Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NMED547	Phase Change Based Thermal Energy Storage Systems	3	0	0	3

Course Objective

The objective of the course is to study the fundamentals of latent heat storage, thermodynamic properties of phase change materials, system design, heat transfer enhancement techniques, and industrial applications.

Learning Outcomes

Upon successful completion of this course, students will:

- Be able to understand the fundamentals of PCMs and thermal storage systems.
- Be able to understand heat transfer phenomenon involved during phase change.
- Be able to design and simulate such energy storage systems.
- Be able to understand the application of PCM based thermal storage systems.

Unit No.	Topics to be Covered	Lecture Hours (L)	Learning Outcome
1	**Introduction:** Need for thermal energy storage in renewable energy systems and waste heat recovery. Various methods of energy storage: sensible heat, latent heat, and thermochemical storage. Performance evaluation parameters: Storage density, efficiency, charging/discharging rates, and cost analysis.	8	Students will learn about energy storage needs and select optimal thermal storage mechanisms based on operating parameters.
2	**Phase Change Materials (PCMs) Fundamentals:** Classification of PCMs: Organic, inorganic, and eutectics. Various thermodynamic properties of PCMs: Melting temperature, latent heat of fusion, and heat capacity, Supercooling, phase segregation, chemical stability, and compatibility with storage system materials. PCMs characterization techniques: Differential Scanning Calorimetry (DSC) and thermal cycling tests.	9	Students will get detailed knowledge of PCM materials, methods of selecting PCM and characterization techniques.
3	**Heat Transfer in Phase Change Systems: S**olid-liquid phase change, Conduction-dominated vs. convection-dominated melting and solidification, Challenges of low thermal conductivity in PCMs and heat transfer enhancement techniques, Use of extended surfaces (fins), metal foams, nanoparticles, and carbon-based structures.	9	Students will learn to mathematically model phase front movement.
4	**Storage System Design and Simulation techniques:** Design of shell-and-tube, direct-contact latent heat storage systems, Governing equations for numerical methods and simulation techniques.	8	Students will learn to design storage systems and simulation techniques.
5	**Engineering Applications:** Building applications: Passive wallboards, floor heating, and active cooling/heating systems, Solar thermal systems, Electronic thermal management: Heat sinks for batteries, electronics, and electric vehicles, Domestic hot water storage and industrial process heat optimization.	8	Students will learn to utilize latent heat concepts for real-world storage systems for various purposes.
	Total	**42**	

Textbook:

1. Dincer, I., and Rosen, M. A., Thermal Energy Storage: Systems and Applications. Wiley Publications, 3rd Edition, (2021).
2. Cabeza, L. F., Advances in Thermal Energy Storage Systems: Methods and Applications. Woodhead Publishing, (2015).

Reference Books:

1. Ali, H. M., Phase Change Materials for Thermal Energy Management and Storage: Fundamentals and Applications (Emerging Materials and Technologies). CRC Press, 2025.
2. Fleischer, A. S., Thermal Energy Storage using Phase Change Materials. Springer International Publishing, (2015).
3. Dhass, A. D. High-Temperature Phase Change Materials for Thermal Energy Storage: Fundamentals to Applications. Elsevier, (2024).