SRI MANAKULA VINAYAGAR
ENGINEERING COLLEGE
(An Autonomous Institution)

Puducherry

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B.TECH. HONOURS / MINOR PROGRAMME

ELECTRIC VEHICLES

ACADEMIC REGULATIONS 2023
(R-2023)

CURRICULUM AND SYLLABI

B. Tech Honours / Minor Programme - ELECTRIC VEHICLES

CURRICULUM

COURSE DETAILS												
Sl. No.	Semester	Course Code	Course Title	Course Type**	Category	Periods			Credits	Max. Marks		
						L	T	P		CAM	ESM	Total
1	IV	U23VXT401	Electrical Vehicles: Design, Dynamics and Testing	T	PC / IC	3	-	-	3	25	75	100
2	V	U23VXT502	Energy Storage and Battery Management System	T	PC / IC	3	-	-	3	25	75	100
3	VI	U23VXB603	Electric Drives and Controls	B	PC / IC	3	-	2	4	50	50	100
4	VII	U23VXB704	Modelling and Simulation of EHV	B	PC / IC	3	-	2	4	50	50	100
5	VIII	U23VXT805	Autonomous and Connected Vehicles	T	PC / IC	3	-	-	3	25	75	100
6	VIII	U23VXW806	Project Work	PA	PC / IC	-	-	4	2	50	50	100
Total									**19**	**225**	**375**	**600**
Equivalent NPTEL courses##												
1	IV	U23VXT401	Electrical Vehicles: Design, Dynamics and Testing	Vehicle Dynamics and Electric Motor Drives					3	**12 WEEKS COURSE**		
2	IV			Vehicles and Renewable Energy					3			
3	V	U23VXT502	Energy Storage and Battery Management System	Electrochemical Energy Storage					3			

The student shall be given an option to earn 3 credits through one 12-week NPTEL course (Equivalent) instead of any one theory course listed for Honour / Minor degree programme and shall be completed before the commencement of eighth semester. The equivalent courses are subject to change based on its availability as per NPTEL course list.

** T – Theory, B – Theory cum Practical, PA – Project Work

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Department	EEE	Programme: **B.Tech Honours / Minor – Electric Vehicles**						
Semester	IV	Course Category Code: **PC/ IC**			End Semester Exam Type: **TE***			
Course Code	**U23VXT401**	Periods/Week			Credit	Maximum Marks		
		L	T	P	C	CAM	ESE	TM
Course Name	**ELECTRICAL VEHICLES: DESIGN, DYNAMICS AND TESTING**	**3**	**-**	**-**	**3**	**25**	**75**	**100**
Common to ALL Branches								
Prerequisite	Engineering Mechanics							

Course Outcomes			BT Mapping (Highest Level)
	On completion of the course, the students will be able to		
	CO1	Summarize the basic functions of both Electric and Hybrid vehicles and their performance.	**K2**
	CO2	Illustrate the automobile configurations, packaging, structural systems, aerodynamics and power demand, etc.,	**K3**
	CO3	Predict the vehicle resistance and proficiently optimize the powertrain performance for FWD, RWD, and multi-wheel drive systems.	**K3**
	CO4	Examine the vehicle testing, homologation, and standards compliance for safe automotive engineering.	**K3**
	CO5	Demonstrate the requirement of vehicular safety systems and road regulations	**K3**

UNIT- I	**Introduction**	**Periods: 9**	
History - Components of Electric Vehicle (EV)- General Layout of EV- EV classification- Comparison with Internal combustion Engine- Technology- Advantages and Disadvantages of EV. Hybrid vehicle – advantages- disadvantages- Architecture and energy flow– series, parallel, series-parallel- Drive train for hybrid and electric vehicles-Hybrid vehicle operating modes.			**CO1**
UNIT- II	**Vehicle Dynamics**	**Periods: 9**	
General Configuration of Automobile- Body and Chassis Fundamentals- General Packaging- Types of Structural System- Backbone Construction- Body and Chassis Materials. Automotive Aero-dynamics- Vehicle Power Demand Analysis- Types of suspension and drive- Tyre Mechanics-Tyres and wheels- Tyre characteristics- Vehicle handling and stability- Automotive instrumentation			**CO2**
UNIT- III	**Vehicle Design**	**Periods: 9**	
Vehicle resistance- **Types:** Rolling Resistance- grading resistance. Aerodynamic drag-vehicle performance- Calculation of Acceleration Force- maximum speed- Total Tractive Effort-Torque Required on drive Wheel- Transmission- Differential- clutch and gearbox- Braking performance. Front-Wheel Drive (FWD) Powertrains- Rear-Wheel Drive Powertrains (RWD)- Multi-Wheel Drive Powertrains (AWD and 4WD)			**CO3**
UNIT- IV	**Vehicle Testing and Homologation**	**Periods: 9**	
Need of vehicle testing and homologation- testing organizations- testing standards (AIS)- Hierarchy of testing- Individual component approval/testing- System level approval and Whole vehicle approval/testing- Conformity of production tests- Crash test- side impact test- rollover test- Impact test- Track testing			**CO4**
UNIT- V	**Vehicular Safety and Government norms**	**Periods: 9**	
Road and Automotive Safety Systems- Active and passive safety- Safety Regulations for vehicular application- occupant protection- Traffic signs- traffic rules- Government Norms- Regulations and Policies- penalties and procedures.			**CO5**

Lecture Periods:45	**Tutorial Periods:-**	**Practical Periods:-**	**Total Periods: 45**

Text Books:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, 2018.
2. David C Barton, John D Fieldhouse, “Automotive Chassis Engineering”, Springer International Publishing, 2018.

