stringent environmental regulations worldwide, there will be a growing emphasis on developing cleaner and low-emission technologies. This includes advancements in emissions control technologies and compliance with global emission standards.

3rd Semester	Professional Elective Course (PE) CONVECTIVE HEAT AND MASS TRANSFER	M23MTP323

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Mathematics	A solid understanding of calculus (differentiation, integration), differential equations, and linear algebra is essential. This will be used for manipulating complex equations and solving problems related to heat transfer rates and boundary layer analysis.
2.	Fluid Mechanics	Prior knowledge of fluid mechanics principles, including fluid properties, basic fluid flow concepts (continuity equation, Bernoulli's equation), and basic understanding of laminar and turbulent flows, is necessary. This provides a foundation for comprehending the interaction between fluids and heat transfer.
3.	Thermodynamics	Familiarity with basic thermodynamic concepts like heat transfer mechanisms (conduction, convection, radiation), first and second laws of thermodynamics, and energy balances will be beneficial. This knowledge helps understand the role of convection in energy transfer processes.
4.	Engineering Problem-Solving	The ability to apply scientific principles to solve engineering problems is crucial. Students should be comfortable with analyzing problems, formulating mathematical models, and interpreting results.
5.	Heat Transfer Fundamentals	A basic understanding of conduction heat transfer can provide a smoother transition to studying convection.
6.	Computational Tools	Some advanced topics might involve using computational fluid dynamics (CFD) software for simulating complex convection problems. Familiarity with programming concepts like loops, functions, and data structures can ease the learning curve when working with such software.

2. Competencies

S/L	Competency	KSA Description
1.	Analyze and solve problems related to convective heat transfer.	**Knowledge:** • Principles of forced, free, and combined convection • Dimensional analysis and dimensionless groups • Governing equations for convective heat transfer (continuity, Navier-Stokes, energy) • Boundary layer theory **Skills:** • Apply dimensional analysis to formulate relevant parameters • Solve governing equations for simple geometries (analytically or numerically) • Analyze heat transfer rates in different convection modes **Attitudes:** • Analytical thinking and problem-solving approach • Ability to handle complex calculations
2.	Design and optimize convective heat transfer systems.	**Knowledge:** • Convection heat transfer in internal and external flows • Convection in porous media • Impact of geometry and flow conditions on heat transfer **Skills:** • Design heat exchangers and other convection-based system • Select appropriate materials and surface properties for heat transfer enhancement • Apply computational tools for simulating convection phenomena **Attitudes:** • Creativity and innovation in design solutions • Attention to detail and optimization of performance
3.	Effectively communicate technical concepts	**Knowledge:** • Terminology and principles of convection heat transfer • Engineering communication principles

	related to convection heat transfer.	**Skills:** • Write clear and concise technical reports • Present findings effectively through presentations and discussions • Explain complex concepts to a technical audience **Attitudes:** • Strong written and verbal communication skills • Ability to collaborate effectively in a team setting
4.	Apply knowledge of convection heat transfer to real-world engineering applications.	**Knowledge:** • Applications of convection in various engineering fields (e.g., thermal management, energy systems, process engineering) • Current trends and advancements in convection heat transfer technology **Skills:** • Identify and analyze convection-related challenges in engineering problems • Apply theoretical knowledge to solve practical engineering problems • Stay updated with new developments in the field **Attitudes:** • Curiosity and interest in real-world applications • Adaptability and willingness to learn new technologies
5.	Utilize computational tools for analyzing convection problems	**Knowledge:** • Basic principles of computational fluid dynamics (CFD) • Capabilities of relevant engineering software for simulating convection **Skills:** • Pre-process and post-process data for CFD simulations • Interpret results from CFD simulations for convection analysis **Attitudes:** • Openness to learning new software tools • Ability to integrate computational tools with theoretical knowledge

3. Syllabus

Convective Heat and Mass Transfer **SEMESTER – III**			
Course Code	M23MTP323	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	03	Exam Hours	**03**

Course objectives: This course will enable students to -

- To analyze details of energy equations and develop models for physical problems.
- To analyze heat transfer for duct flow with different boundary conditions.
- To Implement various turbulence models for heat transfer problems and analyze problems involving convection with phase changes.
- To analyze mass transfer during convection for different physical problems.

Module -1

INTRODUCTION TO FORCED, FREE & COMBINED CONVECTION – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers. **Equations of Convective Heat Transfer:** Continuity, Navier-Strokes equation & energy equation for steady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layer equations for laminar, turbulent flows – Boundary layer integral equations**.**

Module -2

EXTERNAL LAMINAR FORCED CONVECTION: Similarity solution for flow over an isothermal plate– integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flat plate. **External Turbulent Flows:** Analogy solutions for boundary layer flows – Integral equation solutions Effects of dissipation on flow over a flat plate. **Internal Laminar Flows:** Fully developed laminar flow in pipe, plane duct & ducts with other cross-sectional shapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & plane duct flow with developing velocity & temperature fields. **Internal Turbulent Flows:**

Analogy solutions for fully developed pipe flow –Thermally developing pipe & plane duct flow.

Module -3

NATURAL CONVECTION: Boussineq approximation – Governing equations – Similarity – Boundary layer equations for free convective laminar flows – Numerical solution of boundary layer equations. Free Convective flows through a vertical channel across a rectangular enclosure – Horizontal enclosure – Turbulent natural convection.

Module -4

COMBINED CONVECTION: Governing parameters & equations – laminar boundary layer flow over an isothermal vertical plate – combined convection over a horizontal plate – correlations for mixed convection – effect of boundary forces on turbulent flows – internal flows - internal mixed convective flows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct

Module -5

CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA: Area weighted velocity – Darcy flow model – energy equation – boundary layer solutions for 2-D forced convection – Fully developed duct flow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers. **Convective Mass Transfer:** Basic Definitions and Formulation of a Simplified Theory, Evaluation of The Mass-Transfer Conductance, Examples for application of the Simplified Method.

Text Books:

- Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001
- Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003
- Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, New York, 2001.

Reference Books:

- Spalding D B, "Introduction to Convective Mass Transfer", McGraw Hill, 1963.
- Bird R. B., Stewart W. E. and Lightfoot E. N., " Transport Phenomena ", John Wiley and Sons, Inc., 1960.
- Schlichting H., " Boundary Layer Theory ", Sixth edition, McGraw Hill, 1968.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/112/104/112104159/
- https://archive.nptel.ac.in/courses/112/101/112101002/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Convection	Lecture 1: Introduction to Forced, Free & Combined Convection Lecture 2: Dimensional Analysis in Convection Skill Development 1: Problem-solving exercises on dimensional analysis Skill Development 2: Case study - Applying convection principles
2	Week 3-4: External and Internal Flows	Lecture 3: External Laminar Forced Convection Lecture 4: Internal Laminar Flows Skill Development 3: Simulation of external laminar flow Skill Development 4: Project - Analyzing internal flow in a duct
3	Week 5-6: Natural Convection	Lecture 5: Governing Equations and Boundary Layers Lecture 6: Free Convection Flows Skill Development 5: Numerical solution of boundary layer equations Skill Development 6: Guest Lecture (optional) - Applications of Natural Convection
4	Week 7-8: Combined Convection	Lecture 7: Governing Parameters and Equations Lecture 8: Laminar and Turbulent Combined Flows Skill Development 7: Problem-solving exercises on combined convection Skill Development 8: Student presentations - Research on combined convection
5	Week 9-10: Convection in Porous Media and Mass Transfer	Lecture 9: Convective Heat Transfer in Porous Media Lecture 10: Basic Definitions of Convective Mass Transfer Skill Development 9: Project - Simulation of convection in porous media

		Skill Development 10: Case study - Applying convective mass transfer principles
6	Week 11-12: Final week	Course review and Q&A sessions Final exam or project

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Analyze convection with dimensions	Students will demonstrate the ability to identify relevant variables, formulate dimensionless groups, and interpret their physical significance in the context of forced, free, and combined convection.
2	Solve equations for convection	Students will develop the skills to apply continuity, Navier-Stokes, and energy equations to analyze steady-state convective flows. They will be able to solve these equations for simple geometries using analytical or numerical techniques.
3	Distinguish convection modes	Students will gain a comprehensive understanding of the driving forces behind each convection mode. They will be able to identify governing parameters, analyze boundary layer behavior, and predict heat transfer rates for different scenarios.
4	Design convection in porous media	Students will learn about modeling techniques for heat and mass transfer in porous materials. They will be able to apply their knowledge to solve practical problems encountered in various engineering fields.
5	Communicate convection knowledge	Students will develop critical thinking and communication skills by presenting their solutions to convection problems and participating in class discussions. They will learn to effectively explain complex concepts and technical details in a clear and concise manner.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP323.1	Understand the fundamental and advanced principles of forced and natural convection heat transfer processes.
M23MTP323.2	Formulate and solve convective heat transfer problems
M23MTP323.3	Relate the principles of convective heat transfer to estimate the heat dissipation from devices.
M23MTP323.4	Estimate the energy requirements for operating a flow system with heat transfer.
M23MTP323.5	Relate to the current challenges in the field of convective heat transfer.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP323.1	3		
M23MTP323.2			3
M23MTP323.3			3
M23MTP323.4			3
M23MTP323.5			3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The future of convection heat transfer is bright and holds exciting possibilities for a variety of fields. Here are some key areas of exploration:

1. **Advanced Computational Techniques:** The future lies in leveraging sophisticated computational tools like CFD (Computational Fluid Dynamics) to analyze complex turbulent flows and heat transfer in intricate geometries. This will enable the design of highly efficient heat transfer systems.
2. **Nanofluids and Metamaterials:** Research on nanofluids (fluids with suspended nanoparticles) and thermal metamaterials with tailored properties is expected to unlock new possibilities for enhanced heat transfer rates and precise thermal management in various applications.
3. **Microfluidics and Miniaturization:** With miniaturization trends across various industries, understanding and manipulating convection at the microscale will be crucial. This could lead to breakthroughs in microfluidic devices for lab-on-a-chip applications and thermal management in miniaturized electronics.
4. **Sustainable Energy Systems:** Optimizing heat transfer processes will be vital for developing efficient and sustainable energy technologies. This includes advancements in heat exchangers for power plants, thermal management in solar energy systems, and designing efficient cooling systems for buildings.
5. **Biomedical Applications:** Understanding heat transfer principles will play a role in developing new medical technologies, such as hyperthermia cancer treatment or targeted drug delivery using thermal stimuli.

3rd Semester	Professional Elective Course (PE) GAS DYNAMICS	M23MTP324

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Thermodynamics	To excel in Alternative fuels for IC engines, students need to understand thermodynamic systems and properties, including open, closed, and isolated systems, as well as state properties like pressure, volume, temperature, and specific heats. They should be able to apply laws of thermodynamics, encompassing concepts of internal energy, work, heat, and energy conservation, covering entropy, irreversibility, and the Carnot cycle. Additionally, proficiency in analyzing thermodynamic processes (isothermal, adiabatic, isobaric, and isochoric) is essential.
2.	Heat transfer	Students should have fundamental knowledge of conduction, convection, and radiation, Knowledge of heat transfer equations and their applications.
3.	Understanding of Physical Quantities and Units	Students should be comfortable with concepts like mass, length, time, temperature, pressure, and be able to work with different unit systems (SI units are preferred).
4.	Physics Fundamentals	Students need a strong grasp of Newtonian mechanics, including the concepts of force, motion, and energy. They should understand the principles of work and energy, as well as power and efficiency. A basic understanding of heat transfer, temperature scales, and the properties of matter is an added advantage.
5.	Chemistry Fundamentals	Students should be familiar with the basic structure of atoms, molecules, and ions. They must understand chemical reactions, including stoichiometry and conservation of mass. Knowledge of the ideal gas law and other gas laws, as well as phase changes and basic thermodynamic quantities such as enthalpy and entropy, is an added advantage.

