Blended-mode M. Tech programme in Electric Vehicle Technology

1. Course Structure:

Semester	Course Name	Code	L-T-P	Credit
1 (Autumn)	Electric Vehicle Systems	ID6L301	3-0-0	3
	Traction Motors, converters and drives	ID6L302	3-0-0	3
	Battery Technology for EVs	ID6L303	3-0-0	3
	EV sub-systems laboratory – I	ID6P301	0-0-3	2
	Elective - I	XXXXXX	3-0-0 / 3–1-0	3 / 4
	Seminar*	ID6S301	0-0-4	3
	Semester-wise credits			17/18
2 (Spring)	Control System in Electric Vehicles	ID6L304	3-0-0	3
	Design of Electric Vehicles	ID6L305	3-0-0	3
	EV sub-systems laboratory – II	ID6P302	0-0-3	2
	Elective - II	XXXXXX	3-0-0 / 3–1-0	3 / 4
	Elective - III	XXXXXX	3-0-0 / 3–1-0	3 / 4
	Project - Part I	ID6D301		2
	Semester-wise credits			17/19
3 (Autumn)	Elective - IV	XXXXXX	3-0-0 / 3–1-0	3 / 4
	Project - Part II	ID6D302	---	14
	Semester-wise Credits			17/18
4 (Spring)	Project - Part III	ID6D303	---	14
	Semester-wise credits			14
	Total credits			65 / 69

* In the ‘Seminar’ course the students are exposed to certain advanced techniques/tools. Senior industry experts are invited to interact and share their knowledge. In addition, the students are required to give seminars on assigned topics. An examination is conducted on the items learned by students.

List of Electives:

Elective	Course	Code	L-T-P	Credit
I & IV	Battery thermal management systems	ID6L306	3-0-0	3
	Vehicle Dynamics	ID6L307	3-0-0	3
	Switched Mode Power Conversion	EE6L051	3-1-0	4
	Soft computing and applications	ME6L060	3-0-0	3
II & III	Engineering Measurements	ME6L009	3-1-0	4
	Charging Infrastructure	ID6L308	3-0-0	3
	Maintenance, Diagnostics and Prognostics	ID6L309	3-0-0	3
	Engineering Design Optimization	ME6L007	3-0-0	3

Syllabus

Subject name: Electric Vehicles Systems
Subject code: ID6L301
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Introduction to electric mobility: Classification of electric vehicles- IC engine vehicles, Hybrid electric vehicles (HEVs), pure electric vehicles, fundamentals of operation; electrical system architecture for electric vehicles; regulations and policies for electric vehicles, role of policies for deployment of charging infrastructures; Topologies for electric vehicles, plug-in HEVs;

Vehicle mechanics: mathematical modeling of electric vehicle dynamics, air drag, rolling and climbing force, torque and power in electric vehicles, system modeling, performance of electric vehicles, power source characterization, transmission characteristics, Drive trains for electric vehicles; Regenerative braking concept.

Fundamentals of charging systems: Classification of charging systems, domestic and public charging systems, ac charging versus dc charging systems, battery swapping technology, Fast charging mechanisms, Standards for electric vehicle charging systems, Economics of charging systems, Metering, Concept of vehicle to grid (V2G), smart grid application for electric vehicles.

Electronic systems in electric vehicles: Electronic measurements in electric vehicles, Embedded systems in electric vehicles, Vehicle communications: OSI seven layer model, in-vehicle communication and control area network (CAN), processors for electric vehicle control, concept of autonomous vehicles, image processing in electric vehicle applications.

Recommended Books:

1. Electric and Hybrid Vehicles Design Fundamentals by Iqbal Husain, 2nd Ed., CRC Press (2010)
2. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design by Mehrdad Ehsani, Y. Gao, S. E. Gay and Ali Emadi, CRC Press (2004)
3. Electric Vehicle Machines and Drives, Design, Analysis and Application by K. T. Chau, IEEE Press and Wiley (2015)
4. E-Mobility by M. Kathiresh, G. R. Kanagachidambaresan, Sheldon S. Williamson Springer, ISBN: 978-3-030-85424-9. (2022)
5. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design by Lino Guzzella and Antonio Sciarretta CRC Press, 2nd Edition, ISBN – 978-1-4200-5398-2 (2009)

Subject name: Traction Motors, converters and drives
Subject code: ID6L302
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Electric machines for eVs: fundamentals of dc motors and generators, synchronous machines, single phase and three phase induction machines, permanent magnet (BLDC and PMSM) and switched and synchronous reluctance machines, stepper motors;

Fundamentals of single-phase and three-phase powers, Power switching devices and their characteristics, Power electronics for eVs: Concept of power electronic conversion: dc-ac, ac-dc, dc-dc, ac-ac conversion; types of power electronic converters: isolated and non-isolated converters; pulse width modulation.

Fundamentals of motor drives for electric vehicles: Components of electric drive trains, dc drives, ac drives, BLDC and PMSM drives, SRM drives; Braking of electric vehicles; Regeneration of energy during braking, topologies for implementation of regenerative braking, Control of electric drives, closed loop control of electric drives, stability criteria, drive cycle, electrical modeling of electric vehicle load.