Reference Books:

1. Thomas Gillespie, “Fundamentals of Vehicle Dynamics”, SAE International, April 2021.
2. Ulrich Seiffert, Lothar, Wech, “Automotive Safety Handbook, SAE International, 2007.

Web Reference:

1. https://www.nhtsa.gov/
2. https://www.ais.gov.in/
3. https://www.opal-rt.com/automotive-overview/

*** TE – Theory Exam, LE – Lab Exam**

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COs/POs/PSOs Mapping

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	3	2	1	2	1	-	-	-	-	1	3	3	2
2	3	2	3	2	1	2	1	-	-	-	-	1	3	3	2
3	3	2	3	2	1	2	1	-	-	-	-	1	3	3	2
4	3	2	3	2	1	2	1	-	-	-	-	1	3	3	2
5	3	2	3	2	1	2	1	-	-	-	-	1	3	3	2

Correlation Level: 1 – Low, 2 – Medium, 3 – High

Evaluation Methods

<table>
<tr><th></th><th colspan="5">Continuous Assessment Marks (CAM)</th><th>End Semester Examination##</th><th>Total Marks (CAM+ESM)</th></tr>
<tr><th></th><th>CAT 1</th><th>CAT 2</th><th>Model##</th><th>Assignment#</th><th>Attendance##</th><th></th><th></th></tr>
<tr><td>Portion for Test</td><td>2 Units</td><td>2 Units</td><td>All 5 Units</td><td></td><td rowspan="3"></td><td>All 5 Units</td><td rowspan="6"></td></tr>
<tr><td rowspan="2">Assessment Methodology</td><td>MCQ Test</td><td>MCQ Test</td><td rowspan="2">Written Exam</td><td rowspan="2">Individual Task #</td><td rowspan="2">Written Exam</td></tr>
<tr><td colspan="2">50 Questions for Analytical Course
75 Questions for Theory Course</td></tr>
<tr><td>Duration of the Test</td><td>1 hour 30 Minutes</td><td>1 hour 30 Minutes</td><td>3 hours</td><td></td><td>3 hours</td></tr>
<tr><td>Test Marks</td><td>50</td><td>50</td><td>75</td><td>20</td><td>5</td><td>75</td></tr>
<tr><td>Weightage for CAM</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td></td></tr>
<tr><td>CAM / ESE Marks</td><td colspan="5">CAM Marks = 25</td><td>ESE Marks = 75</td><td>100</td></tr>
</table>

Open Book Analytical Exam/Analyse Real world problems and propose solutions/ Tool or Subject Proficiency Analysis – Test the Students skill by giving individual task/ Paper Presentation/Micro Project Presentation/Idea Presentation for the Societal Problem;(Questions standard shall be of level 3 or more in Blooms Taxonomy)

Distribution of Marks for Attendance, the Question Paper Pattern for Model and ESE are same as given in B. Tech. Regulations R2023 for Theory Courses.

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Department	EEE	Programme: **B.Tech Honour / Minor – Electric Vehicles**						
Semester	V	Course Category: **PC /IC**			End Semester Exam Type: **TE***			
Course Code	**U23VXT502**	Periods/Week			Credit	Maximum Marks		
		L	T	P	C	CAM	ESE	TM
Course Name	**ENERGY STORAGE AND BATTERY MANAGEMENT SYSTEM**	**3**	**-**	**-**	**3**	**25**	**75**	**100**

Common to ALL Branches

Prerequisite	Physics, Electrical machines	
Course Outcomes	**On completion of the course, the students will be able to**	BT Mapping (Highest Level)
	CO1 Explain electrical parameters of energy storage systems, including energy capacity, voltage, power, efficiency, and lifecycle characteristics.	**K2**
	CO2 Compare and evaluate battery chemistries, fuel cells, ultra-capacitors, and flywheel storage, assessing their applications, advantages, and limitations in EVs.	**K2**
	CO3 Analyze the Battery Management System (BMS) for monitoring, protection, thermal management, and balancing, ensuring safe and efficient battery operation.	**K3**
	CO4 Explain the different levels of EV charging (Level 1, Level 2, Level 3) and the technology behind fast charging, comparing their advantages and charging speeds.	**K3**
	CO5 Explain charging technologies and systems such as conventional grid charging, smart grids (V to X, X to V), microgrids, and charging with PV systems, highlighting their roles in EV charging infrastructure.	**K3**