2. Competencies

S/L	Competency	KSA Description
1.	Fundamental equations of steady flow and Isentropic flow	**Knowledge:** Understand the basic principles and equations governing steady and isentropic fluid flow. **Skills:** Apply continuity, momentum, and energy equations to steady and isentropic flow problems. **Attitudes:** Appreciate the importance of steady flow and isentropic analysis in engineering applications.
2.	Variable area flow:	**Knowledge:** Understand the principles of fluid flow through ducts with varying cross-sectional areas. **Skills:** Apply the equations governing variable area flow to analyze changes in velocity, pressure, and area. **Attitudes:** Appreciate the significance of variable area flow in designing efficient fluid systems.
3.	Flow with normal shock waves	**Knowledge:** Understand the principles and characteristics of normal shock waves in compressible flow. **Skills:** Apply shock wave equations to analyze changes in pressure, temperature, and density across the shock. **Attitudes:** Recognize the importance of normal shock waves in high-speed aerodynamics and engineering applications.
4.	Flow with oblique shock waves	**Knowledge:** Understand the principles and characteristics of oblique shock waves in compressible flow. **Skills:** Apply the equations for oblique shock waves to determine changes in flow properties and shock angles. **Attitudes:** Appreciate the role of oblique shock waves in the design and analysis of supersonic aircraft and related technologies.
5.	Flow in constant area with heat transfer	**Knowledge:** Understand the principles of fluid flow in a constant area duct with heat addition or removal. **Skills:** Apply the energy equation to analyze temperature, pressure, and density changes in the presence of heat transfer.

		Attitudes: Recognize the importance of heat transfer in constant area flow for applications like gas turbines and heat exchangers.

3. Syllabus

GAS DYNAMICS SEMESTER – III			
Course Code	M23MTP324	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	03	Exam Hours	**03**

Course objectives: This course will enable students to:

- To formulate and solve problems in one -dimensional steady compressible flow
- To apply conservation laws to fluid flow problems
- To gain knowledge about main properties which are used for analyzing or modeling of compressible flow
- Solve flow problems with heat addition and with friction, and simulation of One-dimensional flow in Shock tube

Module -1		
Fundamental equations of steady flow: Definition of Compressible Flow, Flow Regimes, Continuity and momentum equation and energy equation. **Isentropic flow:** Acoustic velocity, Mach number, Mach cone and Mach angle. Flow parameters, stagnation temperature, pressure and density.		L3 L4
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs.
Module -2		
Variable area flow: Velocity variation with Isentropic flow, Criteria for acceleration and deceleration. Flow through nozzle, Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle. Effect of back pressure on nozzle flow. Isothermal flow functions and Flow Generalized one dimensional flow.		L3 L4
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Module -3		
Flow with normal shock waves: Development of shock wave, Rarefaction wave, Governing equations, Prandtl-Meyer relation, Mach number downstream, Static pressure rise, Density ratio, Temperature ratio, Tables, and charts for normal shock.		L3 L4 L5
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs.
Module -4		
Flow with oblique shock waves: Fundamental relations, Prandtl's equation, Rankine- Hugoniot equation, Variation of flow parameters and Gas tables for oblique shocks. Over-expanded and under expanded flows.		L3 L4 L5
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Module -5		
Flow in constant area with heat transfer: Stagnation temperature change. Rayleigh line, Pressure ratio and temperature ratio, Entropy considerations and maximum heat transfer. Flow in constant area with friction: Fanno curves, The fanning equation, Friction factor and friction parameter, Fanno line and Fanno flow equations		L3 L4
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs

Suggested Learning Resources:

Text Books

1. Fundamentals of Compressible flow: Yahya, 2nd Edn. 1991; Wieley Eastern.
2. Gas Dynamics, E Radhakrishnan PHI-2006
3. Gas Dynamics, Becker, Academic Press. Inc.
4. Introduction to Gas Dynamics: Rolty, wiley 1998
5. Elements of Gas Dynamics: Liepmann and roshko, Wiley 1994.
6. The dynamics and thermodynamics of compressible fluid flow: Shapiro Ronold press. 1994.
7. Modern Compressible Flow, Anderson John D, McGraw Hill Publication, 1990

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/101/108/101108086
https://archive.nptel.ac.in/courses/112/106/112106196
https://drive.google.com/file/d/1OWSzp9FPMcwpsB1emoQp0pl2tGquncZQ/view
https://drive.google.com/file/d/1G5nMQapAHwRk3nfpwWtovJLlwjDgp-Zp/view

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: **Fundamental equations of steady flow:**	**Fundamental equations of steady flow:** Definition of Compressible Flow, Flow Regimes, Continuity and momentum equation and energy equation.
2	Week 3-4: **Isentropic Flow**	Acoustic velocity, Mach number, Mach cone and Mach angle. Flow parameters, stagnation temperature, pressure and density.
3	Week 5-6: **Variable area flow**	Velocity variation with Isentropic flow, Criteria for acceleration and deceleration. Flow through nozzle, Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle. Effect of back pressure on nozzle flow. Isothermal flow functions and Flow Generalized one dimensional flow.
4	Week 7-8: **Flow with normal shock waves:**	Development of shock wave, Rarefaction wave, Governing equations, Prandtl-Meyer relation, Mach number downstream, Static pressure rise, Density ratio, Temperature ratio, Tables, and charts for normal shock.
5	Week 9-10: **Flow with oblique shock waves:**	Fundamental relations, Prandtl‘s equation, Rankine- Hugoniot equation, Variation of flow parameters and Gas tables for oblique shocks. Over-expanded and under expanded flows.
6	Week 11-12: **Flow in constant area with heat transfer**	**Flow in constant area with heat transfer:** Stagnation temperature change. Rayleigh line, Pressure ratio and temperature ratio, Entropy considerations and maximum heat transfer. Flow in constant area with friction: Fanno curves, The fanning equation, Friction factor and friction parameter, Fanno line and Fanno flow equations

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

	Components	Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10

(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	**Fundamental equations of steady flow**	To formulate and solve problems in one -dimensional steady compressible flow and To apply conservation laws to fluid flow problems
3	**Flow with normal and shock waves:**	To gain knowledge about main properties which are used for analyzing or modelling of compressible flow
4	**Flow with oblique shock waves:**	Solve flow problems with heat addition and with friction, and simulation of One-dimensional flow in Shock tube

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP324.1	Apply continuity, momentum, and energy equations to compressible flows
M23MTP324.2	Analyze isentropic and non-isentropic flows across normal shock waves.
M23MTP324.3	Solve compressible flow problems involving heat transfer and friction.
M23MTP324.4	Apply conservation laws to fluid flow problems and gain knowledge about main properties which are used for analyzing or modelling of compressible flow.
M23MTP324.5	Solve flow problems with heat addition and with friction and Simulation of One-dimensional flow in Shock tube

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP324.1	3		
M23MTP324.2			3
M23MTP324.3			3
M23MTP324.4			3
M23MTP324.5			3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**

Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The "**Gas Dynamics"** course in the third semester of the M.Tech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Thermal Engineering. Here are some notable contributions:

- **Advanced Computational Tools**: Future advancements will leverage computational fluid dynamics (CFD) to model and optimize complex flow regimes with higher accuracy and efficiency.
- **Integration with AI and Machine Learning:** Utilization of AI algorithms for real-time analysis and control of steady flow systems in aerospace, automotive, and energy sectors.
- Flow with Heat Transfer: Innovations in materials and heat exchange systems for improved energy efficiency and thermal performance in constant area flow applications.
- **Project Work and Research:** Research into novel materials and structures to mitigate shock wave impacts and improve aerodynamic efficiency.
- **Industry Applications:** Exploration of shock wave interactions in hypersonic flight to push the boundaries of speed and efficiency in aerospace.

3rd Semester	Professional Elective Course (PE) MEASUREMENT SYSTEMS IN THERMA ENGINEERING	M23MTP325

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Measurement systems and Metrology	Basic knowledge of metrology is essential; The proficiency in quantitative measurement of temperature and pressure is required.
2.	Response characteristics	The proficiency in steady state and transient state response characteristics for heat transfer is required.
3.	Heat transfer	Students should have fundamental knowledge of conduction, convection, and radiation, Knowledge of heat transfer equations and their applications.
4.	Understanding of Physical Quantities and Units	Students should be comfortable with concepts like mass, length, time, temperature, pressure, and be able to work with different unit systems (SI units are preferred).
5.	Physics Fundamentals	Students need a strong grasp of Newtonian mechanics, including the concepts of force, motion, and energy. They should understand the principles of work and energy, as well as power and efficiency. A basic understanding of heat transfer, temperature scales, and the properties of matter is an added advantage.
6.	Chemistry Fundamentals	Students should be familiar with the basic structure of atoms, molecules, and ions. They must understand chemical reactions, including stoichiometry and conservation of mass. Knowledge of the ideal gas law and other gas laws, as well as phase changes and basic thermodynamic quantities such as enthalpy and entropy, is an added advantage.

2. Competencies

S/L	Competency	KSA Description
1.	Proficiency in selecting Sensors and Transducers	**Knowledge**: Fundamental knowledge of mechanical and electrical system. **Skills**: Integration of mechatronics components into system. **Attitudes:** Proficiency in integration of design of mechatronics system.
2.	Measurement of Pressure and Temperature	**Knowledge:** The proficiency in selecting pressure and temperature measuring instruments. **Skills:** Comparison of various pressure and temperature measuring equipments based on specific application **Attitudes:** Effect of measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry with suitable environment.
3.	Measurement of Flow	**Knowledge:** The proficiency of analyzing the mechanics of different types of flow. **Skills:** Analysis and Measurement of flows using probes, flow meters etc **Attitudes:** Flow obstruction methods and techniques and their instrumentation.
4.	Thermal radiation measurement	**Knowledge:** The basic knowledge of radiation heat transfer concepts like reflectivity, transmissivity, emissivity for various bodies. **Skills:** Measurement of radiation heat transfer and its instrumentation.. **Attitudes:** Comparison of characteristics of thermal radiation equipments
5.	Nuclear radiation Measurement	**Knowledge:** Basic knowledge of radioactivity concepts like nuclear fusion and fission. **Skills:**

		Measurement of nuclear radiation.. **Attitudes:** The challenge of safely managing nuclear radiation instrument for environmental contamination is a significant concern

3. **Syllabus**

MEASUREMENT SYSTEMS IN THERMAL ENGINEERING SEMESTER – III			
Course Code	M23MTP325	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	03	Exam Hours	**03**

Course objectives: This course will enable students to:
- To Understand the concept of design of experiments
- To familiarize the students about the design of experiments techniques and their implementation
- To design and analysis a real-life problem using technique

