

**Proposed Semester - Wise Course Curriculum for 2-year M.Tech. in "Electric Vehicle Technology" as per  
New PG Ordinance -2019-2020**

**Applicable for students admitted from Academic Year 2023-24 Onwards**

Semester I				Semester II				
Cat.	Course	L-T-P	Cr.	Cat.	Course/ Thesis	L-T-P	Cr.	
DC	Fundamental of Electric and Hybrid Vehicles	3-0-0	9	DE	Departmental Elective-3	3-0-0	9	
DC	Modelling and Simulation of Electric and Hybrid Vehicles	3-0-3	12	DE	Departmental Elective-4	3-0-0	9	
DC	Modelling and Control of Power Electronics Converters and Drives	3-0-3	12	DE	Departmental Elective-5	3-0-0	9	
DE	Departmental Elective-1	3-0-0	9	DE	Departmental Elective-6	3-0-0	9	
DE	Departmental Elective-2	3-0-0	9	DE	Departmental Elective-7	3-0-0	9	
DP	Electric Vehicle Lab	0-0-3	3	DT	Thesis (One Unit)		11	
General/Communication	Introduction to Data Science and its Applications	2-0-0	6	Electives-3	Advanced Electric Motors and Control			
Electives - 1	Electrical Architecture of Electric and Hybrid Vehicles				Computer Aided Design of Electric Machines			
	Vehicle Dynamics				Hydrogen and Fuel Cell Technology for Electric and Hybrid Vehicles			
Electives - 2	Standards, Testing and Certification of Electric & Hybrid Vehicles				Electives-4	EV Power Train and Its Management Systems		
	EV Batteries and Battery Management System					Vehicle Body Engineering		
	Embedded System for Electric Vehicles				IoT in EV Applications			
	Automotive Transmission				Electives-5	Intelligent Transport System		
						Automotive Safety		
						Autonomous Vehicle Technology		
					Electives-6	Vehicle Diagnostics & Maintenance		
						Plug-in Electric Vehicles in Smart Grid		
	Electives-7				AI and ML for EV Applications			
					Communication and Networking for Electric Vehicles			
Environmental Impacts of Electric and Hybrid Vehicles								
Automotive HVAC and Thermal Management systems								
	Total credits in the semester		60 (50-60)		Total credits in the semester		56 (50-60)	

Semester III				Semester IV			
Cat.	Course	L-T-P	Cr.	Cat.	Course/ Thesis	L-T-P	Cr.
DT	Thesis (Five Unit)		55	DT	Thesis (Five Unit)		55
	Total credits in the semester		55 (50-60)		Total credits in the semester		55 (50-60)

6 Credits of practical components are attached with core courses and 3 Credits of Practical Laboratory added separately as per requirements of the Course.

**Subject Name: Electrical Architecture of Electric and Hybrid Vehicle**

**M. Tech. Year – 1 (Semester – 1)**

**COURSE CATEGORY: PROGRAMME ELECTIVE - I (PE-I)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

<b>Unit</b>	<b>Topics</b>	<b>Contact Hours</b>
<b>1</b>	<b>Power Distribution Architecture in Electric and Hybrid Vehicles:</b> Classification and main vehicle characteristics according to their degree of electrification, Power distribution architecture according to their degree of electrification, Power distribution architecture in hybrid vehicles.	8
<b>2</b>	<b>Vehicle mechanical model:</b> Forces acting in a vehicle, Dynamic model of a vehicle, Example of calculation of the tractive force.	8
<b>3</b>	<b>Fundamental of propulsion, power transmission and brake system of an electric /hybrid vehicle:</b> Sizing of the traction system in electric and hybrid vehicles, Power transmission in Electric and Hybrid Vehicles, Braking and Energy recovery in Electric and Hybrid Vehicles	8
<b>4</b>	<b>Power Semiconductors, Converters and Passive Components in Automotive:</b> Power Semiconductors, Trends in Power semiconductors, Bidirectional Converters, Inverters, Interleaving mode in power converters, Passive Components.	8
<b>5</b>	<b>Modelling and Simulation of Electric Vehicles</b> Modelling and sizing of the power traction system, Modelling and sizing of the storage system, Interaction between the different blocks of the electrical architecture, Standard conduction cycles (ECE, US EPA)	10
	<b>Total Hours</b>	42

**References:**

1. M. Ehsani, Y. Gao, S. Longo, K. Ebrahim, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, 3rd Edition.
2. I. Husain, Electric and Hybrid Vehicles: Design Fundamentals, 2nd Edition.
3. J. M. Miller, Propulsion Systems for Hybrid Vehicles, 2nd Edition.
4. R. W. Erickson, D. Maksimovic, Fundamentals of Power electronics, 2nd Edition.
5. A. Lidow, J. Strydom, M. de Rooij, D. Reusch, GaN Transistors for Efficient Power Conversion.
6. B. J. Baliga, Wide Bandgap Semiconductor Power Devices: Materials, Physics, Design and Applications.