UNIT – I	**Battery Parameters**	**Periods: 9**
Electrical parameter: Energy Capacity (E)- Nominal Voltage- Operating Voltage- Power Output (P)- C-Rate- Charge/Discharge Efficiency- Self-Discharge Rate- Internal Resistance. **Energy & Power Density**- Energy Density- Specific Energy- Specific Power. **Charging & Discharging Parameters-** Fast Charging Rate- Charge Cut-Off Voltage- Discharge Cut-Off Voltage- Charge Time**. Lifecycle & Aging Parameters-** Cycle Life- Depth of Discharge (DoD)- State of Charge (SoC)- State of Health (SoH).**Thermal & Safety Parameters-** Operating Temperature Range- Thermal Runaway Temperature.		**CO1**
UNIT – II	**Energy Storage Technologies to EV**	**Periods: 9**
Lithium-Ion (Li-Ion) Battery Technology and Working Principles- Lithium Cobalt Oxide (LCO)- Lithium Iron Phosphate (LFP)- Lithium Nickel- Manganese Cobalt (NMC)- Lithium Nickel Cobalt Aluminum (NCA)- Lithium Titanate (LTO)- Advantages of Li-Ion Batteries**-** Challenges & Limitations**-**Comparison. Battery cell formats- Cylindrical Cells-Prismatic Cells-Pouch Cells **Fuel Cell Fundamentals** & its Types. Hydrogen Fuel Cell- Key Components- Advantage-**Challenges & Limitations-** Hydrogen fuel cell vs Battery Electric Vehicles. **Alternative Energy Storage Technologies**- Solid-State Batteries- Sodium-Ion Batteries**.** Introduction to Ultra-Capacitor Technologies and Flywheel Energy Storage.		**CO2**
UNIT – III	**Battery Management System**	**Periods: 9**
Battery Management System (BMS) & Importance: Cell Monitoring- State of Charge (SoC) Calculation- State of Health (SoH) Calculation- Thermal Management- Overcharge/Discharge Protection- Balancing Cells **-** Fault Detection & Safety**. BMS Types -** Centralized BMS- Distributed BMS- Modular BMS-Advantages & Disadvantages.		**CO3**
UNIT – IV	**EV Charging Systems and Technologies**	**Periods: 9**
EV Charging - EV Charging level 1-level 2-level 3- Fast Charging. **Battery Chargers and Charging Technologies**-Basic Charger Circuits-Microprocessor-Based Charger Circuits-Charge Equalization. **Conductive Charging Systems**-Principles of Conductive Charging-Standard Power Levels of Conductive Chargers-Arrangement of an Off-Board Conductive Charger. **Inductive Charging Systems**-Principle of Inductive Charging-Soft-Switching Power Converter for Inductive Charging. **Battery Indication and Monitoring Methods.**		**CO4**
UNIT – V	**EV Charging and Power Management Systems**	**Periods: 9**
Charging Technologies and Systems: Conventional Grid Charging-Smart Grid (V to X, X to V)-Microgrid-Charging with PV Systems-Fast/Rapid Charging. **Challenges and Solutions in EV Charging:** Challenges in EV Charging Infrastructure-Solutions to Charging Challenges. **Advanced Charging Systems Management:** Hybridization-Battery Swapping-Advanced Charging Systems Management. **Case Studies in EV Charging-** Case Studies on Charging Solutions and Systems.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

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Text Books

1. Alfred Rufer, “Energy Storage Systems and Components” , CRC Press, 2018.
2. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, “Thermal Management of Electric Vehicle Battery Systems”, John Wiley& Sons Ltd., 2016.

Reference Books

1. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2012.
2. NITI Aayog, Handbook of Electric Vehicle Charging Infrastructure Implementation, Version 1, 2021.
3. T R Crompton, “Battery”, Newnes- Reed Educational and Professional Publishing Ltd. 3rd Edition, 2000.
4. F. Beguin and E. Frackowiak, “Super capacitors- materials, Systems and Applications”, Wiley-VCH & Company, 2013.
5. V.Hacker, S. Mitsushima, “Fuel Cells and Hydrogens: From Fundamentals to applied Research”, Elsevier, 2018.
6. Fraunhofer IEE, IIT Bombay, DTU, and IIT Comillas, A Critical Review: Smart Charging Strategies and Technologies for Electric Vehicles, NDC-TIA, Nov. 2021.
7. D. Kettles, Electric Vehicle Charging Technology Analysis and Standards, Florida Solar Energy Center, Feb. 2015

