WM985-15 Automotive Hybridisation and Electrification

26/27

Department
WMG
Level
Taught Postgraduate Level
Module leader
Kamyar Nikzadfar
Credit value
15
Module duration
4 weeks
Assessment
100% coursework
Study locations
University of Warwick main campus, Coventry Primary
Distance or Online Delivery

Description

Introductory description

This module examines the core principles and concepts that underpin the engineering of hybrid and electrified vehicles, considering both system-level and sub-system-level perspectives. It introduces key customer requirements and associated vehicle-level attributes, such as performance indicators and efficiency targets, and explores how these are systematically translated into technical solutions. The module further covers suitable verification methods to ensure these requirements and expectations are fulfilled. The sizing of components for electric and hybrid systems is explored in detail, alongside an in-depth study of propulsion architectures, control strategies, and integration challenges. By the end of the module, students will have acquired a thorough understanding of the complete engineering process.
When this module is delivered on DA Programmes, it is delivered in a 1 week block with 6 weeks to submit, rather than over 4 weeks

Module web page

Module aims

This module aims to provide students with a comprehensive understanding of hybrid and electric vehicles, with particular emphasis on their core attributes, functional behaviour, and architectural characteristics. Students will learn to define high-level vehicle requirements and apply systems engineering principles to systematically decompose these into sub-system specifications through component sizing. The module also introduces the key sub-systems of hybrid and electric vehicles, establishing a solid foundation for further study in the design and development of advanced hybrid and electric propulsion systems.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Introduction to Battery Electric Vehicles (BEVs)

- Overview of BEV concepts, operating principles, advantages and limitations
- Market trends, regulatory context, and societal impact

Powertrain Theories and Calculations

- Fundamentals of power and energy in vehicle applications
- Vehicle longitudinal dynamics, tractive effort, and energy flow analysis
- Driving cycles and performance estimation

Powertrain Architecture and Systems

- Electric and hybrid powertrain configurations: series, parallel, and power-split
- Functional roles of sub-systems within the propulsion system
- System-level design considerations

Attribute Decomposition in Automotive Engineering

- Defining vehicle-level attributes: performance, range, efficiency, drivability
- Systems engineering approach to requirement breakdown
- Attribute cascading and traceability

Component Sizing for BEVs

- Hands-on methods for sizing motors, batteries, and inverters
- Trade-off analysis and design constraints
- Introduction to sizing tools and models

Hybrid Electric Vehicles (HEVs)

- Principles and types of hybridisation
- Energy management strategies and hybrid control concepts
- Comparison with BEVs in terms of performance and application

Series and Parallel Hybrid Powertrains: Sizing and Control

- Component interaction and energy flow in hybrid systems
- Control strategies and optimisation techniques
- Sizing of components

Electrical and Electronic Systems in Electrified Powertrains

- High-Voltage Battery Systems, Electric Machines and Drives, Power Electronics,

Learning outcomes

By the end of the module, students should be able to:

- Demonstrate a comprehensive understanding of the principles, architectures, and functional characteristics of hybrid and electric vehicles at both system and sub-system levels. [AHEP:4; 7, M4]
- Define key customer requirements and vehicle-level attributes, such as performance and efficiency targets, and translate these into technical specifications. [AHEP:4; 7, M1, M2, M5]
- Apply systems engineering principles to decompose high-level vehicle requirements into sub-system parameters, and perform quantitative powertrain calculations and component sizing for BEVs and HEVs [AHEP:4; 7, M1, M3, M5]
- Identify and explain the roles of key vehicle sub-systems, including high-voltage battery systems, electric machines (such as PMSMs), and associated power electronics. [AHEP:4; 7, M4, M5]
- Apply appropriate verification and validation techniques to ensure system-level requirements are achieved. [AHEP:4; 7, M3]
- Collaborate effectively as part of a multidisciplinary team to solve engineering problems, communicate design decisions, and contribute to the development of hybrid and electric vehicle systems. [AHEP:4; 7, M16]

Indicative reading list

Reading lists can be found in Talis

Specific reading list for the module

Subject specific skills

Apply engineering analysis to real-world vehicle problems; Lead technical teams and group projects; Manage resources, time, and system constraints; Communicate with technical and non-technical audiences; Use tools like MATLAB/Simulink for component sizing; Analyse road load and energy consumption; Define vehicle requirements and performance attributes; Apply systems engineering to powertrain design; Evaluate emerging electrified vehicle technologies

Transferable skills

Problem-Solving and Critical Thinking; Project Management and Time Management; Teamwork and Collaboration; Communication and Presentation Skills; Adaptability and Innovation; Research

and Analytical Skills; Self-Directed Learning and Continuous Improvement; Entrepreneurial Thinking and Innovation

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Study

Study time

Type	Required
Lectures	8 sessions of 1 hour (5%)
Seminars	16 sessions of 1 hour (11%)
Tutorials	6 sessions of 1 hour (4%)
Online learning (independent)	10 sessions of 1 hour (7%)
Private study	50 hours (33%)
Assessment	60 hours (40%)
Total	150 hours

Private study description

Self-study time for preparation for assessed tasks, including independent research activity.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group A1

Assessment component	Weighting	Study time	Eligible for self-certification
Attribute Definition, Powertrain Sizing, and Verification of a HEV Concept- Group project	70%	42 hours	No

In this team-based project, students will design a conceptual hybrid electric vehicle by identifying key customer requirements and translating them into system-level attributes. Applying systems

	Weighting	Study time	Eligible for self-certification

engineering principles and propulsion system theory, teams will break down these attributes into sub-system specifications and carry out powertrain sizing calculations. Peer assessment will be employed to account for individual contributions within each team.

Reassessment component

Attribute Definition, Powertrain Sizing, and Verification of an EV Concept (Individual Re-assessment)			No

In this individual assessment, the student will develop a conceptual electrified vehicle by defining key customer requirements and translating them into system-level attributes. Using systems engineering principles and theories of propulsion systems, they will decompose these attributes into sub-system specifications and perform powertrain sizing calculations. The student will consider the various roles within an engineering team to assess whether a proposed design aligns with current market trends

Assessment component

Individual Video Presentation: Emerging Technologies in Core Sub-Systems of Electric Vehicles	30%	18 hours	Yes (extension)

In this individual assignment, students will produce a video presentation demonstrating their understanding of electric and hybrid vehicle architectures, with a particular focus on the evolving technologies in key sub-systems such as high-voltage batteries, electric machines, and power electronics. The presentation should highlight current trends, technological advancements, and their impact on overall vehicle performance and design.

Reassessment component

Individual Video Presentation: Emerging Technologies in Core Sub-Systems of Electric Vehicles			No

In this individual assignment, students will produce a video presentation demonstrating their understanding of electric and hybrid vehicle architectures, with a particular focus on the evolving technologies in key sub-systems such as high-voltage batteries, electric machines, and power electronics. The presentation should highlight current trends, technological advancements, and their impact on overall vehicle performance and design.

Feedback on assessment

Individual written feedback and overall mark.

Availability

Post-requisite modules

If you pass this module, you can take:

- WM995-15 Battery Electrochemistry, Design and Manufacturing

Courses

This module is Core for:

- MSc in Sustainable Automotive Electrification (L7 DA)
- MSc in Sustainable Automotive Electrification (FT)
- MSc in Sustainable Automotive Electrification (PT)