Module -1		
Basics of Measurements: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs, and their methods of correction. **Pressure measurement:** Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.		L2 L3
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Module -2		
Thermometry: Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer. **Thermal and transport property measurement:** Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.		L3
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Module -3		
Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods. **Nuclear, thermal radiation measurement:** Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.		L3
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Module -4		
Analysis of experimental data: Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data. **Sensing Devices:** Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.		L3 L4
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Module -5		
Air-Pollution: Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement. **Advanced topics**: Issues in measuring thermo physical properties of micro and Nano fluids. **Design of Experiments:** Basic ideas of designing experiments, Experimental design protocols with some examples and DAS.		L2 L3
Peadagogy	Effective Lecturing, Active Learning, Digital Learning, Case-Based Learning, Effective Class Discussions and Assignments at home.	10 Hrs
Suggested Learning Resources: **Text Books**		

1. Coleman, Hugh W.; Experimentation and uncertainty analysis for engineers. ISBN: 0-471- 63517-0
2. Miller, Richard W; Flow Measurement Engineering Handbook. ISBN: 0-07-042366-0
3. Guide to the Expression of Uncertainty in Measurement, ISO, Genéve, 1995
4. Holman, J. P.; Experimental methods for engineers. ISBN: 0-07-118165-2
5. Robert P. Benedict; Fundamentals of temperature, pressure, and flow measurements
6. Robert A. Granger; Experiments in heat transfer and thermodynamics. ISBN: 0-521-44925-1
7. S P Venkateshan, Mechanical Measurements, Anne Books Pvt. Ltd., 2015.2.
8. J P Holman, Experimental Methods for Engineers, McGraw-Hill, 2011.
9. J R Taylor, An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, University Science Books, 1997
10. Doebelin, Measurement System, Tata McGraw-Hill Education, 1984
11. Beckwith, Mechanical Measurements, Pearson Education India, 2007

Web links and Video Lectures (e-Resources):
https://archive.nptel.ac.in/courses/112/107/112107242
https://drive.google.com/file/d/16NM5xKdvdemE_kp_PJVSaAwPoGLWVVg7/view

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: **Bsics of Measurements**	**Basics of Measurements:** Introduction, General measurement system, Signal flow diagram of measurement system, Inputs, and their methods of correction.
2	Week 3-4: **Pressure Measurements**	**Pressure measurement:** Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.
3	Week 5-6:**Thermometry and thermal and transport property measurement**	**Thermometry:** Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer. **Thermal and transport property measurement:** Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.
4	Week 7-8: **Flow and Nuclear thermal radiation measurement**	**Flow Measurement:** Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods. **Nuclear, thermal radiation measurement:** Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.
5	Week 9-10: **Analysis of experimental data**	**Analysis of experimental data:** Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data. **Sensing Devices:** Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.
6	Week 11-12: **Air pollution and DOE**	**Air-Pollution:** Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement. **Advanced topics**: Issues in measuring thermo physical properties of micro and Nano fluids. **Design of Experiments:** Basic ideas of designing experiments, Experimental design protocols with some examples and DAS.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
5	Problem-Based	Implement PBL to enhance analytical skills and practical application of

	Learning (PBL)	competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Principles of Measurement	Understand the basic principles behind measurement systems and the importance of accurate thermal measurements in engineering applications.
2	Standard and Calibrations	Understand the standards and protocols related to thermal measurements, such as those from the National Institute of Standards and Technology (NIST
3	Design of Experiments	Design experiments involving thermal measurements, including selecting appropriate measurement instruments and methods
4	NDT Methods	Explore non-invasive thermal measurement techniques, such as thermal imaging and infrared thermography.
5	Safety and Risk Management	Learn the safety protocols and procedures for working with thermal measurement equipment, especially in high-temperature environments.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP325.1	Identify the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation, and estimation of uncertainty
M23MTP325.2	Utilize the working principles in the measurement of field and derived quantities
M23MTP325.3	Examine sensing requirements for measurement of thermo-physical properties, radiation properties of surfaces, and vibration
M23MTP325.4	Apply conceptual development of zero, first and second order systems.
M23MTP325.5	Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP325.1	3		
M23MTP325.2	3		
M23MTP325.3	3		
M23MTP325.4	3		
M23MTP325.5	3		
M23MTP325	3		

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The “**Measurement Systems in Thermal Engineering”** course in the third semester of the M.Tech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Thermal Engineering. Here are some notable contributions:

- **Advancements in Sensor Technology** Development of nanoscale thermal sensors, smart sensor, micro sensors provides higher sensitivity and faster response times for precise temperature measurements..
- **IOT Integration:** Incorporation of thermal measurement systems into IoT frameworks for remote monitoring and control of thermal environments in real-time.
- **Energy efficient and Sustainability:** Development of measurement systems that support green technologies by optimizing thermal management in renewable energy systems, such as solar panels and wind turbines.
- **Industry Applications:** They will contribute to innovations in engine design, fuel blending techniques, and emissions control technologies, shaping the future of sustainable transportation..
- **Multidisciplinary:** Encouragement of interdisciplinary research combining thermal measurement with fields like materials science, electronics, and biotechnology to develop innovative solutions.

3rd Semester	Professional Elective Course (PE) THEORY OF IC ENGINES	M23MTP331

1. **Prerequisites**

S/L	Proficiency	Prerequisites
1	Fundamentals of IC engines	Basic knowledge of internal combustion engine operation and performance metrics. Familiarity with fuel properties and their impact on engine efficiency and emissions.
2	Thermodynamics	To excel in Alternative fuels for IC engines, students need to understand thermodynamic systems and properties, including open, closed, and isolated systems, as well as state properties like pressure, volume, temperature, and specific heats. They should be able to apply laws of thermodynamics, encompassing concepts of internal energy, work, heat, and energy conservation, covering entropy, irreversibility, and the Carnot cycle. Additionally, proficiency in analyzing thermodynamic processes (isothermal, adiabatic, isobaric, and isochoric) is essential.
3	Heat transfer	Students should have fundamental knowledge of conduction, convection, and radiation, Knowledge of heat transfer equations and their applications.
4	Understanding of Physical Quantities and Units	Students should be comfortable with concepts like mass, length, time, temperature, pressure, and be able to work with different unit systems (SI units are preferred).
5	Physics Fundamentals	Students need a strong grasp of Newtonian mechanics, including the concepts of force, motion, and energy. They should understand the principles of work and energy, as well as power and efficiency. A basic understanding of heat transfer, temperature scales, and the properties of matter is an added advantage.
6	Chemistry Fundamentals	Students should be familiar with the basic structure of atoms, molecules, and ions. They must understand chemical reactions, including stoichiometry and conservation of mass. Knowledge of the ideal gas law and other gas laws, as well as phase changes and basic thermodynamic quantities such as enthalpy and entropy, is an added advantage.

2. **Competencies**

S/L	Competency	KSA Description
1	Comparison of SI and CI Engines for efficiency	**Knowledge:** Understand operational differences and efficiency factors between SI and CI engines. **Skills:** Analyze performance metrics and apply optimization techniques for SI and CI engines. **Attitudes:** Appreciate technological advancements and prioritize sustainable practices in engine efficiency evaluation.
2	Super Charging and carburetor	**Knowledge:** Understand the principles and mechanisms of supercharging and carburetion in internal combustion engines. **Skills:** Apply knowledge to optimize engine performance through supercharging and carburetion adjustments **Attitudes:** Appreciate the role of supercharging and carburetion in enhancing engine power and efficiency, and their relevance in automotive and aerospace industries.
3	Combustion in I.C. engines	**Knowledge:** Understand the principles and phases of combustion in internal combustion engines, including ignition, flame propagation, and combustion chamber dynamics. **Skills:** Analyze combustion characteristics, optimize fuel-air mixture ratios, and troubleshoot combustion-related issues in IC engines. **Attitudes:** Appreciate the importance of efficient combustion processes in achieving optimal engine performance, reducing emissions, and improving fuel efficiency.
4	Fuel Injection and Ignition:	**Knowledge:** Understand the principles and mechanisms of fuel injection and ignition systems in internal combustion engines. **Skills:** Ability to analyze, troubleshoot, and optimize fuel injection and ignition systems for improved engine performance

		Attitudes: Appreciate the critical role of precise fuel injection and ignition timing in enhancing engine efficiency, reliability, and emissions control.
5	Rating, Testing and Performance	**Knowledge:** Understand the methodologies and standards used in rating, testing, and evaluating the performance of engines and related components. **Skills:** Ability to conduct performance tests, analyze data, and interpret results to assess the efficiency and reliability of engines. **Attitudes:** Appreciate the importance of accurate testing and rating procedures in ensuring quality, reliability, and compliance with performance standards in engine design and manufacturing.

3. **Syllabus**

Theory of IC Engines SEMESTER – III			
Course Code	**M23MTP331**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives:
- To understand the concept of design of experiments.
- To familiarize the students about the design of experiments techniques and their Implementation.
- To design and analysis a real-life problem using technique.

Module -1	
Comparison of SI and CI Engines: Difference in thermodynamic and operating variables, Comparison of performance characteristics, comparison of initial and maintenance costs application of SI and CI engine. **Two Stroke Engines:** Comparison of Two stroke and Four stroke engines, theoretical scavenging processes, comparison of different scavenging systems, supercharging of two stroke engines. **Air Capacity of Four Stroke Engines:** Ideal air capacity, determination of volumetric efficiency and factors affecting volumetric efficiency, Ideal and actual induction processes.	L1, L2
Module -2	
Super Charging: Limits of super charging, super charging power problems and turbo charging, methods of arrangements of exhaust manifold in multi cylinder engine, limitations of turbo charging. **Carburetor:** Properties of air, petrol mixture, mixture requirements of SI engine for steady state operation, transient operation various systems of complete carburetor, air compensating devices, theory of simple carburetor, air compensating devices, carburetor types, introduction to some important makes of carburetor like sole, crater, and SU carburetor, carburetor trouble, petrol injection, Lucas petrol injection system, electronic fuel injection, advantages and disadvantages of petrol injection.	L1, L2
Module -3	
Combustion in I.C. engines: Combustion in SI engines: Limits and stages of combustion, factors affecting ignition lag, flame propagation, effect of engine variable on flame propagation, abnormal combustion, effect of detonation, detonation and engine variables and other factors affecting knocking and its prevention, theory of detonation in SI engines and chemistry of detonation, control of detonation surface ignition, design principle of combustion chamber, types of combustion chamber and their comparison. Combustion in CI engines: Stages of combustion in CI engines, air fuel ratio, delay period or ignition lag, variables effecting delay period, diesel knock, methods of controlling diesel knock, CI engine combustion chamber requirements, types of combustion chambers, cold starting of CI engine and cold starting aids.	L1, L2
Module -4	
Fuel Injection: Principle and Heat release pattern, nozzles their construction and working, quantity of fuel per cycle, calculation of diameter and stroke of plunger, size of nozzle orifice, formation of diesel spray, atomization, penetration, dispersion factors affecting spray characteristics, resilience of components and effect of elasticity of pipe and fuel. **Ignition:** Ignition timing and its advance vacuum advance, centrifugal spark advance, ignition timing and its effects on exhaust, spark plugs heat range electronic ignition system using contact breaker and contact less triggers, factors affecting energy requirements of the ignition systems.	L1, L2
Module -5	

Rating, Testing and Performance: Measurements of speed, air flow, fuel consumption, indicated power brake power, frictional horse power, and smoke, testing of engines as per Indian Standard 10001, performance test for variable speed I C Engines, heat balance sheet, governing test for constant speed IC engines, effect of fuel injection parameters in CI engines and ignition advance of SI engines on performance of engine. Rating of internal combustion engine based on (I) continuous operation of engine (II) Maximum power an engine can develop (III) Power calculated from empirical formula. **Emission of IC engine:** Emission from SI engine, effect of engine maintenance on exhaust emission control of SI engine, diesel emission, diesel smoke and control, diesel and control comparison of gasoline and diesel emission. Measurement and calculation for of emission constituents.	L1, L2

Text Books:
1. V. Ganesan, ―Internal Combustion Engines‖, Tata McGraw-Hill Publications, 4th Edition.
2. John B Heywood, ―IC Engines fundamentals‖, McGraw- Hill Publications, 2011.
3. C R Fergusan, ―Internal Combustion Engines: Applied Thermo sciences‖, John Wiley & Sons.

