FACULTY OF ENGINEERING & TECHNOLOGY

Effective from Academic Batch: 2022-23

Programme: **Bachelor of Technology (Automobile Engineering)**

Semester: **VI**

Course Code: **202010603**

Course Title: **Electric and Hybrid Vehicles**

Course Group: **Professional Core Course**

Course Objectives: The electric vehicle has drawn attention of the designers, researchers and manufacturers for the skilled persons needed in this era. This course is intended to cover concept, drive lines, battery charging and swapping technology, propulsion, and safety issues related to EVs.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Internal		External		Total
Lecture	Tutorial	Practical		Theory	J/V/P*	Theory	J/V/P*	
3	0	2	4	50 / 18	25 /9	50 / 17	25 / 9	150 / 53

* **J**: Jury; **V**: Viva; **P**: Practical

Detailed Syllabus:

Sr.	Contents	Hours
1	**Introduction:** Need, Requirements and History of electric, hybrid and fuel cell vehicles, environmental and social importance of electric, hybrid and fuel cell vehicles, Government promotions: Role of government, benefits, promotional schemes.	5
2	**Electric Drive-trains**: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, ICE Vs EV, EV systems and sub systems, fuel efficiency and cost analysis of EVs, EV strategy in India.	6

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3	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. **Fuel cell Technology**: Basic concept of fuel cell vehicle, introduction to fuel cell drive-train topologies, Fuel cell characteristics, alkaline fuel cell, proton exchange membrane fuel cell, direct methanol fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, fuel cell model, hydrogen storage systems.	**7**
4	**EV Batteries:** Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Lithium-ion battery, Lead-acid battery, Nickel-based batteries, Metal/air batteries Sodium-β batteries, Evaluation of batteries, Battery parameters: SOH, SOC, DOD, EOL, C-rate of battery, factors affecting battery life, Capital and operational cost analysis of EV battery, Parameters to select EV battery. Introduction and working of ultra-capacitor and high-speed flywheels, future batteries.	**8**
5	**Battery Charging and Swapping Technology:** Battery swapping stations, advantages, split battery, range extender battery, business viability approaches, Standardization, charging strategy for best battery life. Battery chargers, on-board chargers, public chargers, bulk chargers, charging infrastructure and protocols, battery indication and management.	**8**
6	**Electric Propulsion**: Introduction to electric motors, power electronics and control strategies used in electric propulsion, Configuration and control of DC and BLDC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of permanent magnet motor and switched reluctance motors. Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor and energy storage.	**5**
7	**EV auxiliary, Communications & safety:** EV auxiliary power supplies, regenerative braking systems, temperature control units. In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, Automotive Industry Standards (AIS) for EVs.	**6**

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List of Practicals / Tutorials:

1	To understand need and importance of electric vehicles.
2	To understand wiring layout of an electric vehicle and its integrated components.
3	Demonstration of various topologies of hybrid electric vehicle.
4	To understand fuel cells and their characteristics.
5	To understand different batteries and demonstration of battery charging system.
6	Demonstration of electric vehicles.
7	To understand propulsion and driveline system of electric vehicles.
8	To understand battery management system.
9	To understand technical specifications of an electric vehicle.
10	Case Study.

Reference Books:

1	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011
2	C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, Oxford University Press, 2001
3	James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.
4	Fuel Cell Handbook by EG &G Technical Services, Inc.Seventh Edition
5	Ali Emadi, Mehrdad Ehsani, John M. Muller, "Vehicular Electric Power Systems", Marcel Dekker, Inc., 2004.
6	Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011
7	Hoogers, G., Edr. "Fuel Cell Technology Handbook", CRC Press, Washington D. C., 2003
8	Larminie, J. and Dicks, A., "Fuel Cell Systems Explained" John Wiley & Sons, Ltd., New York, 2001

Supplementary learning Material:	
1	NPTEL Resources

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Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment

Internal Evaluation :
The internal evaluation comprised of written exam (40% weightage) along with combination of various components such as Certification courses, Assignments, Mini Project, Simulation, Model making, Case study, Group activity, Seminar, Poster Presentation, Unit test, Quiz, Class Participation, Attendance, Achievements etc. where individual component weightage should not exceed 20%.

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks						**R**: Remembering; **U**: Understanding; **A**: Application, **N**: Analyze; **E**: Evaluate; **C**: Create
R	**U**	**A**	**N**	**E**	**C**	
20	30	35	5	5	5	

Course Outcomes (CO):

Sr.	Course Outcome Statements	%weightage
CO-1	Understand EV concept and drive line systems.	**25**
CO-2	Understand concept and working of Hybrid and fuel cell based vehicles.	**15**
CO-3	Understand battery parameters and concept of battery swapping technology.	**35**
CO-4	Understand electric propulsion systems.	**10**
CO-5	Understand EV auxiliary, communications & safety systems.	**15**

Curriculum Revision:	
Version:	2
Drafted on (Month-Year):	June-2022
Last Reviewed on (Month-Year):	
Next Review on (Month-Year):	June-2027

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