## Subject Name: Embedded System for Electric Vehicles

M. Tech. Year – 1 (Semester – I)

COURSE CATEGORY: PROGRAMME ELECTIVE - II (PE-II)

### Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

### Contents:

Unit	Topics	Contact Hours
1	<b>AUTOMOTIVE EMBEDDED SYSTEM OVERVIEW</b> Automotive Embedded System Technology, Overview of Embedded System Categories, Various Embedded Sub Systems like Chassis, Body, Driveline, Engine, Fuel, Emission, Brakes, Suspension, Emission, Brakes, Suspension, Doors, Safety & Security, Comfort & Multimedia, Communication & Lighting and Future Trends in Automotive Embedded Systems: X by Wire technologies.	9
2	<b>AUTOMOTIVE HARDWARE MODULE</b> Concept to Market: Understanding Automotive Product Design Cycle, Microcontroller, architecture, Memory map, I/O map, Building Blocks of Automotive Electronic Product: Actuators, Sensors, Semiconductor Components, Devices, Integrated Circuits (ICs), Relay, Stepper motor, PCBs etc.	9
3	<b>AUTOMOTIVE SENSORS</b> Automotive Sensors and Transducers: Temperature, Force, Oxygen Sensor, LAMBDA Sensor, Proximity Distance Sensors, Speed, Engine Knock Sensor, Resistive Potentiometer & Flow. Typical Sensors Specifications & Microcontroller Interfacing, Signal Processing circuit, Sensor Calibration..	9
4	<b>AUTOMOTIVE SOFTWARE</b> Structure of embedded program, infinite loop, and compiling, linking and locating, downloading and debugging, Intra processor Communication Protocols: I2C & I2S, SPI & USB, LIN and CAN. Coding Standards and Guidelines: MISHRA C & Automotive Operating System: OSEK/VDX, AUTOSAR.	9
5	<b>VERIFICATION &amp; VALIDATION</b> The Validation and Verification Process, Introduction to NI Lab VIEW for Automotive, Test Categories like Functional Test, Black Box Test, Boundary level Test & Test Case Development, Reliability and Certifications Tests: EMI / EMC Tests as per AIS 004 standard, Environmental Test, Vibration Tests, Protection against Dust, Water Ingress and IP Standards Vehicle Diagnostic Interface like OBD, OBD - II.	9
	<b>Total Hours</b>	45

**References:**

1. Mirosław Staron, “Automotive Software Architectures: An Introduction”, Springer, 2017. (ISBN: 978-3-319-58609-0)
2. Nicolas Navet and Françoise Simonot-Lion, “Automotive Embedded Systems Handbook”, CRC Press, 2009. (ISBN: 978-0-8493-8026-6)
3. Ronald K. Jurgen, “Distributed Automotive Embedded Systems”, SAE International, 2007. (ISBN: 978-0-7680-1966-7)
4. Ronald K. Jurgen, “Automotive Software”, SAE International, 2006. (ISBN: 978-0-7680-1714-4).

**Subject Name: EV Batteries & Battery Management System****M. Tech. Year – 1 (Semester – 1)****COURSE CATEGORY: PROGRAMME ELECTIVE - II (PE-II)****Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
1	<b>EV BATTERIES</b> <b>Lead Acid Batteries</b> Lead acid battery basics, Special characteristics of lead acid batteries, Battery life and maintenance, Battery charging, Summary <b>Nickel-based Batteries</b> Introduction, Nickel cadmium, Nickel metal hydride batteries <b>Sodium-based Batteries</b> Introduction, Sodium sulphur batteries, Sodium metal chloride (Zebra) batteries <b>Lithium Batteries</b> Introduction, The lithium polymer battery, The lithium ion battery <b>Metal Air Batteries</b> Introduction, The aluminium air battery, The zinc air battery	7
2	<b>BATTERY CHARACTERISTICS &amp; PARAMETERS</b> Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters- Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance	7
3	<b>BATTERY MODELLING</b> Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Data -driven modelling approach for Batteries, Electric Vehicle range calculations, Simulating constant power and voltage requirements, Simulation of battery packs.	6
4	<b>BATTERY PACK AND BATTERY MANAGEMENT SYSTEM</b> Introduction to BMS functionality, Voltage Sensing, Temperature Sensing, Current Sensing, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Battery health estimation, Battery thermal Management system and its types.	8

5	<b>Charge Balancing and Fault Detection:</b> Charge Balancing - CC/CV Charging Method, Target Voltage Method, Balancing Strategies, Balancing Optimization, Charge Transfer Balancing, Flying Capacitor, Inductive Charge Transfer Balancing, Transformer Charge Balancing, Dissipative Balancing, Balancing Faults, Failure Detection - Overview, Overcharge/Overvoltage, Over-Temperature, Overcurrent Battery Imbalance/Excessive Self-Discharge, Internal Short Circuit Detection, Detection of Lithium Plating, Venting Detection, Excessive Capacity Loss, Reaction Strategies.	8
6	<b>EV Charging:</b> Battery Chargers: Charge equalisation, Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.	6
	<b>Total Hours</b>	42

#### References:

1. James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained
2. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
3. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
5. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
6. G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"
7. Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power Batteries", John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
8. T R Crompton, "Battery Reference Book-3<sup>rd</sup> Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.
9. Ibrahim Dincer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", JohnWiley& Sons Ltd., 2016.
10. Chris Mi, Abul Masrur& David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.
11. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric Hybrid Electric and Fuel Cell Vehicles", Taylor& Francis Group, 2010.
12. Arno Kwade, Jan Diekmann, "Recycling of Lithium-Ion Batteries: The LithoRec Way", Springer, 2018. (ISBN: 978-3-319-70571-2)
13. Gregory L Plett Battery Management System Volume 1 Battery modelling, Artech House , 2015.