Reference Books:
1. Richard stone _‘Introduction to IC Engines‘‘Palgrave Publication 3rd edition.
2. Charles Fayette Taylor _‘The Internal-Combustion Engine in Theory and Practice ‘‘MIT Press 2nd edition.

4. **Syllabus Timeline**

S/L	Syllabus Timeline	Description
1	Week 1-2: **Comparison of SI and CI Engines**	Difference in thermodynamic and operating variables. Comparison of performance characteristics. Comparison of initial and maintenance costs application of SI and CI engine. Comparison of Two stroke and Four stroke engines. Factors Air Capacity of Four Stroke Engines.
2	Week 3-4: **Super Charging and Carburetor**	Super charging power problems and turbo charging Methods of arrangements of exhaust manifold in multi cylinder engine. Properties of air, petrol mixture, mixture requirements of SI engine for steady state operation. Transient operation various systems of complete carburetor. Different types of petrol injection systems.
3	Week 5-6: **Combustion in I.C. engines**	Combustion in SI engines Theory of detonation in SI engines and chemistry of detonation control of detonation surface ignition. Design principle of combustion chamber. Combustion in CI engines.
4	Week 7-8: **Fuel Injection and Ignition**	Fuel injection principle and Heat release pattern. Nozzles their construction and working. Calculation of diameter and stroke of plunger, size of nozzle orifice. Ignition timing and its advance vacuum advance. Types of ignition systems. Factors affecting energy requirements of the ignition systems.
5	Week 9-10: **Rating, Testing and Performance and Emission of IC engine**	Measurements of speed, air flow, fuel consumption, indicated power brake power, frictional horse power, and smoke. Performance test for variable speed I C Engines, heat balance sheet, governing test for constant speed IC engines. Effect of fuel injection parameters in CI engines and ignition advance of SI engines on performance of engine. Rating of internal combustion engine. Emission from SI engine, effect of engine maintenance on exhaust emission control of SI engine. Comparison of gasoline and diesel emission. Measurement and calculation for of emission constituents.
6	Week 11-12:	Apply learned concepts and competencies to real-world scenarios.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6 Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	3	50%	20	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	20	10
	Total Marks			**100**	**50**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7 Learning Objectives

S/L	Learning Objectives	Description
1	**Fundamental Concepts of IC engines**	Understand the basic principles of internal combustion (IC) engines and identify different types of IC engines and their applications.
2	**Fundamentals of Thermodynamic Cycles**	Understand the thermodynamic cycles used in IC engines, such as the Otto, Diesel, and Dual cycles.
3	**Fundamentals of Engine Components and Functions**	Identify different types of IC engines and their applications.
4	**Concepts of Fuel and Combustion**	Analyze factors affecting combustion, such as air-fuel ratio, ignition timing, and temperature.
5	**Concepts of Heat Transfer in IC Engines**	Understand the principles of heat transfer in IC engines, including conduction, convection, and radiation.

9 Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP331.1	Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation, and estimation of uncertainty.
M23MTP331.2	Describe the working principles in the measurement of field and derived quantities.
M23MTP331.3	Examine sensing requirements for measurement of thermo-physical properties, radiation properties of surfaces, and vibration.
M23MTP331.4	Understand conceptual development of zero, first and second order systems.
M23MTP331.5	Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP331.1	**3**		
M23MTP331.2	**3**		
M23MTP331.3	**3**		
M23MTP331.4	**3**		
M23MTP331.5	**3**		

- **Assessment Plan**

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10 Future with this Subject

The future of the subject "Theory of IC Engines" in mechanical engineering education is influenced by various technological, environmental, and market trends. Here are some key points that outline its future:

1. **Hybrid and Electric Vehicles:** The curriculum will likely incorporate more content on hybrid systems and electric vehicles (EVs), focusing on the interplay between internal combustion engines (ICEs) and electric propulsion systems.
2. **Advanced Fuel Technologies:** There will be a greater emphasis on alternative fuels, including biofuels, hydrogen, and synthetic fuels, to address sustainability and environmental concerns.
3. **Emission Control Technologies:** Future courses will delve deeper into emission reduction technologies, such as catalytic converters, particulate filters, and advanced exhaust gas recirculation (EGR) systems.
4. **Lifecycle Analysis:** Students will learn about the environmental impact of IC engines throughout their lifecycle, from production to disposal, emphasizing sustainable engineering practices.
5. **Simulation and Modeling:** The use of advanced computational tools and simulation software to model engine performance, combustion processes, and emissions will become more prevalent in the curriculum.
6. **Data Analytics:** The incorporation of data analytics and machine learning to optimize engine performance and predict maintenance needs will be a growing area of focus.
7. **Advanced Materials:** The study of new materials for engine components that enhance performance, reduce weight, and improve thermal efficiency will be critical.

8. **Thermodynamics and Heat Transfer:** There will be an increased emphasis on advanced thermodynamic cycles and heat transfer techniques to improve engine efficiency.
9. **Systems Engineering:** The subject will adopt a more holistic approach, integrating knowledge from electrical, control, and materials engineering to address complex engine systems.
10. **Renewable Energy Integration:** Courses may explore how IC engines can be integrated with renewable energy sources, such as in hybrid systems that use solar or wind energy to charge electric batteries.
11. **Autonomous and Connected Vehicles:** The curriculum will address the role of IC engines in autonomous and connected vehicles, focusing on engine management systems and their integration with other vehicle systems.
12. **Global Trends:** Understanding global trends, including shifts in automotive markets, regulations, and consumer preferences, will be important for future engineers.

While the traditional internal combustion engine will continue to be a significant focus, the curriculum for the "Theory of IC Engines" will evolve to include a broader perspective on sustainable, efficient, and technologically advanced engine systems. This evolution ensures that graduates are well-equipped to contribute to the future of automotive and power generation industries.

3rd Semester	Professional Elective Course (PE) ENVIRONMENTAL ENGINEERING & POLLUTION CONTROL	M23MTP332

1. Prerequisites:

S/L	Proficiency	Prerequisites
1.	Basic Chemistry	A strong foundation in chemistry is essential for understanding the properties and interactions of air and water pollutants, as well as the chemical processes involved in pollution control technologies
2.	Basic Physics	Knowledge of fundamental physics principles like mechanics, thermodynamics, and fluid mechanics will be helpful in grasping concepts related to atmospheric dispersion, air pollution control equipment operation, and wastewater treatment processes.
3.	Basic Biology	An understanding of biological processes is crucial for comprehending the impacts of pollution on ecosystems and human health.
4.	Mathematics (Algebra and Calculus)	The ability to perform algebraic calculations and solve basic calculus problems is necessary for understanding quantitative aspects of environmental engineering, such as modeling pollution dispersion and optimizing treatment processes.
5.	Environmental Science	A background in environmental science can provide students with a broader understanding of environmental issues and their interconnectedness

2. Competencies:

S/L	Competency	KSA Description
1.	Air Quality & Control	**Knowledge:** Properties & interactions of air pollutants - Atmospheric stability & dispersion models - Air pollution control technologies & principles (e.g., filtration, electrostatic precipitation) - Environmental regulations & standards for air quality **Skills:** Analyze air quality data (e.g., indices, meteorological data) - Apply scientific principles to evaluate air pollution control methods - Read & interpret technical information (e.g., equipment manuals) **Attitudes:** Commitment to environmental protection - Awareness of public health impacts of air pollution - Appreciation for sustainable practices in air pollution control
2.	Control of Gaseous Pollutants	**Knowledge:** Chemical reactions & adsorption/absorption processes - Gaseous pollutant control technologies (e.g., adsorption, incineration) **Skills:** Apply chemical principles to analyze pollution control options - Design and optimize basic gas treatment systems (calculations optional) **Attitudes:** Attention to detail and safety protocols - Problem-solving skills for optimizing treatment processes
3.	Solid Waste Management	**Knowledge:** Environmental & health impacts of solid waste - Solid waste characterization & management practices (reduction, recycling, composting) - Landfill siting & operation regulations **Skills:** Evaluate waste management options based on environmental impact - Develop basic waste management plans - Apply knowledge of regulations for responsible waste disposal **Attitudes:** Concern for resource conservation - Initiative in promoting sustainable waste management practices
4.	Industrial Waste Management	**Knowledge:** Characteristics & treatment of diverse industrial wastes (chemical, biological) - Waste minimization & treatment processes (neutralization, precipitation) - Safe handling procedures for hazardous waste **Skills:** Analyze industrial waste data (composition, characteristics) - Design basic industrial wastewater treatment systems (calculations optional) - Implement safe handling practices for hazardous waste **Attitudes:** Commitment to worker safety and environmental responsibility - Ability to adapt treatment approaches to specific industrial wastes
5.	Wastewater Treatment	**Knowledge:** Wastewater composition & treatment principles - Biological & physico-chemical wastewater treatment processes - Basic laboratory

		techniques for wastewater analysis (pH, BOD, COD) **Skills:** Design basic wastewater treatment systems (calculations optional) - Conduct basic wastewater analyses using laboratory techniques - Interpret data to evaluate treatment effectiveness **Attitudes:** Importance of water quality and ecosystem health - Continuous learning and improvement in treatment technologies

3. Syllabus:

Environmental Engineering and Pollution Control **SEMESTER – III**			
Course Code	**M23MTP332**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students :

- To make the students aware of history of air pollution; definition of air pollution and various types of sources and classification of air pollutants.
- To make the student aware of techniques and instrumentation of ambient air monitoring, establishment of ambient air monitoring stations; stack monitoring and experimental analysis of air gaseous and particulate air pollutants; standards and limits.
- Understanding of problems of municipal waste, biomedical waste, hazardous waste, e-waste, industrial waste etc.
- Industrial waste generation patterns, as well as management and disposal techniques. Central and state pollution control board guidelines on industrial waste management.

Module -1

Air Quality and Standards, Important air pollutants, their sources, characteristics and effects. Sampling and Analysis: Ambient air sampling, stack sampling, Air quality standards. Air Pollution Meteorology and Dispersion Models, Atmospheric motion, Lapse rate, atmospheric stability, inversion, atmospheric dispersion, maximum mixing depth, Diffusion models, plume rise. Control of Particulates, Characteristics of particulates. Filters, gravitational, centrifugal-multiple type cyclones, prediction of collection efficiency, pressure drop, wet collectors, Electrostatic Precipitation theoryparticle charging-particle collection-ESP design procedure.

