AUPC3005 HYBRID ELECTRIC VEHICLES AND RENEWABLE ENERGY (3-0-0)

Course Objectives:

1. To introduce students to hybrid and electric vehicle fundamentals and powertrain topologies.
2. To develop analytical skills in drivetrain configuration, control strategies, and energy storage systems.
3. To integrate renewable energy technologies for sustainable vehicle operation.

Module I: Introduction (06 Hours)

History of electric vehicles and hybrid technology evolution. Social, economic, and environmental relevance of HEVs. Comparison of conventional and alternative vehicle technologies. Impact on emissions, fuel economy, and energy security. Basics of fuel cells – working principle, efficiency, and application in mobility.

Module II: Drive Train Components and Control (09 Hours)

Overview of vehicle drivetrain – ICE vs electric drive. Electric traction motor types: DC, BLDC, PMSM, induction motor – characteristics and control. Transmission systems in EVs and hybrids: single-speed, multispeed, reduction gearing. Power electronics: inverters, converters, controllers. Drive cycle analysis: FTP, NEDC, WLTP, real driving emissions (RDE). Torque-speed-speed characteristics of hybrid drives. Regenerative braking systems and energy recovery mechanisms.

Module III: Hybrid Vehicle Architectures (09 Hours)

Classification of HEVs: micro, mild, full hybrids. Series hybrid architecture: working, advantages, limitations. Parallel hybrid architecture: torque coupling, control flow. Series- parallel (power-split) architecture – planetary gear-based systems. Plug-in hybrids (PHEV) and extended-range electric vehicles (EREVs). Control strategies for energy management: rule-based, optimization-based. Integration of CVTs and in-wheel motors in EV layouts.

Module IV: Sizing the Drive System (09 Hours)

Matching ICE and electric motor for target drive cycle. Propulsion sizing: power, torque, and acceleration requirements. Powertrain system layout optimization. Battery pack sizing and configuration based on energy requirement and voltage levels. Role of power electronics in switching, control, and safety. Subsystems in EVs: thermal management, auxiliaries, safety systems (BMS, EMS).

Module V: Energy Storage and Renewable Integration (08 Hours)

Battery technologies: Lead-acid, NiMH, Li-ion, LiFePO4, solid-state – construction, operation, charging. Battery modeling: internal resistance, state of charge (SoC), state of health (SoH). Fuel cells for electric mobility: PEMFC design, integration, and performance. Supercapacitors and ultra-capacitors – energy and power densities. Hybrid storage systems (battery + supercapacitor/fuel cell). Introduction to solar and wind energy systems in electric vehicles. Photovoltaic vehicle integration, rooftop panels, regenerative assist. Role of charging infrastructure and grid-connected energy systems.

Course Outcomes (COs):

Upon completion of this course, students will be able to:

CO1: Explain the need for hybrid electric vehicles and their environmental impact. CO2: Analyze different drivetrain configurations and control strategies.

CO3: Evaluate series, parallel, and power-split hybrid architectures.

CO4: Design and size electric motors, internal combustion engines, and power electronics for HEVs.

CO5: Assess different energy storage technologies and renewable energy applications in vehicles.

Text Books:

1. Chris Mi, M. Abul Masrur, David Wenzhong Gao – Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley
2. Iqbal Husain – Electric and Hybrid Vehicles: Design Fundamentals, CRC Press
3. Mehrdad Ehsani et al. – Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press

Reference Books:

1. James Larminie – Electric Vehicle Technology Explained, Wiley
2. Sheldon S. Williamson – Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer
3. A.K. Bansal – Electric and Hybrid Vehicles, Khanna Publishers