**Subject Name: Fundamental of Electric and Hybrid Vehicles**

**MTech. Year – 1 (Semester – 1)**

**Course Category: Programme Core (PC)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
1	<b>Introduction to EV &amp; HEV:</b> Past, Present & Feature of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.	3
2	<b>EV System:</b> EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives	4
3	<b>EV Parameters:</b> Weight, size, force, energy & performance parameters.	3
4	<b>EV Propulsion:</b> <i>Electric Motor:</i> Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In-wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electric Motors for EV applications <i>Required Power Electronics &amp; Control:</i> Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller & Control Strategies	6
5	<b>EV Motor Drive:</b> <b>DC Motor:</b> Type of wound-field DC Motor, Torque speed characteristics DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor <b>Induction Motor Drive:</b> Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control,	12

6	<b>HEV (Hybrid Electric Vehicle):</b> Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples. Power flow control in all HEV configurations, Examples of HEV system performance	6
7	<b>Introduction to Energy Storage Requirements:</b> Introduction to Energy Storage Requirements in Electric Vehicles - Different types of energy storage; Mechanical: Flywheel based energy storage; Chemical: Hydrogen production and storage; Electrical: Capacitors for EV, Super Capacitor, EDLC; Electrochemical: battery, fuel cell, biological, thermal; Magnetic Energy Storage, Superconducting Energy Storage systems, Hybridization of different energy storage devices. Modelling of various emerging storage systems – Simulation case studies.	8
	<b>Total Hours</b>	42

### References:

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
5. F. A. Silva and M. P. Kazmierkowski, "Energy Storage Systems for Electric Vehicles [Book News]," in IEEE Industrial Electronics Magazine, vol. 15, no. 4, pp. 93-94, Dec. 2021.
6. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), 2011.
7. Rufer, Alfred. Energy storage: systems and components. CRC Press, 2017

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## Modelling and Control of Power Electronic Converters and Drives

MTech. Year – 1 (Semester – 1)

Course Category: Departmental Core (DC)

### Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks				Total Marks
Theory	Tutorial	Practical		ESE (E)	MSE (M)	Laboratory Work	Internal (I)	
3	0	3	12	50	20	20	10	100

### Contents:

Unit	Topics	Contact Hours
1	<b>BASIC POWER ELECTRONIC DEVICES</b> Diodes, Thyristors, Bipolar Junction Transistors, Metal–Oxide–Semiconductor Field Effect Transistors, Insulated Gate Bipolar Transistors, Ultracapacitors.	6
2	<b>DC/DC CONVERTER</b> Basic Principle of DC–DC Converter, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck–Boost Converter, DC–DC Converters Applied in Hybrid Vehicle Systems, Isolated Buck DC–DC Converter, Four-Quadrant DC–DC Converter.	9
3	<b>RECTIFIERS AND INVERTERS</b> Single-phase Diode Rectifiers, Three-phase Diode Rectifiers, Poly-phase Diode Rectifiers, Filtering Systems in Rectifier Circuits, High-frequency Diode Rectifier Circuits. Single-phase Voltage Source Inverters, Three-phase Voltage Source Inverters, Current Source Inverters, Closed-loop Operation of Inverters, Regeneration in Inverters, Multistage Inverters.	9
4	<b>ELECTRIC MOTOR DRIVES</b> DC motor operation and its types, BLDC Motor and Control, Operation of BLDC Motor, Torque and Rotating Field Production, BLDC Motor Control, BLDC Motor Torque–Speed Characteristics and Typical Technical Parameters, Sensorless BLDC Motor Control, AC Induction Motor and Control, Basic Principle of AC Induction Motor Operation, Controls of AC Induction Motor.	9
5	<b>Power Electronics and Control for Hybrid and Fuel Cell Vehicles</b> Series Hybrid Vehicle Propulsion System, Parallel Hybrid Vehicle Propulsion System, Fuel Cell Vehicles, Power Electronics Requirements, Propulsion Motor Control Strategies, APU Control System in Series Hybrid Vehicles, Fuel Cell for APU Applications.	9
	<b>Total Hours</b>	42

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## **Reference Books:**

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third Edition, New Delhi, 2011.
2. Ali Emadi, "Handbook of Automotive Power Electronics and Drives", Taylor & Francis Group, First Edition, USA, 2005.
3. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education, second Edition, 2003.
4. Dubey. G.K., "Thyristorised power controllers", new age International, New Delhi, 2002.
5. Bhimbhra P.S., "Power Electronics", Khanna Publishers, New Delhi, 2005.
6. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, Third edition, New Delhi, 2008.

## **Suggested List of Experiments:**

1. Obtain dynamic characteristics of IGBT and MOSFET under different loading conditions.
2. Design an opto-coupler based driver circuit for IGBT/MOSFET
3. Design of step up chopper.
4. Design of step down chopper.
5. Analyse the operation of Buck Converter under CCM and DCM.
6. Analyse the operation of Boost Converter under CCM and DCM.
7. Three phase IGBT based PWM inverter control of induction motor.
8. Study of driver circuits and generation of PWM signals for three phase inverters.
9. Study the operation of 12-pulse converter.
10. Load test and speed control of D.C shunt motor.
11. Load test and speed control of three-phase induction motor.
12. Study of Series hybrid electric vehicle layout.
13. Study of Parallel hybrid electric vehicle layout.