Module -2

Control of Gaseous Pollutants. Adsorption, absorption. Emission control in coal-fired power plants and other important industries. Condensation and incineration Automobile Pollution, Legislation for motor vehicle emission control, control of automobile pollution, internal combustion engines, modification of IC engines to reduce emission, air fuel ratio, catalytic converters. Odour pollution and control, Indoor air pollution, Noise pollution and control.

Module -3

Solid waste sources - nature and characteristics - Quantities and Qualities - generation rates – Potential of disease - nuisance and other problems. Collection and Storage Solid waste management – Functional elements of solid waste-on-site storage, collection and separation. – Containers and its location – collection systems- vehicle routing- route balance- transfer station - Processing- recovery and reuse. Disposal methods – sanitary land filling, planning, site selection, design. hazardous waste – Bioremediation of hazardous waste – Treatment of nuclear waste and Radio-active waste.

Module -4

Industrial waste source, Nature and characteristics, quantity and quality of industrial wastes and their impact on the environment, waste volume reduction, waste strength reduction, neutralization, removal of suspended and colloidal solids, removal of inorganic and organic dissolved solids, disposal of sludge solid – treatment of cyanide waste – heavy metal and radio activity.

Module -5

Management of industrial waste for various industries like dairy, sugar, paper, distillery, textile, tannery, food processing, fertilizer, pharmaceutical industrial. Development of integrated treatment for waste water – physico chemical treatment tertiary treatment methodologies - recent trends in clean technologies – zero polluting industry concept – Reuse and recycle of waste water.

Suggested Learning Resources:

1. Air Pollution Control Engineering by De Nevers, McGraw-Hill, New York.
2. Air Pollution Its Origin and Control by Wark K, Warner C F and Davis W., Harper and Row, New York.
3. Air Pollution by Rao M N, Tata McGraw Hill, New Delhi.

4. Principles of Air Quality Management by Griffin R D, CRC Press, Boca Raton, USA.
5. Municipal Solid Waste Management: Pollution Technologies Review by David Rimbers, Noyes Data Corporation, London.
6. Hazardous Waste Management by Michael D. Lagrega, Phillip L. Buckingham, Jeffrey C. Evans, McGraw Hill, New York.
7. Wastewater Treatment by Rao M N and Datta A K, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
8. Industrial Water Pollution Control by Eckenfelder, McGraw-Hill.
9. Wastewater Engineering-treatment, Disposal, Refuse by Metcalf and Eddy, T.M.H. Edition, New Delhi.

4. Syllabus Timeline:

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction, Air Quality and Standards	Air Quality and Standards, Important air pollutants, their sources, characteristics and effects. Sampling and Analysis: Ambient air sampling, stack sampling, Air quality standards. Air Pollution Meteorology and Dispersion Models, Atmospheric motion, Lapse rate, atmospheric stability, inversion, atmospheric dispersion, maximum mixing depth, Diffusion models, plume rise.
2	Week 3-4: Control of Particulates, Control of Gaseous Pollutants	Control of Particulates, Characteristics of particulates. Filters, gravitational, centrifugal-multiple type cyclones, prediction of collection efficiency, pressure drop, wet collectors, Electrostatic Precipitation theoryparticle charging-particle collection-ESP design procedure. Control of Gaseous Pollutants. Adsorption, absorption. Emission control in coal-fired power plants and other important industries. Condensation and incineration Automobile Pollution, Legislation for motor vehicle emission control, control of automobile pollution.
3	Week 5-6: Internal combustion engines, Solid waste sources	Internal combustion engines, modification of IC engines to reduce emission, air fuel ratio, catalytic converters. Odour pollution and control, Indoor air pollution, Noise pollution and control. Solid waste sources - nature and characteristics - Quantities and Qualities - generation rates – Potential of disease - nuisance and other problems.
4	Week 7-8: Collection and Storage Solid waste management, Disposal methods	Collection and Storage Solid waste management – Functional elements of solid waste-on-site storage, collection and separation. – Containers and its location – collection systems- vehicle routing- route balance- transfer station - Processing- recovery and reuse. Disposal methods – sanitary land filling, planning, site selection, design. hazardous waste – Bioremediation of hazardous waste – Treatment of nuclear waste and Radio-active waste.
5	Week 9-10: Industrial waste sources, disposal of sludge solid	Industrial waste source, Nature and characteristics, quantity and quality of industrial wastes and their impact on the environment, waste volume reduction, waste strength reduction, neutralization, removal of suspended and colloidal solids, removal of inorganic and organic dissolved solids, disposal of sludge solid – treatment of cyanide waste – heavy metal and radio activity.
6	Week 11-12: Management of industrial waste, Development of integrated treatment for waste water	Management of industrial waste for various industries like dairy, sugar, paper, distillery, textile, tannery, food processing, fertilizer, pharmaceutical industrial. Development of integrated treatment for waste water – physico chemical treatment tertiary treatment methodologies - recent trends in clean technologies – zero polluting industry concept – Reuse and recycle of waste water.

5. Teaching-Learning Process Strategies:

S/L	TLP Strategies:	Description
1	Lectures & Presentations	Deliver core concepts and foundational knowledge. - Utilize multimedia (images, diagrams, animations, videos) to enhance understanding.
2	Interactive Discussions & Q&A	Encourage active participation and clarification of doubts. Facilitate critical thinking and analysis of concepts through student-led discussions
3	Case Studies	Present real-world engineering challenges and have students analyze potential solutions.
4	Multiple Representations	Introduce topics in various representations to reinforce competencies

5	Project-Based Learning	Encourage research and design thinking through project-based learning activities
6	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
7	Educational Technology	Utilize online learning platforms, simulations, and interactive software to supplement classroom learning. Provide opportunities for self-paced learning and personalized learning experiences.

6. Assessment Details (both CIE and SEE) :

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives:

S/L	Learning Objectives	Description
1.	Understand air quality and air pollutants	Students will be able to understand the fundamentals of air quality, including important pollutants, their sources, effects, and sampling techniques.
2.	Identify sampling and analysis methods for air quality	Students will be able to explore various methods for sampling and analyzing ambient and stack air, along with air quality standards.
3.	Explain air pollution meteorology and dispersion models	Students will be able to explain atmospheric factors influencing air pollution dispersion, including wind, temperature inversions, and atmospheric stability.
4.	Describe methods for controlling particulate matter	Students will be able to discuss methods for controlling particulate matter emissions, including filtration, electrostatic precipitation, and wet collectors.
5.	Discuss control strategies for gaseous pollutants	Students will be able to explore strategies for controlling gaseous pollutants through adsorption, absorption, and emission control technologies in industries.
6.	Explore automobile pollution and its control	Students will be able to examine the sources and control of automobile pollution, including legislation and emission control technologies.
7.	Examine the concept of internal combustion engines and emission control	Students will be able to delve into internal combustion engines, emission reduction techniques, air-fuel ratio adjustments, and catalytic converters.
8.	Learn about odor pollution and control	Students will be able to explore odor pollution, its sources, and control methods.
11.	Identify sources, characteristics, and management of solid waste	Students will be able to identify the sources, nature, characteristics, and potential health and environmental impacts of solid waste.
12.	Explain collection, storage, and disposal methods for solid waste	Students will be able to explore collection, storage, and disposal methods for solid waste, including containers, routing, transfer stations, and sanitary landfills.

13.	Analyze the nature, characteristics, and treatment of industrial waste	Students will be able to analyze the nature, characteristics, treatment methods, and environmental impact of industrial waste from various industries.
14.	Explore wastewater treatment methodologies and recent trends	Students will be able to explore wastewater treatment methodologies, including physico-chemical treatment, tertiary treatment, and recent trends in clean technologies and zero-polluting industries.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

CO's	DESCRIPTION OF THE OUTCOMES
M23MTP332.1	**Define** key air quality concepts, pollutants, and their characteristics, explaining their sources and health effects.
M23MTP332.2	**Apply** control methods for particulate matter (filtration, ESP) and gaseous pollutants (adsorption), understanding emission control strategies in key industries.
M23MTP332.3	**Gain** understanding of solid waste characteristics, generation rates, **analyze** the impact of improper management, and describe collection, storage, and disposal methods.
M23MTP332.4	**Understand** the nature and impact of industrial waste, evaluating different treatment methods for various industries.
M23MTP332.5	**Describe** physico-chemical and advanced wastewater treatment methods, explaining recent trends in clean technologies and zero-polluting industries.

CO's	PO		
	1	**2**	**3**
M23MTP332.1	3		
M23MTP332.2	3		
M23MTP332.3	3		
M23MTP332.4	3		
M23MTP332.5	3		

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

8.

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10 Future with this Subject

The Future of Environmental Engineering and Pollution Control: A Mechanical Engineer's Perspective

As a mechanical engineer venturing into the realm of environmental engineering and pollution control, you bring a unique skillset to the table. Here's a glimpse into the exciting future you can help build:

- **Merging Expertise:** Leverage your knowledge of mechanics, heat transfer, and design principles to develop cutting-edge air pollution control equipment. Imagine designing high-efficiency filters, optimizing electrostatic precipitators, or creating innovative scrubber designs.
- **Optimizing Renewables:** Your understanding of mechanics and fluid dynamics is crucial for optimizing renewable energy systems. You can contribute to making wind turbines and solar thermal collectors more efficient and reliable. Furthermore, your skills can be applied to developing efficient energy storage solutions.
- **Sustainable Manufacturing:** Your background equips you to design and implement sustainable manufacturing processes. Minimize waste and energy consumption through innovative approaches. Life cycle analysis becomes a powerful tool, allowing you to assess the environmental impact of products throughout their lifespan.
- **Cleaner Combustion and Emissions:** Mechanical engineers play a pivotal role in developing cleaner combustion engines. Contribute to the design of improved catalytic converters and innovative exhaust treatment systems for vehicles and industries.
- **Nanotech's Potential:** Explore the exciting possibilities of nanotechnology in pollution control. Develop new air and water filters with enhanced efficiency and selectivity for removing pollutants, drawing inspiration from the wonders of nanomaterials.
- **Thermal Management Expertise:** Your understanding of heat transfer is vital in designing efficient cooling systems for pollution control equipment, ensuring optimal performance.
- **Biomimicry for Inspiration:** Look to nature for inspiration! Imagine designing filters based on spider silk or self-cleaning surfaces inspired by lotus leaves. Biomimicry offers a treasure trove of ideas for sustainable solutions.
- **Assessing Environmental Impact:** Your grasp of mechanical systems and their potential environmental impact is valuable. Conduct environmental impact assessments for various industrial projects, also contributing to developing risk management strategies for accidental pollution events.

3rd Semester	Professional Elective Course (PE) SAFETY IN ENGINEERING INDUSTRY	M23MTP333

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basic Engineering Knowledge	Understanding fundamental principles of engineering disciplines relevant to the industry where safety is a concern (e.g., mechanical, electrical, civil, chemical engineering).
2.	Understanding of Safety Concepts	Familiarity with basic safety concepts and principles, including hazard identification, risk assessment, and safety management systems.
3.	Awareness of Industry-specific Hazards:	Understanding of common hazards and risks specific to engineering disciplines such as mechanical, electrical, chemical, or civil engineering.
4.	Legal and Regulatory Knowledge:	Awareness of legal responsibilities and liabilities related to workplace safety in engineering contexts.

