Course Syllabus
Gyanmanjari Institute of Technology
Semester- 4

Subject: Solar Thermal System- BETME14308

Type of course: Elective

Prerequisite: Engineering Thermodynamics

Rationale: For mechanical engineering students, studying solar thermal energy sources offers a critical foundation for sustainable engineering. As the world shifts toward environmentally friendly and renewable energy solutions, mechanical engineers with expertise in solar thermal systems are well-equipped to contribute to these efforts. Solar thermal energy combines core mechanical principles such as thermodynamics, fluid mechanics, and heat transfer, enabling students to apply their theoretical knowledge to real-world energy systems. This knowledge fosters innovation in system design and performance, allowing engineers to develop more efficient, cost-effective energy solutions. With the renewable energy sector on the rise, mechanical engineers who are proficient in solar technologies are increasingly sought after, opening new career opportunities in energy and environmental engineering. Additionally, an understanding of the policy and regulatory frameworks surrounding solar energy enables engineers to bridge the gap between technical design and regulatory compliance, contributing to the successful implementation of sustainable projects. Through this study, students gain both technical expertise and a broad perspective on the future of energy, making them invaluable in the evolving energy landscape.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
CI	T	P	C	Theory Marks		Practical Marks		CA	
				ESE	MSE	V	P	ALA	
3	-	2	4	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment; ALA- Active Learning Activities.

Course Content:

Sr. No	Course content	Hrs	% Weightage
1	**Introduction to Solar Thermal Energy and Solar radiation Fundamentals:** Overview of renewable energy sources, Importance of solar energy in the context of renewable energy, Solar thermal vs. photovoltaic systems, Solar radiation and its measurement, Solar geometry and angles, Insolation and solar irradiance.	08	15
2	**Solar Liquid and Air Heating System:** Classification of solar thermal collector, Flat plate collector – Liquid and air heating - Evacuated tubular collectors - Overall heat loss coefficient, heat capacity effect - Thermal analysis. Design of solar water heating systems, with natural and pump circulation. Solar dryers and applications. Thermal energy storage systems.	10	25
3	**Solar thermal power plants:** Parabolic trough system, distributed collector, hybrid solar-gas power plants, solar pond based electric-power plant, central tower receiver power plant, Concept of solar temperature and its significance, calculation of instantaneous heat gain through building envelope. Solar thermomechanical refrigeration system – Carnot refrigeration cycle. **Solar Thermal Applications:** Solar systems for process heat production - Solar cooking -- Performance and testing of solar cookers. Seawater desalination – Methods, solar still and performance calculations. Solar Dryer – Methods, design and performance evaluation, Solar Pond, Solar greenhouse, Space heating and cooling using solar energy.	20	45
4	**Integration and Hybrid Systems and Emerging Trends and Future Prospects:** Integration of solar thermal systems with existing energy systems, Hybrid systems: solar thermal combined with biomass, geothermal, etc., Economic and environmental consideration, Advanced solar thermal technologies: nanofluids, high-temperature materials, Solar thermal in urban environments, Policy and regulatory aspects of solar thermal energy.	07	15

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Solar data collection:** Collect and analyze solar radiation data to understand how solar angles and irradiance vary throughout the day and apply these insights to optimize solar energy systems, draw a plot and upload it on GMIU web portal.	10
2	**Derive and Calculate Parameters for Solar Desalination:** Derive energy requirement and collector area required for a solar desalination system per unit water production, prepare an excel worksheet and upload it on GMIU web portal.	10
3	**Derive and Calculate Parameters for Solar Drying System:** Derive energy requirement, collector area, and drying chamber area for a solar drying system, using input specifications given by professor, prepare an excel worksheet and upload it on GMIU web portal.	10
	Total	30

Suggested Specification table with Marks (Theory): 60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage	15%	20%	40%	10%	10%	5%

Course Outcome:

After learning the course, the students should be able to:	
CO1	Comprehend the significance of solar energy and differentiate between solar thermal and photovoltaic systems.

CO2	Design and analyze solar liquid and air heating systems, including thermal calculations.
CO3	Understand solar thermal power plants, thermo mechanical systems, and solar thermal applications.
CO4	Assess the integration of solar thermal systems with other energy sources and explore advanced technologies.

List of Practical:

Sr. No	Descriptions	Unit No	Hrs
1	**Measurement of Solar Radiation:** Use solar radiation measurement tools (like pyranometers) to measure and record solar irradiance at different times of the day and under varying weather conditions. Analyze the data to understand solar energy availability.	1	04
2	**Design of a Solar Water Heater:** Design a simple solar water heating system using a flat plate collector. Measure the temperature rise of water and calculate the efficiency of the system based on solar radiation received.	2	04
3	**Heat Transfer Analysis in Solar Thermal Collectors:** Conduct experiments to analyze heat transfer in flat plate and evacuated tube collectors. Measure inlet and outlet temperatures and flow rates to calculate heat transfer coefficients.	2	04
4	**Field Visit to Solar Thermal Installations:** A visit to a local solar thermal power plant or solar heating installation. Observe the operation, equipment, and maintenance practices, and engage with professionals in the field.	3	02
5	**Performance Testing of Solar Cookers:** Build a solar cooker using reflective materials and evaluate its cooking performance by measuring temperature changes and cooking times for various food items under different sunlight conditions.	4	04
6	**Solar Dryer Design and Evaluation:** Design a solar dryer and test its effectiveness in drying different agricultural products. Measure moisture content before and after drying to assess efficiency and compare with conventional drying methods.	4	06
7	**Seawater Desalination Experiment:** Set up a simple solar still to demonstrate the desalination process. Measure the volume of distilled water produced over time and analyze the efficiency of the system.	4	06
	Total		30

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Instructional Method:

The course delivery method will depend upon the requirement of content and the needs of students. The teacher, in addition to conventional teaching methods by black board, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.
Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory

The internal evaluation will be done on the basis of Active Learning Assignment. Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in the laboratory.

Reference Books:

[1] Solar Energy: Principles of Thermal Collection and Storage, S. P. Sukhatme, McGraw-Hill

[2] Solar Energy Engineering: Processes and Systems, S. A. Kalogirou, Academic Press Inc

[3] Solar Energy: Fundamentals and Applications, G. N. Tiwari, Alpha Science International Ltd.

[4] Solar Energy: Fundamentals and Applications, A. J. Chandorkar and R. B. Jain, Jain Book

[5] Principles of Solar Engineering, FrankKreith and Jan F. Kreider, Taylor and Francis

[6] Solar Thermal Technologies for Energy Efficiency, Springer

[7] Handbook of Solar Energy: Theory, Analysis and Applications, G.N. Tiwari, Arvind Tiwari, Shyam, Springer