PC	MODELLING AND SIMULATION OF EHV	L	T	P	C
		3	0	3	12

**Course Category:** Programme Core (PC)

**UNIT-I MODELLING IN PERFORMANCE PARAMETER** **L - 9**

Modelling Vehicle Acceleration - Acceleration performance parameters, modelling the acceleration of an electric scooter, modelling the acceleration of a small car

**UNIT-II MODELLING OF BATTERY ELECTRIC VEHICLES** **L - 9**

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

**UNIT-III DRIVETRAIN CHARACTERISTICS** **L - 9**

Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics, Electric Motor Performance Characteristics – Battery Performance Characteristics-Transmission and Drivetrain 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

**List of Demonstration:**

**UNIT-IV ENERGY MANAGEMENT** **L - 9**

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

**UNIT-V VEHICLE DYNAMIC CONTROL** **L - 9**

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

**Simulation Tools:** Matlab/Simulink, ADVISOR and AVL Cruise.

**List of Demonstration:**

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.

#### **REFERENCES:**

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, 2014.
3. Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation", IGI Global, 2013.
4. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles\_ Fundamentals, Theory, and Design, Second Edition", CRC Press, 2010.

**Subject Name: Standards, Testing and Certification of Electric and Hybrid Vehicles**

**M. Tech. Year – 1 (Semester –I)**

**COURSE CATEGORY: PROGRAMME ELECTIVE - I (PE-I)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
<b>1</b>	<b>INTRODUCTION</b> Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.	9
<b>2</b>	<b>STATIC TESTING OF VEHICLE</b> Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement of Temporary Cabin For Drive- Away – Chassis, Electric vehicle – Safety Norms, Energy consumption and Power test.	9
<b>3</b>	<b>DYNAMICS TESTING OF VEHICLE</b> Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.	9
<b>4</b>	<b>VEHICLE COMPONENT TESTING</b> Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC (CI, BCI, RE,RI and CTE).	9
<b>5</b>	<b>TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION</b> Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW	9

	< 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.	
	<b>Total Hours</b>	45

**References:**

1. "Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators
2. Michael Plint & Anthony Martyr, "Engine Testing & Practice", Butterworth Heinemann, 3rd ed, 2007
3. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE
4. Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007.

**Subject Name: Vehicle Dynamics****MTech. Year – 1 (Semester – 1)****COURSE CATEGORY: PROGRAMME CORE (PC)****Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Sr No	Topics	Duration
1	<b>Basics of Vehicle Dynamics:</b> History, vehicle classifications, fundamental approaches to vehicle dynamics modelling; SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, Brake proportioning, braking efficiency.	8
2	<b>Acceleration Performance</b> Power train components; power and traction limited acceleration; transverse weight shift; front wheel drive vs rear wheel drive vs. all-wheel drive vehicles	5
3	<b>Braking Performance</b> Braking force analysis; brake design and analysis; federal regulation on braking performance; antilock braking system; wheel lock-up; tire/road friction; safety and maintenance issues in braking	5
4	<b>Road Loads</b> Wind drag and car body design, rolling resistance; breakdowns of total road loads; gas mileage analysis and driving styles; Aerodynamics	6
5	<b>Tire and Tire Dynamics</b> Tire specifications and constructions; tire motion analysis; tire force analysis; tire contact stress analysis; tire vibration analysis; tire models	6
6	<b>Ride &amp; Cornering/steering</b> Riding comfort; perception of vibration; vibration sources; vibration transmission to the passengers; lower speed cornering; high speed corner; cornering bicycle model; Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover	7

7	<p><b>Chassis and Suspension Systems</b></p> <p>Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension Elements: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and aft directions.</p>	8
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**References:**

1. Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication.
2. The Multibody systems Approach to Vehicle Dynamics, Mike Blundell and Damian Harty, Elsevier, 2004.
3. Vehicle Dynamics, Theory and Application, Reza N. Jazar, Springer, 2009, ISBN 978-0-387-74243-4, e-ISBN 978-0-387-74244-1.
4. Race Car Vehicle Dynamics, W.F. Milliken and D.L. Milliken, SAE, 1995, ISBN 1-56091-526-9.
5. Reimpell, Stoll and Betzler: The Automotive Chassis: Engineering Principles.
6. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012
7. Rajesh Rajamani, Vehicle Dynamics & control, Springer.
8. R.V. Dukkipati, Vehicle dynamics, Narsova Publications.