2. Competencies

S/L	Competency	KSA Description
1.	Need for safety	**Knowledge:** Understand the importance of safety in preventing accidents and ensuring a healthy work environment. **Skills:** Identify and assess potential hazards to implement effective safety measures. **Attitudes:** Value the critical role of safety in protecting lives and enhancing productivity in the workplace.
2.	Personal protection in the work environment	**Knowledge:** Understand the various types of personal protective equipment (PPE) and their specific uses. **Skills:** Properly select, use, and maintain PPE to ensure maximum protection. **Attitudes:** Appreciate the importance of using PPE to prevent injuries and promote safety in the workplace.
3.	Introduction to construction industry and safety issues	**Knowledge:** Understand the key characteristics and common safety hazards in the construction industry. **Skills:** Identify and mitigate construction site hazards through effective safety practices. **Attitudes:** Recognize the critical importance of safety measures in protecting construction workers and improving site productivity.
4.	Safety in turning, and grinding and welding	**Knowledge:** Understand the specific hazards associated with turning, grinding, and welding operations. **Skills:** Implement appropriate safety procedures and use of personal protective equipment (PPE) for turning, grinding, and welding activities. **Attitudes:** Value the importance of strict adherence to safety protocols to prevent accidents and ensure a safe working environment in machining and welding processes.
5.	Hazard and risk, Types of hazards	**Knowledge:** Understand the definitions of hazard and risk in the context of workplace safety. **Skills:** Identify different types of hazards and assess associated risks in various work environments. **Attitudes:** Appreciate the importance of recognizing and managing hazards to mitigate risks and promote a safe workplace culture.

3. Syllabus

Safety in Engineering Industry SEMESTER – III			
Course Code	**M23MTP333**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**3.:0:0**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**
Course Objectives: This course will enable students to: • To discuss various accident causation theories and define Accident, Reportable accident,			

Dangerous occurrence. • To discuss different types of personal protective equipment and how to compare the safety performance of two industries. • Distinguish ladders and scaffolds along with their safety features and discuss the safety requirement for a confined space entry. • To explain the various principles used in machine guarding and explain the issues in mechanical material handling. • Selection of different types of fire extinguishers accordance to type of fire. Conduct a HAZOP study for a batch rector of your choice.	
Module -1	
Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.	L1, L2
Module -2	
Personal protection in the work environment, Types of PPEs, Personal protective Equipment respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.	L1, L2
Module -3	
Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.	L1, L2
Module -4	
Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas 5 welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries.	L1, L2
Module -5	
Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).	L1, L2

Text Books:

- R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications. Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
- Krishnan, N.V. (1997). Safety management in Industry. Jaico Publishing House, New Delhi.
- John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All IndiaTraveller Book Seller, Delhi.
- Ronald P. Blake. (1973). Industrial safety. Prentice Hall, NewDelhi.
- Alan Waring. (1996). Safety management system. Chapman & Hall, England.

Additional References:

- Industrial Safety and Management L M Deshmukh McGraw Hill Education (India) private Limited ISBN-13: 978-0-07- 061768-1
- Fire Prevention Hand Book Derek, James Butter Worth's and Company, London

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Need for safety. Safety and productivity.	**Week 1:** Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, **Week 2:** supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.
2	Week 3-4: Personal protection in the work environment	**Week 3:** Types of PPEs, Personal protective Equipment respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. **Week 4:** Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.
3	Week 5-6: Introduction to construction industry and safety issues	**Week 5:** Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. **Week 6:** Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.
4	Week 7-8: Machinery safeguard	**Week 7:** Principle of machine guarding -types of guards and devices. safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas 5 welding and Arc Welding, Handling assessments and techniques **Week 8:** Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries.
5	Week 9-10: Hazard and risk,	**Week 9:** Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: **Week 10:** Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Chalk and Talk	This method is very useful in while engaging students and facilitating a deep understanding of the subject matter.
2	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies
3	Video/Simulation	Incorporate visual aids like videos/simulations/animations to enhance understanding of safety methods
4	Collaborative Learning	Encourage collaborative learning for improved competency application
6	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

	Components	Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	To Understand various accident causation theories and define Accident, Reportable accident, Dangerous occurrence.	Domino theory, Human factor theory, behavioural theory, fatalities, impact on individuals, nature of incident.
2	To Understand different types of personal protective equipment	Protection from hazards, regulatory compliance, maintenance and replacement.
3	Distinguish ladders and scaffolds along with their safety features	Safety labels and instructions, types of scaffolds, access points, fall protection.
4	To explain the various principles used in machine guarding	Fixed guards, ergonomic hazards, overloading equipments, mechanical failures.
5	Selection of different types of fire extinguishers accordance to type of fire	Classes of fire, types of fire extinguishers, selecting the right extinguishers, maintenance and training, identify deviation and causes.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP333.1	Describe the theories of accident causation and preventive measures of industrial accidents.
M23MTP333.2	Explain about personal protective equipment, its selection, safety performance & indicators and importance of housekeeping.
M23MTP333.3	Explain different issues in construction industries.
M23MTP333.4	Describe various hazards associated with different machines and mechanical material handling.
M23MTP333.5	Utilize different hazard identification tools in different industries with the knowledge of different types of chemical hazards.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP333.1	3		
M23MTP333.2	3		
M23MTP333.3	3		
M23MTP333.4	3		
M23MTP333.5	3		

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	20					20
Module 2		20				20
Module 3			20			20
Module 4				20		20
Module 5					20	20
Total	20	20	20	20	20	100

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	20					20
Module 2		20				20
Module 3			20			20
Module 4				20		20
Module 5					20	20
Total	20	20	20	20	20	100

10. Future with this Subject

The “Safety **in Engineering Industry** " course in the Third semester of the Thermal Power Engineering program lays a strong foundation for several future courses in the post graduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of digital systems. Here are some notable contributions:

- Integration of Advanced Technologies:
  Artificial Intelligence (AI) and Machine Learning: These technologies can predict potential safety hazards by analyzing data from sensors, historical incident reports, and environmental conditions. AI can also automate safety monitoring and compliance checks.
- Internet of Things (IoT):
  IoT devices can provide real-time monitoring of equipment and environmental conditions, helping to detect anomalies that could lead to safety incidents.
- Enhanced Safety Protocols and Regulations:
  As industries evolve, so too will the regulations and standards governing safety. There will likely be an increase in stringent safety protocols, driven by both regulatory bodies and industry best practices.
- Human Factors and Ergonomics:
  There will be a greater focus on designing work environments and systems that consider human capabilities and limitations, thereby reducing human error and improving overall safety.
- The future of safety in the engineering industry will be characterized by the integration of cutting-edge technologies, enhanced data analytics, stringent regulations, and a strong emphasis on human factors and safety culture. These advancements will collectively lead to safer working environments and more efficient management of safety risks.

3rd Semester	Professional Elective Course (PE) BIOMASS ENERGY CONVERSION TECHNIQUES	M23MTP334

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Fundamental Chemistry and Biology:	Understanding basic principles of chemistry and biology is essential for comprehending biochemical processes involved in biomass conversion, such as fermentation and enzymatic reactions.
2.	Basic Engineering Knowledge	A strong understanding of fundamental engineering principles, especially in thermodynamics, heat transfer, and fluid mechanics. Familiarity with basic chemical reactions and processes.
3.	Environmental Science:	Awareness of environmental impacts and regulations related to biomass energy production is essential for ensuring sustainable practices.
4.	Science Background	Basic knowledge of biology and biochemistry, particularly regarding cell structure and metabolic processes relevant to biomass conversion. Understanding of the composition and properties of different types of biomass feed stocks.
5.	Safety and Risk Management:	Knowledge of safety protocols and risk management practices is important due to the potential hazards associated with biomass handling and energy conversion processes.

2. Competencies

S/L	Competency	KSA Description
1.	Comprehensive Understanding of Biomass Energy	**Knowledge:** World energy trends, fossil fuel depletion, and environmental issues. Understand biomass availability, composition, and energy potential. **Skills:** Analyze biomass properties (particle size, heat capacity) and evaluate conversion processes (biological, thermal, chemical). **Attitudes:** Appreciate the importance of sustainable energy sources.
2.	Bio-refinery Concepts and Biomass Pretreatment	**Knowledge:** Types of bio-refineries, feedstock properties, and economic considerations. Recognize barriers in lignocellulosic biomass conversion. **Skills:** Assess pretreatment technologies (acid, alkali, hybrid methods) and their role in biorefineries. **Attitudes:** Value efficient biomass utilization for energy production.
3.	Biomass Conversion Processes and Biodiesel Production	**Knowledge:** Understand biomass gasification, combustion, microbial conversion, and biodiesel synthesis. **Skills:** Calculate gasifier parameters, evaluate biodiesel production processes, & analyze fuel properties. **Attitudes:** Embrace innovative solutions for sustainable biofuel production.
4.	Bioethanol, Bio-butanol, and Hydrogen Generation	**Knowledge:** Learn about ethanol, butanol, and hydrogen production from biomass. Understand fermentation processes and biogas technology. **Skills:** Explore SSF, CBP, ABE fermentation, and biohydrogen integration with fuel cells. **Attitudes:** Advocate for cleaner energy alternatives.
5.	Organic Chemicals from Biomass and Integrated Biorefinery	**Knowledge:** Recognize organic chemicals (e.g., lactic acid, polylactic acid) from biomass. Understand different biorefinery types. **Skills:**

		Evaluate techno-economic aspects and life-cycle assessments in integrated biorefinery processes. **Attitudes:** Promote sustainable practices in chemical production.

3. Syllabus

Biomass Energy Conversion Techniques SEMESTER – III			
Course Code	**M23MTP334**	CIE Marks	**50**
Number of Lecture Hours/Week (L: P: SDA)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	40 hours	Total Marks	**100**
Credits	03	Exam Hours	**03**

Course objectives: This course will enable students to:

- To introduce the energy conversion technologies related to biomass
- To familiarize the properties of biomass and its energy products
- To analyze the feasibility of power production from biomass sources

Module -1

Introduction: World energy scenario, consumption pattern, fossil fuel depletion and environmental issues. **Biomass:** Availability and abundance, photosynthesis, composition and energy potential, Biomass as energy source, Sources, Biomass conversion processes, Biological, Thermal,, Chemical, Hybrid conversions, Application of biomass conversion products, Biomass properties for conversion process, **Physical properties:** Particle size, distribution, heat capacity and thermal conductivity, **Thermal properties:** Proximate, Ultimate and heating value analysis, biorefinery potential, microalgae as feedstock for bio-fuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion.

Module -2

Bio-refinery: Basic concept, types of bio-refineries, biorefinery feedstocks and properties, economics. **Biomass Pretreatment:** Barriers in lignocellulosic biomass conversion, pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept. **Physical and Thermal Conversion Processes:** Types, fundamentals, equipment and applications; thermal conversion products, commercial success stories.

Module -3

Biomass gasification, chemistry, types of gasifiers: TDR, throughput, A/F ratio and equivalence ratio calculations, fluidized bed gasifier, Biomass combustion, types of combustors, **Microbial Conversion Process:** Types, fundamentals, equipment and applications, products, commercial success stories. **Biodiesel:** Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties. **Bio-oil and Biochar:** Factors affecting biooil, biochar production, fuel properties, biooil upgradation.

