

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	20	20	40
Understand (K2)	20	20	40
Apply (K3)	10	10	20
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Give questions indicating bloom's taxonomy level under each CO

Course Outcome 1 (CO1):

1. Which are the resistive forces that retard the motion of a four wheel vehicle?(PO1,K1)
2. Explain briefly the performance parameters of the vehicle.(PO1, PO2,K1)
3. What are the social and environmental importance of EV.(PO7, K1)

Course Outcome 2 (CO2):

1. Architecture and power flow control of hybrid electric vehicle.(PO2, K2)
2. Subsystems of an electric vehicle.(PO1, K1)

3. What is regenerative braking?(PO1, K1)

Course Outcome 3 (CO3):

1. Electric components of an electric vehicle. (PO1, K1)
2. Control of orthogonal flux and torque in a separately excited DC motor(PO2, K2)
3. FOC control concept in PMSM motors.(PO1, PO2,K2)

Course Outcome 4 (CO4):

1. Battery management supporting system for hybrid vehicle.(PO1, K2)
2. Numerical problems in sizing and selection of batteries (PO3, K3)
3. Pin diagrams and differences of various connectors used for EV charging.(PO2,K2)

Course Outcome 5 (CO5):

1. Torque - speed envelope curves of drive train motors (PO2,K1)
2. Numerical Problems in sizing of drive systems (PO3,K3)
3. Different communication protocols used in EV (PO1, K2)

Model Question Paper

QP CODE:

Pages:

Reg No.: _____

Name: _____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHT SEMESTER
B.TECH DEGREE EXAMINATION,**

MONTH & YEAR

Course Code: EET 418

Course Name: ELECTRIC AND HYBRID VEHICLES

Max. Marks: 100

Duration: 3 hours

PART A

Answer all questions; each question carries 3 marks.

1. Explain rolling resistance and aerodynamic drag in vehicles. (3)
2. Write short notes on gradeability of the automobile system (3)
3. With the help of a block diagram, explain the major components of an electric vehicle. (3)
4. What is axial balancing? (3)
5. What are the electric components used in the propulsion unit of EV/HEV? (3)

6. List the advantages of PMSM motors over DC and induction motors. (3)
7. Explain the terms specific energy and energy density as applied to batteries. (3)
8. Explain the V2G concept. (3)
9. What is meant by Constant Power Speed Ratio as applied to an electric motor? (3)
10. What is the significance of a communication network in electric/hybrid vehicles? (3)

PART B

Answer any one complete question from each section; each question carries 14 marks

- 11 (a) Draw and explain ideal traction power plant characteristics of various power plants and various power source characteristics used in electric and hybrid electric vehicles. (8)
 - (b) Why is a gear system needed for an ICE? Explain with relevant characteristic curves. (6)
- OR
- 12 (a) Explain the levels of automation and its significance in autonomous vehicles (5 marks)
 - (b) What are the resistive forces acting on the vehicle movement? Obtain the dynamic equation of the vehicle movement.
- 13 (a) Draw and explain different classification of electric vehicles based on power source configurations. (7)
 - (b) Explain the different power flow control modes of a typical parallel hybrid system with the help of block diagrams. (7)
- OR
- 14 (a) Explain in detail the EV drivetrain alternatives based on drivetrain configurations (6)
 - (b) Explain the different power flow control modes of a typical ICE dominated series-parallel hybrid system with the help of block diagrams (8)
- 15 (a) Explain the Permanent Magnet Synchronous Motor control for application in EV. (10)
 - (b) Describe the advantages of independent control of flux and torque in SEDC Motor (4)

OR

- 16 (a) Discuss in detail the various electrical components used in HEV. (10)
 (b) List the advantages of FOC control. (4)
- 17 (a) What is meant by the C rating of a battery? Explain with an example. (4)
 (b) Explain the operation, advantages and disadvantages of Fuel cells used in EV. (10)

OR

- 18 (a) Explain briefly the different charging systems used for charging of EV. (8)
 (b) With pin diagrams, describe the CCS Type 2 connectors used for EV charging. (6)
- 19 (a) A hybrid electric vehicle has two sources- an ICE with output power of 80kW and battery storage. The battery storage is a 150 Ah, C10 battery at 120V. (i). Calculate the battery energy capacity (ii). Without de-rating the Ahr capacity, what is the maximum power that can be supported by the battery? (iii). What is the electrical motor power output if the total efficiency of power converter and motor combination is 98%? (iv). What is the maximum power that can be transmitted to the wheels if the transmission efficiency is 95%? (8)
 (b) Explain briefly the factors to be considered while sizing the electric motor for EV. (6)