**Subject Name: Automatic HVAC and Thermal Management System**

**M. Tech. Year – 1 (Semester – II)**

**COURSE CATEGORY: PROGRAMME ELECTIVE - VII (PE-VII)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

<b>Unit</b>	<b>Topics</b>	<b>Contact Hours</b>
<b>1</b>	<b>REFRIGERATION</b> Introduction - Methods of refrigeration - Air Refrigeration System and its applications –Vapour compression refrigeration system - Vapour absorption refrigeration system - Applications of refrigeration & air conditioning - automobile air conditioning - Air conditioning for passengers, isolated vehicles, transport Vehicles-Applications related with very low temperatures. Classification, properties and selection criteria - Commonly used refrigerants – Alternative refrigerants - Eco-friendly refrigerants - Applications of refrigerants -Refrigerants used in automobile air conditioning.	9
<b>2</b>	<b>PSYCHROMETRY</b> Review of fundamental properties of psychrometric – use of psychrometric charts – psychrometric processes – Grand and Room Sensible Heat Factors – by pass factor – requirements of comfort air conditioning –factors governing optimum effective temperature, recommended design conditions and ventilation standards. Psychrometric properties, tables, charts - Psychrometric processes – Comfort charts - Factor affecting comfort - Effective temperature - Ventilation requirements.	9
<b>3</b>	<b>AIR CONDITIONING SYSTEMS AND LOAD ANALYSIS</b> Classification and layouts - Central / unitary air conditioning systems - Components like compressors, evaporators, condensers, expansion devices, fan blowers, heating systems etc. Load Analysis: Outside & inside design consideration - Factors forming the load on refrigeration & air conditioning systems - Cooling & heating load calculations – Load calculations for automobiles - Effect of air conditioning load on engine performance	9
<b>4</b>	<b>AIR DISTRIBUTION SYSTEMS</b> Distribution duct system, sizing, supply / return ducts - Types of grills, diffusers, ventilation, air noise level - Layout of duct systems for automobiles and their impact on load calculations. Air Routine & Temperature Control: Objectives - evaporator care air flow - Through the dash recirculating unit - Automatic temperature control - Controlling flow - Control of air handling systems	9

5	<b>AIR CONDITIONING SERVICE AND CONTROL</b> Air conditioner maintenance & service - servicing heater system - Removing & replacing components, Trouble shooting of air conditioning system - Compressor service, methods of dehydration, charging & testing. Air Conditioning Control: Common control such a thermostats- Humidistat us - Control dampers - Pressure cutouts and relays	9
	<b>Total Hours</b>	45

**References:**

1. Refrigeration and Air-Conditioning - W.F. Stoecker and J.W. Jones, Tata McGraw Hill Pub.
2. Paul Lung, "Automotive Air Conditioning", C.B.S. Publisher & Distributor, Delhi.
3. Modern Air-Conditioning Practice - Norman C. Harris, Principles of Refrigeration -R.J. Dcssat, Wiley Eastern Pub.
4. Refrigeration and Air-Conditioning - C.P. Arora, Tata McGraw Hill Pub.
5. Refrigeration and Air-Conditioning – S.S.Thipse, Jaico.
6. Automotive air conditioning by Crouse Harris, "Modern Air Conditioning".
7. Khurmi R.S., and Gupta, J. K., A text book of Refrigeration and Air Conditioning, Eurasia Publishing housing (P) Ltd, New Delhi, 2002.
8. Manohar Prasad, Refrigeration and Air conditioning, New Age International (P) Ltd, New Delhi, 1999.
9. Ashrae Hand Book', 4 Vol., Current Ed., Carrier Air Conditioning Co., 'Hand Book of Air Conditioning', Prentice Hall of India, 1974.

**Subject Name: Automotive Safety****M. Tech. Year – 1 (Semester – II)****COURSE CATEGORY: PROGRAMME ELECTIVE - V (PE-V)****Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
1	<b>INTRODUCTION VEHICLE SAFETY, STRUCTURAL CRASHWORTHINESS AND CRASH TESTING</b> Automotive Safety-Active and passive safety, Driver assistance systems in automobiles, Definitions and terminology. Balance of stiffness and toughness characteristics and energy absorption characteristics of vehicle structures, Design of crash crumple zones, Modelling and simulation studies, Optimization of vehicle structures for crash worthiness, Types of impacts, and Impact with rebound, movable barrier tests, Analysis and simulation of vehicle in barrier impacts, Roll over crash tests, Behavior of specific body structures in crash testing, Photographic analysis of impact tests.	9
2	<b>ERGONOMICS AND HUMAN RESPONSE TO IMPACT</b> Importance of Ergonomics in Automotive safety, Locations of controls, Anthropometry, Human impact tolerance Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Application of Trauma for analysis of crash injuries. Injury criteria's and relation with crash and modelling and simulation studies in dummy.	9
3	<b>VEHICLE SAFETY SYSTEMS</b> Survival space requirements, Restraints systems used automobiles, Types of safety belts, Head restraints, Air bags used in automobiles, Use of energy absorbing systems in automobiles, Impact protection from steering controls, Design of seats for safety, types of seats used in automobiles. Importance of Bumpers in automobiles, Damageability criteria in bumper designs. Introduction to the types of safety glass and their requirements and rearward field of vision in automobiles, Types of rear view mirrors and their assessment. Warning devices, Hinges and latches etc. Active safety.	9
4	<b>FUNDAMENTALS OF LIGHT, VISION AND COLOUR</b> Electromagnetic radiation and light, Propagation of light, Spectral sensitivity of light, Measures of radiation and light, standard elements for optical control. Illuminate calculations, Derivation of luminous flux from luminous intensity, flux transfer and inter reflection, luminance calculations, discomfort glare, eyes as an optical system visual processing, lighting for results, modes of appearance, Pointers for lighting devices. Nature of the colour Trichromatic Calorimetry, Surface colour, colour spaces and colour solids, colour rendering	9

5	<b>LIGHT MEASUREMENTS, TESTING EQUIPMENT, CALIBRATION AND PHOTOMETRIC PRACTICE</b> Basics of standards and detectors, spectral measurements and Calorimetry, illuminate meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in Automotive field; Gonio-Photometer, Reflecto-meter, Colorimeter, integrating sphere, types, application, coordinates system, Types of sensors and working principle, construction, characteristics etc. used in different equipment. National and international Regulations, test requirements and testing procedure.	9
	<b>Total Hours</b>	45

**References:**

1. Jullian Happian-Smith 'An Introduction to Modern Vehicle Design' SAE, 2002
2. Johnson, W., and Mamalis, A.G., "Crashworthiness of Vehicles, MEP, London, 1995
3. Edward. A, Lamps and Lighting, Hodder & Stoughton, London, 1993.
4. Bosch –automotive -handbook, edition 5-SAE Publication-2000
5. Rollover Prevention, Crash Avoidance, Crashworthiness, Ergonomics and Human Factors”, SAE Special Publication, November 2003.