Module -4

Bioethanol and Bio-butanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies. **Hydrogen, Methane and Methanol:** Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization

Module -5

Organic Commodity Chemicals from Biomass: Biomass as feedstock for synthetic organic chemicals, lactic acid, polylactic acid, succinic acid, propionic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanedioil, PHA. **Integrated Biorefinery:** Concept, corn/soybean/sugarcane biorefinery, lignocellulosic biorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation, life-cycle assessment.

Textbooks:

- Donald L. Klass, Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, Elsevier, 2006.
- Sergio C. Capareda "Introduction to Biomass Energy Conversions", 2019, CRC Press, Taylor and Francis Group.
- Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.
- A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), Biomass to Biofuels: Strategies for Global Industries, Wiley, 2010

Reference Books:

- S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers, Wiley, 2013.
- Shang-Tian Yang (Ed.), Bioprocessing for Value Added Products from Renewable Resources, Elsevier, 2007.
- Erik Dahlquist, "Biomass as Energy Source: Resources, systems and applications", Sustainable Energy Developments series, 2012, CRC Press, Taylor and Francis Group.
- Anju Dahiya, "Bioenergy: Biomass to Biofuels", 2014, Academic press, Elsevier Publication.
- D. P. Kothari, K.C Singal and Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", 2011, PHI Learning Private Ltd, New Delhi.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/103/103/103103207/
- https://drive.google.com/file/d/1U7ShntkXCdtCA981zzbKXVzC64faudqf/vie

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Module 1: Introduction	World energy scenario, Consumption patterns, Fossil fuel depletion and environmental issues, Biomass fundamentals, Biomass conversion processes
2	Week 3-4: Module 2: Bio-refinery	Bio-refinery concept and types, Feedstock properties and economics, Pretreatment technologies, Physical and Thermal conversion processes
3	Week 5-6: Module 3: Biomass Conversion Technologies	Gasification (chemistry, types, calculations), Combustion (types of combustors), Microbial conversion processes, Biodiesel production
4	Week 7-8: Module 4: Biofuels and Bioproducts	Bioethanol and Butanol production, Hydrogen, Methane, and Methanol production, Bio-oil and Biochar production, Fuel properties
5	Week 9-10: Module 5: Integrated Biorefinery	Organic chemicals from Biomass, Integrated biorefinery concept, Examples: corn, sugarcane, lignocellulosic biorefinery, Techno-economic and life cycle assessment
6	Week 11-12: Revision and Project Discussions	Course review and Q&A, Student project presentations and discussions.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a

maximum of 3 sub questions), may have mix of topics under that module if necessary.

3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Comprehend the Global Energy Landscape	• Analyze current global energy consumption patterns and trends. • Understand the challenges of fossil fuel depletion and its environmental impact. • Recognize the role of renewable energy sources, particularly biomass, in addressing these challenges.
2	Master Biomass Conversion Technologies	• Gain in-depth knowledge of various biomass conversion processes, including biological, thermal, and chemical methods. • Evaluate the advantages and limitations of each conversion technology. • Analyze the role of pretreatment in enhancing biomass conversion efficiency.
3	Develop Expertise in Biofuel Production	• Understand the principles and technologies for producing biofuels such as biodiesel, bioethanol, and bio-butanol. • Critically evaluate the production processes, feedstock requirements, and product properties. • Explore advanced fermentation technologies for biofuel production.
4	Gain Insights into Biorefinery Systems	• Grasp the concept of integrated biorefineries for generating a wider range of valuable products from biomass. • Analyze different biorefinery configurations based on feedstocks like corn, sugarcane, or lignocellulosic materials. • Evaluate the techno-economic feasibility and life cycle assessment of biorefineries.
5	Develop Research and Communication Skills	• Conduct research on specific topics related to biomass conversion or biorefinery processes. • Effectively communicate technical information through written reports and presentations. • Engage in critical discussions and debates on the future of biomass energy.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP334.1	Develop knowledge in properties of biomass and energy conversion process.
M23MTP334.2	Compare the characteristics of products obtained from biomass pyrolysis.
M23MTP334.3	Understand the basics of biomass gasification and gasifier design.
M23MTP334.4	Assess the potential of electrical power production from biomass.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP334.1	3		
M23MTP334.2	3		
M23MTP334.3	3		
M23MTP334.4	3		

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

By understanding prospects of biomass energy, students can position themselves for exciting careers in research, development, and implementation of advanced biomass energy technologies. Some of the scope of the course is as follows:

1. **Sustainable Alternative:** As fossil fuels deplete, biomass offers a renewable and potentially carbon-neutral energy source if managed sustainably.
2. **Advanced Conversion Technologies:** Research on gasification, pyrolysis, and biochemical conversion is ongoing, aiming for higher efficiency and cleaner product streams.
3. **Waste to Wealth:** Biomass can utilize agricultural and industrial waste streams, promoting a circular bioeconomy and reducing dependence on landfills.
4. **Biorefinery Expansion:** Integrated biorefineries will become more sophisticated, producing not just biofuels but also valuable bio-based chemicals and materials.
5. **Microalgae Potential:** Microalgae cultivation offers a promising avenue for sustainable biomass production with high energy density and minimal land use.
6. **Policy and Market Support:** Government policies and incentives can play a crucial role in encouraging investment and development in the biomass sector.
7. **Integration with Existing Infrastructure:** Biomass can be co-fired with coal in existing power plants, facilitating a smoother transition to a renewable energy mix.

3rd Semester	Professional Elective Course (PE) NON-CONVENTIONAL ENERGY SOURCES	M23MTP335

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basic Physics and Chemistry	Understanding of fundamental principles in physics (such as mechanics, thermodynamics, and electromagnetism) and chemistry (including chemical reactions and properties of materials) provides a foundational knowledge base.
2.	Thermodynamics	Knowledge of thermodynamic principles and laws helps in understanding energy transfer, conversion efficiencies, and the behavior of energy systems.
3.	Mechanical Engineering Concepts	Familiarity with mechanical systems, fluid mechanics, and heat transfer enhances comprehension of energy generation from sources such as biomass and geothermal.
4.	Environmental Science:	Awareness of environmental impacts and sustainability principles related to energy sources aids in evaluating the ecological footprint and feasibility of non-conventional energy projects.
5.	Energy Systems Analysis:	Knowledge of energy systems and analysis techniques helps in assessing the feasibility, efficiency, and economic viability of non-conventional energy sources.

2. Competencies

S/L	Competency	KSA Description
1.	Introduction of energy sources	**Knowledge:** Understanding of various energy sources, production capacities, and reserve estimation methodologies relevant to India. **Skills:** Ability to analyze energy data, assess resource potentials, and evaluate energy policies and regulations affecting production and reserves in India. **Attitudes:** Appreciation for sustainable energy practices, ethical responsibility in energy management, and collaboration for achieving energy security and sustainability goals in India.
2.	Solar Radiation Geometry & Photovoltaic systems	**Knowledge:** Understanding the principles of solar radiation geometry, including solar angles, solar declination, and their effects on solar energy availability. Knowledge of photovoltaic (PV) systems, including PV cell operation, system components, and integration into electrical grids. **Skills:** Ability to calculate solar angles, estimate solar energy availability based on geographical location, and design PV systems for optimal energy capture. Skills in installing, maintaining, and troubleshooting PV systems. **Attitudes:** Appreciation for the potential of solar energy as a renewable resource, commitment to maximizing energy efficiency and reducing carbon footprint through PV technology.
3.	Wind Energy	**Knowledge:** Understanding wind energy principles, turbine operation, and resource assessment. **Skills:** Ability to analyze wind data, optimize turbine placement, and assess project feasibility. **Attitudes:** Appreciation for wind energy's environmental benefits and commitment to sustainability.
4.	Tidal Power:	**Knowledge:** Understanding tidal energy principles, tidal patterns, and turbine technologies. **Skills:** Ability to assess tidal energy potential, design tidal power systems, and optimize energy capture. **Attitudes:** Appreciation for tidal energy's renewable nature and commitment to harnessing ocean resources sustainably.
5.	Geothermal Energy Conversion	**Knowledge:** Understanding geothermal energy principles, heat extraction methods, and geological considerations. **Skills:** Ability to evaluate geothermal resource potential, design geothermal power systems, and optimize heat extraction techniques. **Attitudes:** Appreciation for geothermal energy's reliability and sustainability, and commitment to utilizing underground heat resources responsibly.

3. Syllabus

RENEWABLE ENERGY TECHNOLOGY
SEMESTER – II

Course Code	**M23MTP335**	CIE Marks	**50**
Teaching Hours/Week (L:P:SDA)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:

- To provide a survey of the most important renewable energy resources and the technologies for harnessing these resources within the framework of a broad range of simple to state- of - the-art energy systems.
- To create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
- To learn the fundamental concepts about solar energy systems and devices.
- To design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
- To understand the working of OTEC system and different possible ways of extracting energy from ocean, know about Biomass energy, mini-micro hydro systems and geothermal energy system.

Content	Level
Module -1	
Introduction: Energy source, India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, nuclear (Brief descriptions). **Solar Radiation**: Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.	L1, L2,
Module -2	
Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. **Solar Thermal systems**: Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems. Solar pond, principle of working. **Solar Photovoltaic systems:** Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction.	L1, L2
Module -3	
Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples.	L1, L2
Module -4	
Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion**: Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.	L1, L2
Module -5	
Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **Energy from Bio Mass**: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages	L1, L2

Text Books:

1. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, 2000.
2. Non-Conventional Energy Resources, B. H. Khan, The McGraw Hill, 2017.
3. Renewable Energy Sources, Twidell, J.W. & Weir, A., EFN Spon Ltd., UK, 2006.
4. Solar Energy – Principles of Thermal Collection and Storage, S. P. Sukhatme and J.K. Nayak, Tata McGraw-Hill, New Delhi, 2008.

5. Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGraw Hill, 2017.

Reference Books:

1. Solar Energy, Sukhatme. S.P., Tata McGraw Hill Publishing Company Ltd., 1997.
2. Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K., 1996.
3. Biogas Technology – A Practical Handbook, Khandelwal, K.C., Mahdi, S.S., Tata McGraw-Hill, 1986.
4. Solar Energy – Fundamentals Design, Modelling & Applications, Tiwari. G.N., Narosa Publishing House, New Delhi, 2002.
5. Wind Energy Conversion Systems, Freris. L.L., Prentice Hall, 1990.
6. Principles of Solar Energy, Frank Krieth & John F Kreider, John Wiley, New York, 1987.

Links

1. https://archive.nptel.ac.in/courses/103/103/103103206/
2. https://archive.nptel.ac.in/courses/121/106/121106014/
3. https://drive.google.com/file/d/1TezxsWvbHDda45wGLHt7vDS5zFv7kd56/view

4 Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction, Types and Availability of Energy Sources. Solar Radiation & its measurement.	**Introduction**: Energy source, India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, nuclear (Brief descriptions). **Solar Radiation**: Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.
2	Week 3-4: Solar Radiation Geometry, Thermal Energy Conversion & Storage Systems, Solar Photovoltaic system.	**Solar Radiation Geometry**: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. **Solar Thermal systems**: Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems. Solar pond, principle of working. **Solar Photovoltaic systems:** Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction.
3	Week 5-6: Wind Energy, its types, working principles & its parameters.	**Wind Energy**: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples
4	Week 7-8: Tidal Energy & OTEC	**Tidal Power**: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion**: Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.
5	Week 9-10: Geothermal energy.	**Geothermal Energy Conversion**: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy.
6	Week 11-12: Biomass Energy	**Energy from Bio Mass**: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages

5 Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1.	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2.	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of RET concepts.
3.	Collaborative Learning	Encourage collaborative learning for improved competency application.
4.	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5.	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies.