Web References

1. https://archive.nptel.ac.in/courses/108/103/108103009/
2. https://www.nhtsa.gov/
3. https://www.ais.gov.in/
4. https://www.opal-rt.com/automotive-overview/
5. https://apem-journal.org/Archives/2019/APEM14-1_065-079.pdf
6. https://ouci.dntb.gov.ua/works/4rrWg5X4/
7. https://www.beny.com/challenges-and-solutions-in-electric-vehicle-charging-infrastructure-development/

*** TE – Theory Exam, LE – Lab Exam**

COs/POs/PSOs Mapping

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	3	2	-	2	1	-	-	-	-	1	3	3	2
2	3	2	3	2	-	2	1	-	-	-	-	1	3	3	2
3	3	2	3	2	-	2	1	-	-	-	-	1	3	3	2
4	3	2	3	2	-	2	1	-	-	-	-	1	3	3	2
5	3	2	3	2	-	2	1	-	-	-	-	1	3	3	2

Correlation Level: 1 – Low, 2 – Medium, 3 – High

Evaluation Methods

	Continuous Assessment Marks (CAM)					End Semester Examination##	Total Marks (CAM+ESM)
	CAT 1	CAT 2	Model##	Assignment#	Attendance##		
Portion for Test	2 Units	2 Units	All 5 Units			All 5 Units	
Assessment Methodology	MCQ Test 50 Questions for Analytical Course 75 Questions for Theory Course	MCQ Test	Written Exam	Individual Task #		Written Exam	
Duration of the Test	1 hour 30 Minutes	1 hour 30 Minutes	3 hours			3 hours	
Test Marks	50	50	75	20	5	75	
Weightage for CAM	5	5	5	5	5		
CAM / ESE Marks	CAM Marks = 25					ESE Marks = 75	100

Open Book Analytical Exam/Analyse Real world problems and propose solutions/ Tool or Subject Proficiency Analysis – Test the Students skill by giving individual task/ Paper Presentation/Micro Project Presentation/Idea Presentation for the Societal Problem;(Questions standard shall be of level 3 or more in Blooms Taxonomy)

Distribution of Marks for Attendance, the Question Paper Pattern for Model and ESE are same as given in B. Tech. Regulations R2023 for Theory Courses.

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Department	EEE	Programme: **B.Tech Honours/ Minor – Electric Vehicles**						
Semester	VI	Course Category: **PC/IC**			End Semester Exam Type: **TE***			
Course Code	U23VXB603	Periods/Week			Credit	Maximum Marks		
		L	T	P	C	CAM	ESE	TM
Course Name	**ELECTRIC DRIVES AND CONTROLS**	**3**	**0**	**2**	**4**	**50**	**50**	**100**

Common to ALL Branches

Prerequisite	Electrical Machines	
Course Outcomes	**On completion of the course, the students will be able to**	BT Mapping (Highest Level)
	CO1 Comprehend the types, design, and sizing of electric vehicle motors, including their torque-speed characteristics and role in EV propulsion systems.	**K2**
	CO2 Analyze the operation and performance of DC and AC motor drives with speed control techniques.	**K2**
	CO3 Apply the various control techniques for PMSM and BLDC motor drives for the performance optimization.	**K3**
	CO4 Analyze and implement DC and AC motor control techniques for various Electric Vehicles.	**K4**
	CO5 Implement control techniques for PMSM, and BLDC motor drives, optimizing performance and minimizing torque ripple.	**K4**

UNIT – I	**Introduction to EV Drives**	**Periods:10**
Overview of EV Motors: Types of motors used in electric vehicles (EVs) and their classifications. **Traction Motors Design:** Design principles and sizing considerations for EV traction motors. **Torque-Speed Characteristics:** Analysis of constant-torque and constant-power modes in motor performance. Selection of Motor Power and converter Rating. **Motor Comparison for EVs:** Suitability analysis of motors for 2W, 3W, 4-wheelers, and large vehicles.		**CO1**
UNIT – II	**DC Drives and Induction Motor Drives**	**Periods:10**
DC Drives: Phase controlled DC-Drives: Operation with continuous and discontinuous modes; Chopper Controlled DC Drives, Multi-Quadrant Operation, harmonics control in chopper, speed control method, closed loop control scheme. **Induction Motor Drives:** Speed control techniques: Stator voltage control, Variable frequency control, V/f control, Static rotor resistance control and Slip power recovery control schemes, Slip compensation technique. Field-oriented control and direct torque control of induction motors for EVs.		**CO2**
UNIT – III	**BLDC and PMSM Drives**	**Periods:10**
BLDC Motor Drives: Principles of BLDC motor operation, inverter switching schemes for AC and DC, trapezoidal back EMF control, and design criteria for BLDC drives in EVs. **PMSM Drives:** Permanent Magnet Synchronous Motor (PMSM) construction, braking methods, field-oriented and flux-weakening control, and sensorless operation.		**CO3**
UNIT – IV	**Electric Drives Practice -I**	**Periods:15**
1. Demonstration of wiring layout of electric vehicle. 2. Speed control of DC drives using phase-controlled rectifier 3. Speed control of DC drives using chopper control. 4. Performance Analysis of Induction motor Drive. 5. V/f Control of PWM Inverter Based Three Phase Induction Motor 6. Simulation of Rotor Resistance Scheme in Wound-Rotor Induction Motor		**CO4**
UNIT – V	**Electric Drives Practice -II**	**Periods:15**
1. Speed control of FPGA based BLDC motor Drive 2. Simulation of PMSM speed control using the Field-Oriented Control method. 3. Sensorless Field Oriented Control for Permanent Magnet Synchronous Motor drive 4. Torques ripples reduction techniques in BLDC and PMSM motor drives. 5. Regenerative/ Dynamic breaking operation for AC motor using simulation software 6. Study of SRM motor drive fed by PWM inverter using simulation software.		**CO5**