## Subject Name: Communication and Networking for Electric Vehicle

M. Tech. Year – 1 (Semester – II)

COURSE CATEGORY: PROGRAMME ELECTIVE - VII (PE-VII)

### Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

### Contents:

Unit	Topics	Contact Hours
1	<b>BASICS OF IN-VEHICLE NETWORKING</b> Overview of Data communication and networking –need for In-Vehicle networking – layers of OSI reference model –multiplexing and demultiplexing concepts –vehicle buses.	9
2	<b>NETWORKS AND PROTOCOLS</b> Overview of general-purpose networks and protocols -Ethernet, TCP, UDP, IP, ARP, RARP – LIN standard overview –workflow concept-applications – LIN protocol specification –signals - Frame transfer –Frame types – schedule tables –Task behaviour model –Network management –status management - overview of CAN –fundamentals –Message transfer – frame types-Error handling –fault confinement-Bit time requirements.	9
3	<b>HIGHER LAYER PROTOCOL</b> Introduction to CAN open –TTCAN –Device net -SAE J1939 - overview of data channels – control channel-synchronous channel – asynchronous channel –Logical device model – functions-methods-properties-protocol basics-Network section-data transport –Blocks – frames –Preamble- oundary descriptor	9
4	<b>FLEXRAY PROTOCOL</b> Introduction –network topology –ECUs and bus interfaces –controller host interface and protocol operation controls –media access control and frame and symbol processing – coding/decoding unit –FlexRay scheduling	9
5	<b>LATEST TRENDS</b> Car networking protocols – Networking future trends –Roadmaps – Competitive advantage	9
	<b>Total Hours</b>	45

### References:

1. J. Gabrielleen, “Automotive In-Vehicle Networks”, John Wiley & Sons, Limited, 2008
2. Robert Bosch,” Bosch Automotive Networking”, Bentley publishers, 2007
3. Society of Automotive Engineers, “In-Vehicle Networks”, 2002.

4. Ronald K Jurgen, "Automotive Electronics Handbook", McGraw-Hill Inc. 1999.
5. Indra Widjaja, Alberto Leon-Garcia, "Communication Networks: Fundamental Concepts and Key Architectures", McGraw-Hill College; 1st edition, 2000.
6. Konrad Etschberger, "Controller Area Network, IXXAT Automation", August 22, 2001.
7. Olaf Pfeiffer, Andrew Ayre, Christian Keydel, "Embedded Networking with CAN and CANopen", Anna books/Rtc Books, 2003

**Subject Name: EV Power Train and Its Management System**

**M. Tech. Year – 1 (Semester – II)**

**COURSE CATEGORY: PROGRAMME ELECTIVE - IV (PE-IV)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

<b>Unit</b>	<b>Topics</b>	<b>Contact Hours</b>
<b>1</b>	<b>FUNDAMENTALS OF OBD SYSTEMS</b> Components for Electronic Engine Management System, Open and Closed Loop Control Strategies, PID Control, Look Up Tables, Introduction to Modern Control Strategies Like Fuzzy Logic and Adaptive Control. Switches, Active Resistors, Transistors, Current Mirrors/Amplifiers, Voltage and Current References, Comparator, Multiplier. Amplifier, Filters, A/D and D/A Converters. Actuators and its types.	9
<b>2</b>	<b>SI ENGINE MANAGEMENT</b> Layout and Working of SI Engine Management Systems like Bosch Motronic (M, ME, MED) Engine Management, System Overview- System Structure. Electronic Control and Regulation- Electronic Diagnosis-Electronic Control Unit and Development. ECU Operating Conditions, Design and Data Processing.	9
<b>3</b>	<b>CI ENGINE MANAGEMENT</b> Fuel Injection System Parameters Affecting Combustion, Noise and Emissions in CI Engines. Pilot, Main, Advanced Post Injection and Retarded Post Injection. Electronically Controlled Unit Injection System. Layout of the Common Rail Fuel Injection System. Working of Components like Fuel Injector, Fuel Pump, Rail Pressure Limiter, Flow Limiter, EGR Valves.	9
<b>4</b>	<b>DIAGNOSIS AND CONTROL SYSTEMS</b> Electronic Control System Overview-Subsystems and Main Functions-Electronics Diagnosis- Self-Diagnosis- Engine Diagnostics - Introduction To Diagnosis, Types Of Engine Diagnostics, Need For OBD, Types Of OBD, General Requirements-Diagnosis System Management-Individual Diagnosis-Data Transfer Between Automotive Electronic System. Model Based Diagnostic Control- Various Engine Systems Diagnostic (Air System, Fuel System, Exhaust System)	9
<b>5</b>	<b>DIGITAL ENGINE AND VEHICLE CONTROL SYSTEMS</b> EMS- Engine Functions and Control-General Terms and Performance – Engine Mapping, Control Strategy-Engine Control Sequence-Calibration Technique in EMS, VVT Control, Camless Control, Variable Swirl Mechanisms- Different Types of Automatic Transmission - Control System - Basics Of Driveline Control, Driveline Speed And Torque Control, Gear Shift	9

