BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE – PILANI, HYDERABAD CAMPUS SECOND SEMESTER 2023-2024

(COURSE HANDOUT: PART-II)

Date: 09/01/2024

In addition to Part-I (a general handout for all courses appended to the time-table), this handout provides the specific details of this course.

Course No.	**:**	**ME F323**
Course Title	**:**	**ENERGY STORAGE TECHNOLOGIES**
Instructor-in-charge	**:**	**R. PARAMESHWARAN**

1. Course Description

Introduction, necessity of energy storage, classification, principles, challenges, comparison and applications of energy storage technologies. Mechanical energy storage: Flywheel, compressed air and pumped hydro energy storage. Thermal energy storage: Sensible heat, cryogenic storage, phase change materials, latent heat enthalpy, charging and discharging, thermochemical energy storage, sorption and desorption reactions. Electrochemical energy storage: Lead-acid batteries, ionic batteries, fuel cells, flow batteries, super- capacitors. Chemical energy storage: Hydrogen storage methods, power-to-gas and synthetic fuels. Superconducting and hybrid energy storage.

2. Scope and Objective

This course is intended to provide students an introduction to the energy storage technologies with an extensive understanding of the scientific aspects that reinforces the operation of systems/devices based on such technologies. This course emphasizes the need for the state-of-the-art methods for energy storage in order to provide innovative solutions to the challenges related to the energy generation, distribution, demand and its balance. More specifically, this course covers the main topics that include mechanical, thermal, electrochemical, chemical, hydrogen storage, superconducting and hybrid energy storage technologies, and their applications. The interactive methods to evaluate the performance attributes of the energy storage systems and their interactions with real world applications will be largely emphasized from the industrial perspectives.

3. Text Books:

T1. A.R. Pendse, Energy Storage Science & Technology, SBS Publishers & Distributors Pvt. Ltd., New Delhi, 2011.

T2: Odne Stokke Burheim, Engineering Energy Storage, Academic Press, 1st Edition, 2017.

Reference Books:

R1. S. Kalaiselvam and R. Parameshwaran, Thermal Energy Storage Technologies for Sustainability Systems Design, Assessment and Applications, Academic Press, 1st Edition, 2014.

R2. Yves Brunet, Energy Storage, Wiley-ISTE, 1st edition. 2013.

R3. Umakanta Sahoo, Energy Storage, Wiley-Scrivener; 1st edition, 2021.

4. Course Plan

Lecture No.	Learning objectives	Topics to be covered	Chapter
1-3	Introduction to energy storage technologies and their applications	Energy scenario, energy consumption, need for energy storage, technology perspectives, basic principles, applications of energy storage technologies.	T1: 1 T2: 1 R1: 1
4-6	Classification of energy storage technologies	Mechanical, thermal, electrochemical, chemical, superconducting and hybrid energy storage, comparison, merits and challenges.	T1: 2 T2: 1 R1: 2
7	Showcase of Energy Storage Devices/Prototypes		Experiential Learning
8-11	Mechanical energy storage	Fundamentals of flywheel, compressed air and pumped hydro energy storage, types, mechanisms and design, state-of-the-art developments, application perspectives.	T1: 6 T2: 3, 5 R1: 2
12-16	Thermal energy storage (TES)	Basics of sensible, latent, and thermochemical energy storage, materials and properties, mechanisms and reactions, design aspects, state-of-the-art developments.	T1: 5 T2: 4 R1: 3-7
17-19	Cryogenic energy storage	Types of cryogens and properties, liquid air/liquid nitrogen and cryo-hydrogen energy storage, cycle efficiency, merits and challenges.	T1, T2: 5 R1: 2 R2: 5
20-21	Field Visits		Experiential Learning
22-25	Electrochemical energy storage	Operating principles of lead-acid batteries, ionic batteries, flow batteries, types, reaction kinetics, electrode materials, catalysis, crucial factors, applications.	T1: 8 T2: 6, 7 R2: 8, 9
26-27	Supercapacitors	Principle of operation, electric double layer, sizing supercapacitor, power interfaces, pseudo- and hybrid supercapacitors, applications.	T1: 7 T2: 9 R2: 9
28-31	Fuel Cells	Principles, types and functional aspects of fuel cells, direct energy conversion, comparison and applications.	T1, T2: 8 R2: 6, 7
32-33	Technical Seminars/Guest Lectures		Experiential Learning
34-36	Chemical energy storage	Hydrogen synthesis and storage methods, materials for hydrogen storage, metal hydrides, metal organic frameworks (MOFs), power-to-gas storage, synthetic fuels.	T1: 5 T2: 8 R2: 5
37-38	Superconducting energy storage	Concept of superconductivity, magnetic energy storage, superconducting materials, benefits, challenges and applications.	T1: 6 R1: 2 R3: 3
39-40	Hybrid energy storage	Power plant operations, renewable energy integration, power grids, challenges.	R3: 3 Research Publications
41-42	Trends in energy storage technologies	Across Industry, transport, commercial and building sectors, future perspectives	Research Publications

*Guest lectures by industry experts may be organized as part of course deliverables.

5. Evaluation Scheme

Evaluation Component	Duration (minute)	Weightage (%)	Date & Time	Nature of Component
Mid-Semester Test	90	25	15/03 - 11.00 - 12.30PM	Closed Book
In-Class Self-Assessment Test (IC-SAT)	10	15	Best 6 out of 8	Open Book (Continuous Evaluation)
Assignments (In-class and Take Home)	---	5	Will be conducted throughout the semester	
Mini Project* (Reports & Presentations)	---	10	Will be announced in the Class	
Comprehensive Exam[#]	180	45	16/05 AN	Closed Book

NOTE:

* Students shall submit project reports on a **topic** of their choice that **aligns** with the **course description** and **course plan**. The project reports (**softcopy**) not exceeding ten pages (A4 size) shall be submitted as per the schedule (to be announced in the Class). The reports will be evaluated based on the problem formulation, quality of the work, demonstration of the work (in the form of short videos and interactive presentations) and Turnitin/DrillBit report (similarity index).

6. **Chamber Consultancy Hour:** To be announced in the class room.

7. **Notices:** All notices concerning this course shall be displayed on the CMS (the Institute's web based course management system). Besides this, students are advised to visit regularly CMS for latest updates.

8. **Make-up Policy:** Make-up shall be granted only to the genuine cases with prior confirmation. Request for the make-up tests, duly signed by the students, should reach the under signed well before the scheduled test.

9. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-Charge
ME F323