

COURSE TITLE	BATTERIES AND BATTERY MANAGEMENT SYSTEMS
COURSE CODE	01EE1605
COURSE CREDITS	3

Objective:

- 1 The objective of this course is to introduce learner to batteries, its parameters, modelling and charging requirements. The course will help learner to develop battery management algorithms for batteries

Course Outcomes: After completion of this course, student will be able to:

- 1 Paraphrase the battery terminologies.
- 2 Interpret the role of battery management system.
- 3 Interpret the BMS specifications in light of the basic functionalities.
- 4 Analyse the different modelling techniques for battery pack and simulate it.
- 5 Calculate the various parameters of battery and battery pack.

Pre-requisite of course: Basics of Electrical Engineering (or equivalent subject), Circuit Network, Physics

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	0	50	30	20	0	0

Contents : Unit	Topics	Contact Hours
1	Batteries Batteries – History, Development and EV application, Cells Chemistry, Preliminaries – Cell, Primary and Secondary Cells, Nominal Cell Voltage, Nominal Charge Capacity, Nominal Energy Capacity, Battery C-Rate, Capacity, Series and Parallel connections of cells, Specific Energy and Energy Density, Cell Discharge and Charge, Energy and Columbic Efficiency, battery life, charging regimes – Constant Current charging, Constant Voltage charging, Taper-current charging, CCCV chargers, State of charge (SOC), State of Health (SOH)	6
2	Introduction to Battery Management System Naming conventions, Li-Ion cells- formats, chemistry, safety, efficiency, aging. Modelling, unequal voltages in series strings, Li-Ion BMS, definition, functions, custom vs off the shelf, BMS functionality, Technology, Topology	10

Contents : Unit	Topics	Contact Hours
3	Battery Management system Requirements Battery-pack topology, BMS design requirements, Battery-pack sensing: Voltage, Battery-pack sensing: Temperature, Battery-pack sensing: Current, High-voltage contactor control, Isolation sensing. Thermal control, Charger control, Communication via CAN bus, Log book function, State of charge estimation, Energy estimation. Power estimation, Diagnostics, Cell Balancing	10
4	Battery Modelling: Equivalent circuit models (ECMs) Open-circuit voltage, , SOC dependence, Equivalent series resistance,, Diffusion voltages, Warburg impedance ,, Hysteresis voltages, ESC cell model Laboratory equipment,, OCV-relationship lab tests,, Dynamic-relationship tests,, Example results, simulating ESC toolbox	10
5	Modelling : Physical Based Models and Simulation Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, simulating constant power and voltage, Simulating battery packs,	6
Total Hours		42

Textbook :

- 1 Battery management systems, Volume I: Battery modeling, Plett, Gregory L., Artech House, 2015
- 2 Battery management systems, Volume II: Equivalent-circuit methods, Plett, Gregory L., Artech House, 2015
- 3 Battery Management Systems -Design by Modelling, Bergveld, H.J., Kruijt, W.S., Notten, P.H.L, Philips Research Book Series, 2002
- 4 Battery Management Systems for Large Lithium-ion Battery Packs, Davide Andrea, Artech House, 2010
- 5 Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9, Pop, Valer, et al., Springer Science & Business Media, 2008
- 6 Electrochemical Methods: Fundamentals and Applications 2nd ed., Bard, Allen J., and Larry R. Faulkner, Wiley– VCH, Verlag, GmbH,, 2000

References:

- 1 Lithium ion Batteries Fundamental and Performance, Lithium ion Batteries Fundamental and Performance, Masataka Wakihara and Osamu Yamamoto, Wiley–VCH, Verlag GmbH, 1999

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking / Creative
15.00	25.00	25.00	20.00	10.00	5.00

Supplementary Resources:

- 1 <https://www.coursera.org/learn/battery-management-systems>
- 2 <https://www.udemy.com/course/lithium-ion-battery-and-battery-management-system-for-an-ev/>
- 3 <https://training.ti.com/introduction-battery-management>