	Control, Anti-Jerk Control, Driveline Diagnostic System- CVT, Advancement in Driveline Control System.	
	<b>Total Hours</b>	45

**References:**

1. William, B. Ribbens, 'Understanding Automotive electronics', Butterworth Heinemann, 2017.
2. Robert Bosch, 'Diesel Engine Management ', SAE Publications, 3rd Edition, 2004
3. Robert Bosch, 'Gasoline Engine Management', SAE Publications, 2nd Edition, 2004
4. Lino Guzzella and Christopher H. Onder, 'Introduction to Modeling and Control of Internal Combustion Engine Systems', Springer-Verlag, 2010.
5. Lars Eriksson and Lars Nielsen, 'Modeling and Control of Engines and Drivelines', John Wiley & Sons, 2014.
6. Rolf Isermann, 'Engine Modeling and Control - Modeling and Electronic Management of Internal Combustion Engines', Springer Verlag, 2014.

**Subject Name: Hydrogen and Fuel Cell Technology for Electric and Hybrid Vehicles**

**M. Tech. Year – 1 (Semester – II)**

**COURSE CATEGORY: PROGRAMME ELECTIVE - III (PE-III)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
<b>1</b>	<b>HYDROGEN AS FUTURE ENERGY CARRIER</b> Hydrogen Production: Thermal Processes, Electrolytic Processes , Photolytic Processes - Hydrogen Distribution - Hydrogen Storage - Hydrogen Storage in High Compressed Gas Form , Hydrogen Storage in Liquid Cryogenic Form, Hydrogen Storage in Solid Materials - Need, Properties, Pollution, Emission standards, World and Indian Scenario.	9
<b>2</b>	<b>HYDROGEN IN S.I. ENGINE SYSTEM</b> Engine Modifications, Combustion Characteristics – Dual Fueling, Direct Injection of Gaseous and Liquefied Hydrogen.	9
<b>3</b>	<b>HYDROGEN IN C.I. ENGINE SYSTEM</b> Engine Modification & Combustion Characteristics - Direct Injection – Gaseous and Liquefied Hydrogen, Dual Fuel Mode, and Hydrogen Enrichment.	9
4	<b>FUEL CELLS FOR AUTOMOTIVE APPLICATIONS</b> Basic Concepts of Electrochemistry - Proton Exchange Membrane Fuel Cells: Membrane, Electrocatalysts, GDL, Bipolar Plates - Sensitivity of PEM Stacks to Operating Conditions: Polarization Curve, Effect of Operative Parameters on the Polarization Curve - Durability of PEM Fuel Cells	9
5	<b>DESIGN OF HYDROGEN FUEL CELL SYSTEMS FOR ROAD VEHICLES</b> Hydrogen Fuel Cell Systems: Preliminary Remarks - Hydrogen Feeding System - Air Feeding System - Thermal Management System - Water/Humidification Management System - Integrated Fuel Cell System: Efficiency, Dynamics, Costs.	9
	<b>Total Hours</b>	45

**References:**

1. Johannes Topler and Jochen Lehmann, Hydrogen and Fuel Cell Technologies and Market Perspectives, Springer, 2016
2. Pasquale Corbo, Fortunato Migliardini and Ottorino Veneri, Hydrogen Fuel Cells for Road Vehicles (Green Energy and Technology), Springer, 2011.
3. Alternative Fuels (A decade of success and Promise) edited by Reda Moh. Bata, SAE PT-48, ISBN 1-56091 – 593 – 5.
4. Osamu Hirao and Richard K. Pefley, Present and future Automotive Fuels, John Wiley and Sons, 1988.
5. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications, 1990.
6. Richard L. Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997.
7. Hydrogen Fuel Cells for Road Vehicles, April 2010, Springer.

## Subject Name: Intelligent Transport System

M. Tech. Year – 1 (Semester – II)

COURSE CATEGORY: PROGRAMME ELECTIVE - V (PE-V)

### Teaching and Examination Scheme

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

### Contents:

Unit	Topics	Contact Hours
1	<b>DIGITAL MAP DATABASE MODULE</b> Introduction to Modern Vehicle Location and Navigation – Basic Representations – Reference Coordinate Systems – Standards - Proprietary Digital Map Databases - Digital Map Compilation.	9
2	<b>POSITIONING MODULE</b> Introduction-Dead Reckoning-Global Positioning System - Sensor fusion - Conventional map matching - Fuzzy logic Based Map matching - Other Map matching algorithms - Map aided Sensor calibration	9
3	<b>DIRECTION MODULE</b> Shortest Path - Heuristic Search - Bidirectional Search - Hierarchical search - other algorithms - Guidance while En Route - Guidance while off Route - Guidance with dynamic information.	9
4	<b>WIRELESS COMMUNICATION MODULE</b> Introduction - Communication Subsystem Attributes – Existing Communication Technologies - Communication Subsystem Integration.	9
5	<b>AUTONOMOUS LOCATION AND NAVIGATION</b> Introduction – Vehicle Location: Standalone Technologies - Radio Technologies – Satellite Technologies - Vehicle Navigation: Coping with complex requirements - Dual use navigation and entertainment components - Centralized location and Navigation Introduction -Automatic Vehicle Location: Centralized and Distributed Approach- Dynamic Navigation :Centralized and Distributed.	9
	<b>Total Hours</b>	45

### References:

1. “Intelligent Vehicle Technologies Theory and Applications”– L Vlacic, M Parent, F Harashima- Butterworth Heinemann
2. “Vehicle location and Navigation Systems” – Yilin Zhao – Artech House Inc.

