NIRMA UNIVERSITY

Institute:	**Institute of Technology**
Name of Programme:	**M. Tech. in Electrical Engineering (Electric Vehicular Technology)**
Semester:	**I**
Course Code:	**6EE104**
Course Title:	**Energy Storage and Battery Charging Systems**
Course Type:	(√ **Core**/ □ Value Added Course / □ Department Elective / □ Institute Elective/ □ University Elective/ □ Open Elective / □ Any other)
Year of Introduction:	**2022 – 23**

L	T	Practical component				C
		LPW	PW	W	S	
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Course Learning Outcomes (CLOs):

At the end of the course, the students will be able to -

1. select appropriate energy storage system **(BL6)**
2. analyse battery characteristics and parameters **(BL4)**
3. apply the concept of battery management systems **(BL3)**
4. design battery charging system **(BL6)**

Syllabus: **Teaching Hours: 45**

Unit-1: Introduction **05**

Principles of operation of cells and batteries, electrochemical principles and reactions, types of batteries, fuel cells, supercapacitors, flywheel energy storage systems, selection and application of energy storage systems for electric vehicle systems

Unit-2: Batteries for EV **08**

advanced lead-acid, Ni-based, lithium ion and sodium ion batteries, battery performance parameters, battery sizing, battery design, battery assembly, testing, failure analysis, safety issues, battery pack performance, drive cycle analysis and safety testing standards.

Unit-3: Battery Management Systems **20**

Selection of battery for EV, traction battery pack design, requirement of battery monitoring, battery state of charge estimation methods, battery cell equalization problem and solution, thermal control, protection interface, energy and power estimation, battery thermal management system, components of battery management system, battery pack safety, battery standards & tests.

Unit-4: Battery Charging Systems **12**

Types of charging system, levels of charger, DC fast charger, converter topologies for chargers, unidirectional and bidirectional battery chargers, mechanism of wireless charging, V2G and G2V interface, types of connectors, battery charging standards and charging protocols

Self-Study:
The self-study contents will be declared at the commencement of semester. Around 10 % of the questions will be asked from self-study contents.

Laboratory Experiments:
This shall consist of at least 10 experiments / simulations based on the above syllabus.

Suggested Reading:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, John Wiley & Sons.
2. Sandeep Dharmeja, Electric Vehicle Battery Systems, Newnes.
3. Chung Chow Chan, K. T. Chau, Modern Electric Vehicle Technology, Oxford University Press.
4. Michael H Westbrrok, The Electric Car - Development and Future of Battery, Hybrid and Fuel Cell Cars, IEE Power and Energy Series 38, The Institution of Electrical Engineers.
5. Handbook of Electric Vehicle Charging Infrastructure Implementation, NITI Aayog
6. International standards in use, relevant research papers and articles.
7. Research Papers on IEEE/IET/Science Direct etc.
8. Product Literatures

Suggested List of Experiments (not restricted to the following):
(Only for Information)

1. Demonstration of battery characterization for charging and discharging conditions for various battery types.
2. Simulation and analysis of constant current-constant voltage charging technique.
3. Simulation and analysis of trickle charging technique.
4. Simulation and analysis of passive and active cell balancing.
5. Demonstration of battery management system.
6. Simulation and analysis of on-board charger.
7. Simulation and analysis of bidirectional power flow control in vehicle.
8. Simulation and analysis of vehicle to grid interfacing.
9. Simulation of fast dc charging system.

L = Lecture, T = Tutorial, P = Practical, C = Credit

w.e.f. academic year 2022 - 23 and onwards