Short Course: Managing Li-Ion Battery Systems in Electric Vehicles (Duration: 3 Hours)

By Dr. Ryan Ahmed

Course Summary:

This short course is designed to provide learners with a comprehensive understanding of managing Li-Ion battery systems in Hybrid Electric Vehicles (HEVs) and Battery Electric Vehicles (BEVs). The course covers essential topics in Battery Management Systems (BMS), including battery modeling, analysis, aging, thermal management, and the estimation of state of charge and state of health. Learners will explore advanced concepts such as artificial intelligence and machine learning (AI/ML), parameter estimation, system identification, optimization, filtering, and control theory, all applied to battery systems. The course emphasizes a hands-on approach, ensuring students learn through practical experience and real-world applications.

Key Learning Objectives:

- Understand the basic principles of batteries and BMS for electric vehicle applications.
- Develop an understanding of the automotive industry's battery testing techniques and procedures.
- Appy artificial intelligence and machine learning techniques for battery modeling, monitoring, and state estimation.
- Apply their programming skills to develop code scripts and models for battery modeling, optimization, state of charge, and state of health estimation.
- Develop an understanding of battery aging and degradation mechanisms.
- Understand the basics of electrochemical battery modeling (physics-based modeling).

Pre-requisites:

There are no formal prerequisites for this course. However, to maximize the learning experience, a basic knowledge of Matlab, Simulink, and Python is recommended.

Outline:

- Introduction to batteries in electric vehicle applications
- Battery construction and operation
- BMS key functions
- Battery testing equipment and techniques
- Artificial intelligence and deep learning fundamentals
- Battery equivalent-circuit-based modeling and SOC estimation Using Extended Kalman Filtering (**Project 1)**.
- Battery Modeling and SOX Estimation using AI/ML approaches using Feed Forward Artificial Neural Networks, Transformers, and Long Short-Term Memory Networks (LSTMs) (**Project 2)**.
- Battery Electro-thermal Modeling and Management in Matlab/Simulink (**Project 3).**

Instructor Biography

Dr. Ryan Ahmed, Ph.D., MBA

"Dr. Ryan Ahmed is an Assistant Professor at McMaster University, deputy director of the Center for Mechatronics and Hybrid Technologies (CMHT), and co-lead faculty advisor for the Battery Workforce Challenge (BWC)[1]. He received his M.A.Sc., Ph.D., and MBA from McMaster University in 2011, 2014, and 2018 respectively. He has held several senior positions in Electric and Autonomous vehicles at General Motors, Samsung, and Stellantis in Canada and the United States. Dr. Ahmed has taught over half a million learners from 160 countries on Udemy[2] and Coursera[3], and he has over 250,000 subscribers on his YouTube channel[4] titled "Prof. Ryan Ahmed," where he teaches people AI, data science, and ML fundamentals. Dr. Ahmed is a Udemy Instructor Partner, Professional Engineer (P.Eng.) in Ontario, and Stanford Certified Program Manager. He is the principal author/co-author of over 40 journal and conference papers in artificial intelligence, battery systems, electric and hybrid powertrains, and autonomous systems. Dr. Ahmed is the co-recipient of two best papers awards at the IEEE Transactions on Industrial Electronics (2018) and the IEEE Transportation Electrification Conference and Expo (ITEC 2012) in Detroit, MI, USA."

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[1] **The Battery Workforce Challenge (BWC) collegiate competition is a three-year engineering competition that challenges North American universities and their community college partners to design, build, test, and integrate an advanced EV battery pack into a Stellantis vehicle.*

[2] Udemy Profile: https://www.udemy.com/user/ryan-ahmed/

[3] Coursera Profile: https://www.coursera.org/instructor/~48777395

[4] YouTube Channel: https://www.youtube.com/@professor-ryanahmed