# 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.

# 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.

# 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.

# Course Plan

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| --- | --- | --- | --- |
| **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.

# Evaluation Scheme

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| --- | --- | --- | --- | --- |
| **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).

1. **Chamber Consultancy Hour:** To be announced in the class room.
2. **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.
3. **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.
4. **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**