Lecture Periods: 30	**Tutorial Periods: -**	**Practical Periods: 30**	**Total Periods: 60**

Text Books

3. KT. Chau, "Electric Vehicle Machines and Drives: Design, Analysis, and Application," Wiley-IEEE Press, 1st Edition, 2015.
4. John G. Hayes, G. Abas Goodarzi, "Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles," Wiley-Blackwell, 1st Edition, 2018.

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Reference Books

1. C.G. Hochgraf, M.J. Ryan, and H.L. Wiegman, "Engine Control Strategy for a Series Hybrid Electric Vehicle," Warrendale, PA, 2nd Edition, 2002.
2. Seth Leitman, Bob Brant, "Build Your Own Electric Vehicle," McGraw-Hill, 3rd Edition, 2013.
3. C.C. Chan, K.T. Chau, "Modern Electric Vehicle Technology," Oxford University Press, 1st Edition, 2001.

Web References

8. https://archive.nptel.ac.in/courses/108/104/108104140/
9. https://onlinecourses.nptel.ac.in/noc24_ee30/preview
10. https://www.slideshare.net/slideshow/electric-drives-and-controls-unit-1-introduction/250009052
11. https://www.mygreatlearning.com/academy/learn-for-free/courses/introduction-to-inverters-and-electric-drive
12. https://onlinecourses.swayam2.ac.in/ntr24_ed16/preview

*** TE – Theory Exam, LE – Lab Exam**

COs/POs/PSOs Mapping

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	3	2	-	2	1	-	2	-	-	2	3	3	3
2	3	2	3	2	-	2	1	-	2	-	-	2	3	3	3
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4	3	2	3	2	-	2	1	-	2	-	-	2	3	2	3
5	3	2	3	2	-	2	1	-	2	-	-	2	3	2	3

Correlation Level: 1 – Low, 2 – Medium, 3 – High

Evaluation Methods

Assessment	Continuous Assessment Marks (CAM) – Maximum 50 Marks										##End Semester Examination (ESE) (Theory)	Total Marks (CAM+ESE)
	Continuous Assessment (Theory)					Continuous Assessment (Practical)						
	CAT 1	CAT 2	Model##	Attendance##	Total	Conduction of Practical	Report	Viva	Total	End Semester Examination (ESE) Marks (Practical)		
Portion for Test	1 ½ Units	1 ½ Units	All 3 Units								All 3 Units	
Assessment Methodology	MCQ Test	MCQ Test	Written Exam							Practical Exam	Written Exam	
	50 Questions for Analytical Course 75 Questions for Theory Course											
Duration of the Test	1 hour 30 Minutes	1 hour 30 Minutes	3 hours							3 hours	3 hours	
Marks	50	50	75	5		15	10	5	30*	30	75 *(To be weighted for* 50 Marks)	
Weightage of CAM	2.5	2.5	2.5	2.5	**10**	**To be weighted for 10 Marks*			**10**	**30**		
CAM / ESE Marks	***CAM Marks =10+10+30=50***										***ESE Marks = 50***	**100**

Distribution of Marks for Attendance, the Question Paper Pattern for Model and ESE are same as given in B.Tech. Regulations R2023 for Theory cum practical Courses

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Department	**EEE**	Programme: **B.Tech Honour / Minor – Electric Vehicles**						
Semester	**VII**	Course Category Code: **PC/ IC**			End Semester Exam Type: **TE***			
Course Code	**U23VXB704**	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CAM	ESE	TM
Course Name	**MODELLING AND SIMULATION OF EHV**	**3**	**-**	**2**	**4**	**50**	**50**	**100**

Common to All Branches

Prerequisite	Electrical Machines		
Course Outcomes	**On completion of the course, the students will be able to**		BT Mapping (Highest Level)
	CO1	Apply the concept of modeling for electric vehicle and predict the performance.	**K3**
	CO2	Describe the drive train characteristics of electric vehicles	**K3**
	CO3	Analysis the vehicle dynamic control and energy management techniques	**K3**
	CO4	Design and simulate the Electric Vehicle Power train for the analysis	**K4**
	CO5	Implement the battery management system for the battery pack	**K4**