6 Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7 Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Sustainability	Students should grasp the concept of sustainability in energy production and consumption. This involves learning how non-conventional energy sources contribute to reducing environmental impact, conserving natural resources, and promoting long-term viability.
2	Knowledge of Renewable Technologies	Gain knowledge about various non-conventional energy technologies, including solar photovoltaics, wind turbines, hydroelectric power, geothermal systems, biomass conversion, tidal energy, and hydrogen fuel cells. Understanding their principles of operation, advantages, limitations, and applications is crucial.
3	Energy Policy and Economics	Explore the policy frameworks and economic aspects surrounding the adoption of renewable energy. This includes understanding government incentives, subsidies, regulatory environments, and market dynamics influencing the growth of non-conventional energy sectors.
4	Environmental Impacts and Benefits	Analyze the environmental impacts associated with conventional versus non-conventional energy sources. Evaluate factors such as greenhouse gas emissions, air and water pollution, land use, and biodiversity impacts to assess the overall environmental benefits of renewable energy technologies.
5	Technological Advancements	Stay informed about recent advancements and innovations in renewable energy technologies. This includes developments in efficiency improvements, cost reductions, energy storage solutions, and integration into existing energy infrastructures.
6	Global and Local Perspectives	Gain insights into global trends and local initiatives related to renewable energy adoption. Understand the diverse contexts in which non-conventional energy sources are implemented worldwide, considering geographical, cultural, and socio-economic factors.

8 Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP335.1	Demonstrate the generation of electricity from various Non-Conventional sources of energy, have a working knowledge on types of fuel cells.
M23MTP335.2	Estimate the solar energy, Utilization of it, Principles involved in solar energy collection and conversion of it to electricity generation.
M23MTP335.3	Explore the concepts involved in wind energy conversion system by studying its components, types and performance.
M23MTP335.4	Illustrate ocean energy and explain the operational methods of their utilization.
M23MTP335.5	Interpret the sources, types and methods of Biomass energy conversion.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP335.1	**3**		
M23MTP335.2	**3**		
M23MTP335.3	**3**		
M23MTP335.4	**3**		
M23MTP335.5	**3**		

9 Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10 Future with this Subject

- **Technological Advancements**: Continuous advancements in renewable energy technologies are expected to enhance efficiency, reduce costs, and improve reliability. Innovations in materials science, energy storage, and grid integration will further accelerate the deployment of non-conventional energy sources.
- **Global Energy Transition**: As countries strive to meet climate goals outlined in international agreements like the Paris Agreement, there is a growing momentum towards transitioning from fossil fuels to renewable energy sources. Non-conventional energy will play a pivotal role in achieving carbon neutrality and reducing greenhouse gas emissions.
- **Policy Support and Market Growth**: Governments worldwide are increasingly implementing supportive policies, incentives, and regulations to promote renewable energy adoption. This includes subsidies for renewable energy projects, carbon pricing mechanisms, and renewable energy targets. Such policies create a favorable market environment for investment and growth in the renewable energy sector.
- **Energy Security and Resilience**: Non-conventional energy sources contribute to enhancing energy security by diversifying energy supply sources and reducing dependence on imported fossil fuels. They

also improve energy resilience by decentralizing energy production and increasing the reliability of energy supply, especially in remote or vulnerable regions.

- **Integration with Smart Technologies**: The integration of renewable energy with smart grid technologies, energy storage systems, and digitalization will optimize energy management, enhance grid stability, and facilitate the efficient use of renewable energy resources. This trend is crucial for managing intermittent renewable energy sources like wind and solar power.

3rd Semester	Project Work Phase I	M23MTP304

1. Syllabus

PROJECT WORK PHASE I SEMESTER – III			
Course Code	M23MTP304	CIE Marks	**100**
Number of Lecture Hours/Week(L: P: SDA)	**(0:0:4)**	SEE Marks	**-**
Total Number of Lecture Hours		Total Marks	**100**
Credits	03	Exam Hours	**-**

Course objectives: This course will enable students to:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organization, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgment, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instill responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted. Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

2. Assessment Details:

Continuous Internal Evaluation

SL. No.	Description	% of Marks	In Marks
1	Project work by the guide	50%	50
2	Report writing	25%	25
3	Viva-Voce	25%	25
Total		100%	100

3. Learning Objectives

S/L	Learning Objectives	Description
1	Apply core mechanical engineering knowledge	Students will select a project activity that allows them to apply the principles of mechanics, thermodynamics, materials science, or other core mechanical engineering disciplines.
2	Develop hands-on skills	Through project activities like building a device, conducting experiments, or working with simulations, students will gain practical experience in relevant mechanical engineering techniques.
3	Enhance data analysis and interpretation skills	Students will learn to collect and analyze data related to their chosen project, identifying trends and drawing meaningful conclusions.
4	Refine critical thinking and problem-solving abilities	The project selection and execution process will require students to critically assess challenges, propose solutions, and adapt their approach as needed.
5	Strengthen communication and presentation skills	Students will present their project findings in a seminar setting, effectively communicating technical information to a peer audience.

4. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP304.1	Conduct a comprehensive literature survey and demonstrate understanding of the research landscape:
M23MTP304.2	Develop a well-defined project proposal with clear objectives and preliminary plans
M23MTP304.3	Effectively communicate project plans and findings through an introductory document and seminar presentation

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP304.1	3	-	-
M23MTP304.2	3	-	-
M23MTP304.3	-	3	-

3rd Semester	SOCIETAL PROJECT	M23MTP305

1. **Syllabus**

Societal Project (M23MTP305) SEMESTER – III			
Course Code	M23MTP305	CIE Marks	**100**
Number of Lecture Hours/Week(L: P: SDA)	**(0:0:6)**	SEE Marks	**-**
Total Number of Lecture Hours		Total Marks	**100**
Credits	03	Exam Hours	**-**
Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology to workout/proposing viable solutions for societal problems.			

2. **Assessment Details:**

Continuous Internal Evaluation

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this course.

3. **Learning Objectives**

S/L	Learning Objectives	Description
1	Identify and analyze a pressing societal problem	Students will demonstrate the ability to critically evaluate social issues and pinpoint a specific problem that technology can potentially address.
2	Explore existing technological solutions and research emerging trends:	Students will effectively research and analyze existing technology-based solutions for similar societal challenges.
3	Develop a creative and feasible technological solution	By leveraging their understanding of the problem and the technological landscape, students will propose an innovative solution that utilizes technology effectively.
4	Effectively communicate the proposed solution through a project report and presentation	Students will craft a well-structured project report that clearly outlines the identified problem, the proposed solution (including its technological aspects), and its potential benefits for society.

4. **Course Outcomes (COs) and Mapping with POs/ PSOs**

Course Outcomes (COs)

COs	Description
M23MTP305.1	Develop a technology-driven solution for a real-world societal problem
M23MTP305.2	Critically evaluate existing technological solutions and emerging trends
M23MTP305.3	Effectively communicate the proposed solution and its societal impact

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP305.1	3	-	-
M23MTP305.2	-	-	3
M23MTP305.3	-	3	-

3rd Semester	INTERNSHIP	M23MTPI306

1. Syllabus

Internship (M23MTPI36) SEMESTER – III			
Course Code	M23MTPI306	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(0:0:6)**	SEE Marks	**50**
Total Number of Lecture Hours		Total Marks	**100**
Credits	06	Exam Hours	**-**

Course Objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.

The objectives are further,

- To put theory into practice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
- To identify personal strengths and weaknesses.
- To develop the initiative and motivation to be a self-starter and work independently.

Internship:

Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship. Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

2. Assessment Details:

Continuous Internal Evaluation

CIE marks for the Internship report, presentation and question and answer session shall be awarded in the ratio of 50:25:25 for the total CIE of 50 marks by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments.

Semester End Examination

SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded in the ratio of 50:25:25 for the total SEE of 50 marks (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.

3. Learning Objectives:

S/L	Learning Objectives	Description
1	Apply Classroom Knowledge to Practical Work	Description: Students will demonstrate the ability to utilize theoretical knowledge gained in coursework to solve real-world problems encountered during the internship. This may involve applying specific skills, like budgeting or marketing principles, to a project or task.
2	Enhance Professional Skillset	Description: Students will actively participate in learning opportunities that expand their existing skillset. This could include developing presentation skills, mastering time management techniques, or honing interpersonal communication abilities.

3	Bridge the Gap Between Theory and Practice	Description: Students will gain a deeper understanding of professional practices in their field by observing and interacting with experienced professionals. This may involve shadowing colleagues, attending client meetings, or participating in project discussions.
4	Develop Professional Responsibility and Ethics	Description: Students will learn about and adhere to professional standards and ethical codes relevant to their field. This may involve understanding confidentiality protocols, managing liability risks, or completing paperwork with accuracy and attention to detail.
5	Foster Self-Directed Learning and Initiative	Description: Students will take on independent tasks and demonstrate initiative in seeking out learning opportunities. This may involve proposing new ideas, conducting research relevant to their work, or managing personal workload effectively.

4. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTPI306.1	Apply the academic knowledge to solve practical problems encountered during the internship.
M23MTPI306.2	Gain industry experience, explore career options, and refine professional goals.
M23MTPI306.3	Enhance Communication and Self-Directed Learning

CO-PO-PSO Mapping.

COs/POs	PO1	PO2	PO3
M23MTPI306.1	3	-	-
M23MTPI306.2	-	-	3
M23MTPI306.3	-	3	-

4th Semester	Project Work Phase 2	M23MTP401

1. **Syllabus**

PROJECT WORK PHASE I SEMESTER – IV			
Course Code	M23MTP401	CIE Marks	**100**
Number of Lecture Hours/Week(L: P: SDA)	**(0:0:8)**	SEE Marks	**100**
Total Number of Lecture Hours		Total Marks	**200**
Credits	**18**	Exam Hours	**03**

Course Objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instill responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar. CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.
SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

2. **Assessment Details:**

CIE

The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

SEE

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

3. **Learning Objectives**

S/L	Learning Objectives	Description
1	Independent Learning & Ethical Research	Develop skills to research effectively, critically evaluate information, and use sources ethically to support independent learning.
2	Effective Communication & Organization	Learn to organize information logically, present findings clearly (citing sources), and communicate effectively through written and oral formats.
3	Time Management & Teamwork	Develop time management skills to meet deadlines and collaborate effectively within teams, fostering flexibility and adaptability.
4	Seminar Presentation & Public Speaking	Gain confidence in public speaking, overcome stage fright, and present project work effectively in a seminar setting.
5	Critical Thinking & Professionalism	Sharpen critical thinking skills, demonstrate sound judgment and intuition, and cultivate a sense of responsibility towards oneself and others.

4. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MTP401.1	Conduct In-Depth Research and Develop a Comprehensive Project
M23MTP401.2	Effectively Communicate Project Findings and Defend Methodology
M23MTP401.3	Demonstrate Advanced Knowledge and Critical Thinking Skills:

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MTP401.1	3	-	-
M23MTP401.2	-	3	-
M23MTP401.3	-	-	3