3. Sussman Joseph, "Perspectives on Intelligent Transportation Systems (ITS)", New York, NY: Springer, 2010.
4. Mashrur A. Chowdhury, and Adel Sadek, "Fundamentals of Intelligent Transportation Systems Planning", Artech House, Inc., 2003.

**Subject Name: Plug-In Electric Vehicles in Smart Grid****M. Tech. Year – 1 (Semester – II)****COURSE CATEGORY: PROGRAMME ELECTIVE - VI (PE-VI)****Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
1	<b>VEHICLE ELECTRIFICATION &amp; IMPACT OF CHARGING STRATEGIES</b> Introduction, Impact of charging strategies, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid, effect of EV charging on generation and load profile, Smart charging technologies, Impact on investment.	9
2	<b>INFLUENCE OF EVS ON POWER SYSTEM</b> Introduction, identification of EV demand, EV penetration level for different scenarios, classification based on penetration level, EV impacts on system demand: dumb charging, multiple tariff charging, smart charging, case studies.	9
3	<b>FREQUENCY CONTROL RESERVES &amp; VOLTAGE SUPPORT FROM EVS</b> Introduction, power system ancillary services, electric vehicles to support wind power integration, electric vehicle as frequency control reserves and tertiary reserves, voltage support and electric vehicle integration, properties of frequency regulation reserves, control strategies for EVs to support frequency regulation.	9
4	<b>ICT SOLUTIONS TO SUPPORT EV DEPLOYMENT</b> Introduction, Architecture and model for smart grid & EV, ICT players in smart grid, smart metering, information & communication models, functional and logical models, technology and solution for smart grid: interoperability, communication technologies.	9
5	<b>EV CHARGING FACILITY PLANNING</b> Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Micro-grid, Design of V2G Aggregator.	9
	<b>Total Hours</b>	45

**References:**

1. M. Ehsani, Y. Gao, S. Longo, K. Ebrahim, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, 3rd Edition.
2. I. Husain, Electric and Hybrid Vehicles: Design Fundamentals, 2nd Edition.
3. J. M. Miller, Propulsion Systems for Hybrid Vehicles, 2nd Edition.
4. R. W. Erickson, D. Maksimovic, Fundamentals of Power electronics, 2nd Edition.
5. A. Lidow, J. Strydom, M. de Rooij, D. Reusch, GaN Transistors for Efficient Power Conversion.
6. B. J. Baliga, Wide Bandgap Semiconductor Power Devices: Materials, Physics, Design and Applications.

**Subject Name: Vehicle Diagnostics and Maintenance**

**M. Tech. Year – 1 (Semester – II)**

**COURSE CATEGORY: PROGRAMME ELECTIVE - VI (PE-VI)**

**Teaching and Examination Scheme**

Teaching Scheme (Hours)			Credits	Theory Marks			Total Marks
Theory	Tutorial	Practical		ESE (E)	Mid Sem (M)	Internal (I)	
3	0	0	9	60	30	10	100

**Contents:**

Unit	Topics	Contact Hours
<b>1</b>	<b>THE COMPUTER ECM</b> Fundamental parts of a computer, practical automotive computer system, Principles of operation, Computer data, Computer interfaces, Control of output devices, Computer memories, Fault codes, Adaptive operating strategy of the ECM, Networking of computers, Vehicle network systems, Prototype network systems.	9
<b>2</b>	<b>SELF DIAGNOSIS AND FAULT CODES</b> Access to Diagnostic trouble codes (DTC), Developments in self-diagnosis, Diagnostic equipment and limitations of DTCs, Diagnostic equipment and limitations of DTCs.	9
<b>3</b>	<b>DIAGNOSTIC TOOLS AND EQUIPMENT</b> Breakout boxes, Diagnostic tools that connect to ECM, The digital multimeter, Portable flat screen oscilloscopes, Diagnostic tool and oscilloscope combined, Pressure gauges, Calibrating test instruments, Location charts and wiring diagrams, Sources of diagnostic data ,Exhaust gas emissions and emission system testing.	9
<b>4</b>	<b>DIAGNOSTIC TECHNIQUES</b> Circuit testing, Vehicle specific details, six-steps approach, Skills required for effective diagnosis, An approach to fault finding, Emissions related testing, Ignition system tests, Diesel injection, Sensor tests on other systems, Intermittent faults.	9
<b>5</b>	<b>ON-BOARD DIAGNOSTICS</b> On-board diagnostics – a first perspective, Petrol/gasoline on-board diagnostic monitors, On-board diagnostics – a second perspective, OBD for Engine systems, chassis systems, electrical systems, transmission systems.	9
	<b>Total Hours</b>	45

**References:**

1. Allan W. M. Bonnick, Automotive Computer Controlled Systems Diagnostic tools and techniques, Butterworth-Heinemann, 2011.
2. Tom Denton, Advanced Automotive Fault Diagnosis, Second Edition,2006.