UNIT - I	**Modeling of Electric Vehicles**	**Periods: 10**	
Modeling Vehicle Acceleration - Acceleration performance parameters, modeling of acceleration of an electric scooter, modeling of acceleration of a small car. Electric Vehicle Modeling - Tractive Effort- Rolling resistance force- Aerodynamic drag- Hill climbing force- Acceleration force- Total tractive effort - Modeling Electric Vehicle Range - Driving cycles - Constant velocity range modeling - Range modeling of battery electric vehicles - fuel cell vehicles - hybrid electric vehicles			**CO1**
UNIT - II	**EV Drive Train Characteristics**	**Periods: 10**	
Modeling 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 - Modeling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modeling and Analysis - Vehicle Braking Modeling and Analysis.			**CO2**
UNIT - III	**Vehicle Dynamic Control and Energy Management**	**Periods: 10**	
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 Vehicles. 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.			**CO3**
UNIT - IV	**Modeling of EHV Practice -I**	**Periods: 15**	
1. Determination of SoC, DoD, Cell Cycle for battery 2. Mathematical Modeling of lithium ion cell and design of battery pack / format. 3. Design and Development of Battery Pack for specified Rating 4. Electric Vehicle Power train Simulation using MATLAB/Simulink 5. Transmission and Drive train Simulation for EVs in MATLAB/Simulink 6. Rule-Based Power Management for Hybrid Electric Vehicles in Simulink			**CO4**
UNIT - V	**Modeling of EHV Practice -II**	**Periods: 15**	
1. Implementation of Wiring Diagram for a 36V, 10S Battery Management System (BMS) 2. Implementation of Wiring Diagram and Testing of Smart BMS for a 48V, 15S battery pack 3. Battery Management System using battery pack equalizer through active balancer with Bluetooth monitoring 4. Microcontroller- Programmable Battery Management System 5. Design and Implementation of Conductive Charging Setup 6. Simulation of Vehicle Dynamic Control for Hybrid and Battery Electric Vehicles			**CO5**

Lecture Periods: 30	**Tutorial Periods:-**	**Practical Periods: 30**	**Total Periods: 60**

Text Books

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd., 2nd Edition, 2012.
2. Amir Khajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid Vehicles -Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 1st Edition, 2014.

Reference Books

Dr. P. Tamuna

1. Antoni Szumanowski, “Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation”, Idea Group, 1st Edition, 2013.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles - Fundamentals, Theory, and Design, CRC Press, 2nd Edition”, 2017.

Web References

1. https://archive.nptel.ac.in/content/syllabus_pdf/108103009.pdf
2. https://www.researchgate.net/publication/309548969_MODELING_AND_SIMULATION_OF_HYBRID_ELECTRIC_VEHICLES
3. https://www.sciencedirect.com/science/article/pii/S2405896322014446
4. https://www.academia.edu/1003352/A_Matlab_Based_Modeling_and_Simulation_Package_for_Electric_and_Hybrid_Electric_Vehicle_Design
5. https://www.academia.edu/90442341/Modeling_and_Simulation_of_Hybrid_Electric_Vehicle_Power_Systems?uc-sb-sw=17290990

*** TE – Theory Exam, LE – Lab Exam**

COs/POs/PSOs Mapping

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	3	3	2	2	-	2	2	-	2	3	3	3
2	3	3	3	3	3	2	2	-	2	2	-	2	3	3	3
3	3	3	3	3	3	2	2	-	2	2	-	2	3	3	3
4	3	3	3	3	3	2	2	-	2	2	-	2	3	3	3
5	3	3	3	3	3	2	2	-	2	2	-	2	3	3	3

Correlation Level: 1 - Low, 2 - Medium, 3 – High

Evaluation Methods

<table>
<tr><td rowspan="2">Assessment</td><td colspan="10">Continuous Assessment Marks (CAM) – Maximum 50 Marks</td><td rowspan="2">##End Semester Examination (ESE) (Theory)</td><td rowspan="2">Total Marks (CAM+ESE)</td></tr>
<tr><td colspan="5">Continuous Assessment (Theory)</td><td colspan="5">Continuous Assessment (Practical)</td></tr>
<tr><td></td><td>CAT 1</td><td>CAT 2</td><td>Model##</td><td>Attendance##</td><td>Total</td><td>Conduction of Practical</td><td>Report</td><td>Viva</td><td>Total</td><td>End Semester Examination (ESE) Marks (Practical)</td><td></td><td></td></tr>
<tr><td>Portion for Test</td><td>1 ½ Units</td><td>1 ½ Units</td><td>All 3 Units</td><td rowspan="4"></td><td rowspan="5"></td><td colspan="4" rowspan="3"></td><td rowspan="2">Practical Exam</td><td>All 3 Units</td><td rowspan="6"></td></tr>
<tr><td rowspan="3">Assessment Methodology</td><td>MCQ Test</td><td>MCQ Test</td><td>Written Exam</td><td>Written Exam</td></tr>
<tr><td colspan="2">50 Questions for Analytical Course
75 Questions for Theory Course</td><td></td><td colspan="4"></td><td></td></tr>
<tr><td>Duration of the Test</td><td>1 hour 30 Minutes</td><td>1 hour 30 Minutes</td><td>3 hours</td><td colspan="4"></td><td>3 hours</td><td>3 hours</td></tr>
<tr><td>Marks</td><td>50</td><td>50</td><td>75</td><td>5</td><td>15</td><td>10</td><td>5</td><td>30*</td><td>30</td><td>75 (To be weighted for 50 Marks)</td></tr>
<tr><td>Weightage of CAM</td><td>2.5</td><td>2.5</td><td>2.5</td><td>2.5</td><td>10</td><td colspan="3">*To be weighted for 10 Marks</td><td>10</td><td>30</td><td></td><td></td></tr>
<tr><td>CAM / ESE Marks</td><td colspan="10">CAM Marks =10+10+30=50</td><td>ESE Marks = 50</td><td>100</td></tr>
</table>