OR

- 20 (a) What does CP and PP pins denote in connectors and explain its functions (5)
 (b) Draw and explain the FLEXRAY communication systems used in EV. (9)

Syllabus

Module 1 - 8 hrs

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. (2 hrs)

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. (5 hrs)

Autonomous Vehicles: Levels of automation, significance & effects of automation in vehicles (1 hr)

Module 2 - 7 hrs

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. (4 hrs)

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.(3 hrs)

Module 3 - 7 hrs

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles (2 hrs)

DC Drives: Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque - Closed loop control of speed and torque (block diagram only) (2 hrs)

PMSM Drives: PMSM motor basics – Independent control of orthogonal flux and torque (concept only)- Field Oriented Control (FOC) – Sensored and sensorless control (block diagram only) (3 hrs)

Module 4 - 7 hrs

Energy Storage: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems,Battery Management System, Types of battery- Fuel Cell based energy storage systems- Supercapacitors-Hybridization of different energy storage devices (3 hrs)

Overview of Electric Vehicle Battery Chargers - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams – Types of charging stations - AC Level 1 & 2, DC - Level 3 – V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences (4hrs)

Module 5 - 5 hrs

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics (3 hrs)

Vehicle Communication protocols : Need & requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY (Basics only)- Power line communication (PLC) in EV (2 hrs)

Text Books

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. Chris Mi, M A Masrur, D W Gao, “ Hybrid Electric Vehicles – Principles and applications with practical perspectives,” Wiley, 2011
4. Anderson JM, Nidhi K, Stanley KD, Sorensen P, Samaras C, Oluwatola OA, Autonomous vehicle technology: A guide for policymakers, Rand Corporation, 2014

Online Resources:

1. NPTEL courses/Materials (IITG, IITM, IITD) – Electric and Hybrid vehicles
<https://nptel.ac.in/courses/108/103/108103009/> (IIT Guwahati)
<https://nptel.ac.in/courses/108/102/108102121/> (IIT Delhi)
<https://nptel.ac.in/courses/108/106/108106170/> (IIT Madras)
2. FOC Control - video lecture by Texas Instruments
<https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors>
3. Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
<https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html>
4. Electric Vehicle Conductive AC Charging System
<https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf>
[Electric Vehicle Conductive AC Charging System](#)

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	Introduction to hybrid/electric, conventional & autonomous vehicles (8 hours)	
1.1	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles	1
1.2	Impact of modern drive-trains on energy supplies	1
1.3	Conventional Vehicles: Basics of vehicle performance	1
1.4	Vehicle power source characterization, transmission characteristics	2
1.6	Mathematical models to describe vehicle performance	2

1.7	Autonomous Vehicles: Levels of automation, significance & effects of automation in vehicles	1
2	Hybrid & Electric drive-trains (7 hours)	
2.1	Hybrid Electric Drive-trains: Basic concept of hybrid traction	1
2.2	Introduction to various hybrid drive-train topologies	1
2.3	Power flow control in hybrid drive-train topologies, fuel efficiency analysis.	2
2.4	Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies	1
2.5	Power flow control in electric drive-train topologies, hub motors, fuel efficiency analysis.	2
3	Electric Propulsion System (7 Hours)	
3.1	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles	2
3.2	DC Drives: Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque – Closed loop control of speed and torque (block diagram only)	2
3.3	PMSM Drives: PMSM motor basics – Independent control of orthogonal flux and torque (concept only)	2
3.4	Field Oriented Control (FOC) of Permanent Magnet Synchronous Motor – Sensored and sensorless control (block diagram only)	1
4	Energy Storage (7 Hours)	
4.1	Energy Storage: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems, Battery Management System	1
4.2	Types of battery-Lithium ion, Lead acid	1
4.3	Fuel Cell based energy storage systems- Supercapacitors-Hybridization of different energy storage devices	1
4.4	Overview of Electric Vehicle Battery Chargers – On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams	2
4.5	Types of charging stations - AC Level 1 & 2, DC - Level 3	1
4.6	V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences	1

5	Sizing the drive system (5 Hours)	
5.1	Sizing the drive system :Matching the electric machine and the internal combustion engine (ICE)	1
5.2	Sizing the propulsion motor	1
5.3	Sizing the power electronics	1
5.4	Vehicle Communication protocols : Need and requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins	1
5.5	Communication Protocols - CAN, LIN, FLEXRAY(Basics only) –Power Line Communication (PLC) in EV	1

