GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Electric Vehicle Technology
Subject Code: ME02064081
Subject Name : Computer Aided Modeling and Analysis of Electric Vehicles

WEF Academic Year :	2024 - 25
Semester :	2
Category of the Course :	Professional Elective Course

Prerequisite :	A bachelor's degree in electrical engineering, mechanical engineering, or a related field. Basic knowledge of electric vehicles and energy storage systems.
Rationale :	This course focuses on the modeling of various components of electric vehicles, including battery, drive-train, energy management and control. Students will learn about various modeling various performance parameters, methods, energy management system and dynamic control to ensure the safe and reliable operation of electric and hybrid vehicles.

Course Outcomes :
At the end of the course, student should be able to :

Sr. No.	CO statement	Topics Mapped	Marks % weightage
CO-1	Understand the modeling of vehicle performance parameters. Model battery electric vehicles.	1	20%
CO-2	Understand the various characteristic of EVs	2,3,4,6	45%
CO-3	Apply the concepts of energy management system.	5	20%
CO-4	Explain the vehicle dynamic control systems.	7	15%

Teaching and Examination Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
3	0	2	4	70	30	20	30	150

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Modelling of Performance Parameter :** EV Modelling block diagram, Flow chart of EV modelling, Derive Mathematical model of vehicle, Simulation model of vehicle with MATLAB Speed-torque characteristics, Store characteristics in look up table. Modelling Vehicle Acceleration - Acceleration performance parameters, modelling the acceleration of an electric scooter, modelling the acceleration of a small car.	10	25
2	**Modelling of Battery Electric Vehicles :** Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range - Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles.	8	20
3	**Characteristics of EV Components and Analysis :** Modelling and Characteristics of EV/HEV Power-trains Components-ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics-Transmission and Drive-train Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis.	10	25
4	**Energy Management :** Handling Analysis of Electric and Hybrid Electric Vehicles, Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers - Rule-Based Control Strategies -Optimization-Based Control Strategies.	9	20
5	**Vehicle Dynamic Control :** Control of Electric and Hybrid Electric Vehicle Dynamics - Fundamentals of Vehicle Dynamic Control (VDC) Systems, VDC Implementation on Electric and Hybrid Vehicles – Case Studies, Rechargeable Battery vehicles, Hybrid Vehicles, Fuel Cell Powered Bus.	8	10
	Total	**45**	**100**

Reference Book :

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.
2. Amir Khajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd.
3. Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation", IGI Global.
4. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design, Second Edition", CRC Press.

Suggested Specification table with Marks (Theory) : (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**15**	**20**	**20**	**30**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

1. **Remembering :** Retrieving, recognizing, and recalling relevant knowledge from long-term memory.
2. **Understanding :** Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Applying :** Carrying out or using a procedure for executing or implementing.
4. **Analyzing :** Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
5. **Evaluating :** Making judgments based on criteria and standards through checking and critiquing.
6. **Creating :** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

Note : This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Laboratory/Practical Work :

Simulations using tools like MATLAB may be done to obtain performance parameters.

Suggested list of experiments :

1. Develop a simulation model for Electric Vehicle to analyze the effect of changing of

parameters on vehicle range and performance.

2. Develop a simulation model for different driving cycles and analyze these driving cycles.
3. Develop a simulation model to analyze the effect of Rolling Resistance on vehicle range and performance
4. Develop a simulation model to analyze the effect of vehicle mass on vehicle range and performance
5. Develop a simulation model to analyze the effect of Aerodynamic drag on vehicle range and performance
6. Develop a simulation model to analyze the effect of Hill Climbing force on vehicle range and performance.
7. Develop a simulation model for Series HEV to analyze the effect of changing of parameters on vehicle range and performance.
8. Develop a simulation model for Parallel HEV to analyze the effect of changing of parameters on vehicle range and performance.
9. Develop a simulation model to analyze Electric Motor Performance Characteristics
10. Develop a simulation model to analyze Electric Motor Regenerative Braking Characteristics for different Driving Cycles.
11. Develop a Control strategy for Parallel HEV for developed simulation model and analyze it.
12. Develop a Control strategy for Series HEV for developed simulation model of Parallel HEV and analyze it.

Online Available Resources :

1. https://in.mathworks.com/solutions/automotive/electric-vehicle.html
2. Wiley online library
3. https://www.autosar.org/ AUTOSAR (AUTomotive Open System Architecture)

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