Distribution of Marks for Attendance, the Question Paper Pattern for Model and ESE are same as given in B.Tech. Regulations R2023 for Theory cum practical Courses

Dr. P. Jamuna

Department	EEE	Programme: **B.Tech Honours / Minor – Electric Vehicles**						
Semester	VIII	Course Category: **PC/ IC**			End Semester Exam Type :**TE***			
Course Code	U23VXT805	Periods/Week			Credit	Maximum Marks		
		L	T	P	C	CAM	ESE	TM
Course Name	**AUTONOMOUS AND CONNECTED VEHICLES**	**3**	**-**	**-**	**3**	**25**	**75**	**100**
Common to All Branches								
Prerequisite	Electrical Vehicles: Design, Dynamics and Testing							

Course Outcomes	On completion of the course, the students will be able to	BT Mapping (Highest Level)
	CO1 Summarize the advanced driver assistance systems for connected vehicle	**K2**
	CO2 Interpret the recent global navigation and Lidar technology for vehicle integration	**K2**
	CO3 Apply the Perception path, Deep Learning, planning for autonomous and connected vehicles	**K3**
	CO4 Demonstrate the hardware used in E-vehicle an computer architecture for Autonomous Driving	**K3**
	CO5 Illustrate the ECU evolution in architecture by software defined vehicles	**K3**

UNIT – I	**Autonomous System Architecture**	**Periods: 9**
Overview-Autonomous Driving Algorithms-Sensing- Perception- Object Recognition and Tracking- Action- Autonomous Driving Client System-Robot Operating System- Hardware Platform- Autonomous Driving Cloud Platform-HD Map Production, Deep Learning Model Training.		**CO1**

UNIT – II	**Autonomous Vehicle Integration**	**Periods: 9**
Localization with GNSS- GNSS Overview- GNSS Error Analysis- Satellite-based Augmentation Systems- Real-Time Kinematic and Differential GPS- Precise Point Positioning- GNSS INS Integration. Localization with LiDAR and High-Definition Maps- LiDAR Overview-High-Definition Maps Overview- Localization with LiDAR and HD Map- Visual Odometry- Stereo Visual Odometry- Monocular Visual Odometry- Visual Inertial Odometry- Dead Reckoning and Wheel Odometry- Wheel Encoders- Wheel Odometry Errors- Reduction of Wheel Odometry Errors		**CO2**

UNIT – III	**Perception and Deep Learning in Autonomous Driving Perception**	**Periods: 9**
Introduction- Datasets- Detection- Segmentation- Stereo- Optical Flow- Scene Flow- Tracking- Deep Learning in Autonomous Driving- Convolutional Neural Networks- Detection- Semantic Segmentation- Stereo and Optical Flow- Planning and Control Overview- Architecture-Traffic Prediction -Lane Level Routing		**CO3**

UNIT – IV	**Client Systems for Autonomous Driving**	**Periods: 9**
Hardware platform for autonomous driving- Operating system-ROS overview- system reliability- performance improvement- Resource Management And Security- Computing Platform- existing computing solution- computer architecture design exploration- Autonomous Driving on Mobile Processor- V2V-System Architecture-Safet application- V2I overview- BIM- V2P- System Architecture- Vehicle Warning Strategy		**CO4**

UNIT – V	**Cloud Platform for Autonomous Driving**	**Periods: 9**
Infrastructure-distributed computing framework-distributed storage-heterogeneous computing- Simulation-BINPIPERDD-connecting spark and ROS-performance- Model training-need of SPARK-Training platform architecture-HD map generation. Autonomous driving-Vehicle Onboard Architecture- ECU software architecture –AUTOSAR- COVESA		**CO5**

Lecture Periods: 45	**Tutorial Periods:-**	**Practical Periods: -**	**Total Periods: 45**

Text Books

1. Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, “Creating Autonomous Vehicle Systems”, Morgan & Claypool Publishers, 1st Edition, 2018
2. Radovan Miucic, “Connected Vehicles: Intelligent Transportation Systems”, Springer, 2018

Reference Books

1. Domokos Esztergár-Kiss, Pierluigi Coppola, “Autonomous Vehicles and Future Mobility”, Elsevier, 2019.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory and Design”, CRC Press, 2nd Edition, 2017.

Dr. P. Tamuna

Web References

1. https://www.ibm.com/blogs/digitale-perspektive/2023/06/the-software-defined-vehicle/
2. https://www.sciencedirect.com/science/article/pii/S2405896322014446
3. https://www.ais.gov.in/
4. https://www.opal-rt.com/automotive-overview/

*** TE – Theory Exam, LE – Lab Exam**

COs/POs/PSOs Mapping

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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5	3	3	3	2	3	-	-	-	-	-	-	2	3	3	3

Correlation Level: 1 - Low, 2 - Medium, 3 – High

Evaluation Methods

	Continuous Assessment Marks (CAM)					End Semester Examination##	Total Marks (CAM+ESM)
	CAT 1	CAT 2	Model##	Assignment#	Attendance##		
Portion for Test	2 Units	2 Units	All 5 Units			All 5 Units	
Assessment Methodology	MCQ Test	MCQ Test	Written Exam	Individual Task #		Written Exam	
	50 Questions for Analytical Course 75 Questions for Theory Course						
Duration of the Test	1 hour 30 Minutes	1 hour 30 Minutes	3 hours			3 hours	
Test Marks	50	50	75	20	5	75	
Weightage for CAM	5	5	5	5	5		
CAM / ESE Marks	**CAM Marks = 25**					**ESE Marks = 75**	**100**

Open Book Analytical Exam/Analyse Real world problems and propose solutions/ Tool or Subject Proficiency Analysis – Test the Students skill by giving individual task/ Paper Presentation/Micro Project Presentation/Idea Presentation for the Societal Problem;(Questions standard shall be of level 3 or more in Blooms Taxonomy)

Distribution of Marks for Attendance, the Question Paper Pattern for Model and ESE are same as given in B. Tech. Regulations R2023 for Theory Courses.

Dr. P. Tamuna

Department	EEE	Programme: **B.Tech Honours / Minor – Electric Vehicles**						
Semester	**VIII**	Course Category: **PC/ IC**			End Semester Exam Type :**LE***			
Course Code	**U23VXW806**	Periods/Week			Credit	Maximum Marks		
		L	T	P	C	CAM	ESE	TM
Course Name	**Project Work**	**-**	**-**	**4**	**2**	**50**	**50**	**100**
Common to All Branches								
Prerequisite	**-**							

Course Outcomes		On completion of the course, the students will be able to	BT Mapping (Highest Level)
	CO1	Apply literature survey techniques to identify and define the problem statement for the project	**K3**
	CO2	Comprehend, plan, and implement a project related to electric mobility	**K2**
	CO3	Develop a real-time application utilizing electric vehicle components, processes, or systems	**K3**
	CO4	Interpret and apply knowledge of publication and copyright processes in research	**K3**
	CO5	Justify and present project findings through structured oral and written reports	**K4**

Course Description

Student must select a project topic either from published lists or propose a suitable topic in consultation with his/her supervisor. The objective of the project is to enhance understanding of fundamental principles by applying them to a new challenge, which may involve designing and manufacturing a device, conducting research, developing a computer or management project, or solving a design problem.

The project progress will be assessed through a minimum of two reviews. The project evaluation shall be carried out by a Project evaluation committee comprising the Head of the Department or his/her nominee (Chairperson), Project coordinator (Professor / Associate Professor) and the project supervisor(s). The End Semester Examination for the project work will include an evaluation of the final project report by an external examiner, followed by a viva-voce examination conducted by a panel comprising the external examiner and an internal examiner.

Lecture Periods: -	**Tutorial Periods:-**	**Practical Periods: 60**	**Total Periods: 60**

*** TE – Theory Exam, LE – Lab Exam**

COs/POs/PSOs Mapping

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
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3	3	3	3	2	3	2	-	-	3	3	2	2	3	3	3
4	3	3	3	2	3	-	2	-	3	3	-	2	3	3	3
5	3	3	3	2	3	-	2	2	3	3	-	2	3	3	3

Correlation Level: 1 - Low, 2 - Medium, 3 – High

Evaluation Methods

Sl. No	Description			Weightage
1	**Continuous Assessment Marks**			
a	Review 1	Review Committee	15	25
		Supervisor	10	
b	Review 2	Review Committee	15	25
		Supervisor	10	
			Total CAM	50
2	**End Semester Marks**			
a	Evaluation of project work report and Viva-voce	Report	15	50
		Presentation and Viva	20	
		Demonstration	15	
			Total ESM	50
			Total Marks	100

Dr. P. Jamuna