Practical aspects, case studies on Motors, converters and drives used in EVs.

Recommended Books:

1. M. H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India (2009)
2. N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons (2007)
3. B. K. Bose “Modern Power Electronics and AC Drives”, Pearson Eduction (2002)
4. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media (2007)
5. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India (2009)

Subject name: Battery Technology for EVs
Subject code: ID6L303
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Fundamentals of electrochemistry including redox reactions and electrode potential. Key battery parameters such as capacity, energy and power, C-rate, state of charge (SOC), depth of discharge (DOD), state of health (SOH), cycle and calendar life, internal resistance, and impedance. Mechanical characteristics, form factor, nominal voltage, energy density, and basic safety considerations.

Introduction to electrochemical cells including Daniell cell, lead-acid, and nickel-metal hydride (NiMH) batteries, with comparison to lithium-ion systems. Overview of battery pack architecture and battery management systems (BMS).

Battery characterization including capacity testing, cycle life, and impedance spectroscopy. Modeling approaches: empirical, equivalent circuit, electrochemical, and machine learning models. Estimation of SOC, SOH, and remaining useful life (RUL).

Lithium-ion battery fundamentals including cell components, charge-discharge mechanisms, ion transport and diffusion. Performance metrics and degradation mechanisms such as SEI formation and lithium plating.

Materials and design aspects including electrode materials (graphite, LTO, NMC, NCA, LFP, LCO), electrode structures, cell configurations (cylindrical, prismatic, pouch), electrolytes, and separators.

Safety and thermal management including thermal runaway, short circuits, fire hazards, and thermal management systems.

Battery selection for EVs including energy–power trade-offs, lifetime, temperature effects, maintenance, cost and lifecycle analysis, recycling, second-life applications, and emerging technologies such as solid-state batteries, fast charging, AI-based diagnostics, and grid integration.

Recommended Books:

1. Lithium-Ion Batteries: Fundamentals and Applications, Yoshio et al., Springer (2009)
2. Electrochemical Energy Storage for Renewable Sources and Grid Balancing, P. T. Moseley & J. Garche, Elsevier (2015)
3. Electric Vehicle Technology Explained, James Larminie & John Lowry, Wiley (2012)
4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani et al., CRC Press (2018)
5. Battery Systems Engineering, Christopher D. Rahn & Chao-Yang Wang, Wiley (2013)
6. Lithium-Ion Battery Systems, Gianfranco Pistoia, Elsevier (2014)

Subject name: Design of Electric Vehicles
Subject code: ID6L305
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Power sources for electric vehicles; Estimation of power and torque requirements considering real time conditions

Design aspects of batteries: Types of batteries, working principles and their characterization, influence of anode, cathode materials, failure analysis, performance optimization.

EV Battery Pack design; Design of battery packs for the required power. Battery thermal management systems (BTMS).

Electric vehicle chassis design: stability, aerodynamic and materials for vehicle body.

Power train design; Hybrid Electric Drive-trains: hybrid traction, various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

Study of IC engine-based vehicle designs; Design aspects of electric and hybrid electric vehicles; Efficiency and performance studies of EV and HEV.

Motor controller design, power electronics; Braking System design, regenerative braking

Design for vehicle accessories: cooling system, lighting system, tire, road load absorption.

Measurement of performance parameters; Life estimation and endurance of battery packs; Recycling of battery packs.

Challenges in Practical development of EV and HEV considering two wheelers, three wheelers, four wheelers and transport vehicles.

Recommended Books:

1. Husain, Iqbal. Electric and hybrid vehicles: design fundamentals. CRC press (2010)
2. Larminie, James, and John Lowry. Electric vehicle technology explained. John Wiley & Sons (2012)
3. Jahn, Robert G. Physics of electric propulsion. Courier Corporation (2006)
4. Du, Haiping, Dongpu Cao, and Hui Zhang, eds. Modeling, dynamics, and control of electrified vehicles. Woodhead Publishing (2017)

Subject name: Control Systems in Electric Vehicles
Subject code: ID6L304
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Introduction to EV Control: Various EV controllers - BMS, MCU, VCU; Sensors & actuators. Automotive controller development process - model-based development, MiL, SiL, HiL.

System Modelling and Control fundamentals: Modelling-Electrical, Mechanical and Electromechanical systems in transfer function and state-space viewpoints, nonlinear dynamics and linearization. EV powertrain modelling.

Feedback systems, Stability and performance metrics, classical and modern approaches.

Classical Control Design: Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram. Design of PID controllers: Design of P, PI, PD and PID controllers in frequency domain. Applications in Motor control, drive control etc.

Modern Control Design: Controllability, Observability; state-feedback, LQR; observers, Kalman filters, LQG, separation principle. Case studies employing Adaptive control, Robust control, Model predictive control for EVs.

Optimization and Control in EVs: Energy Management-Optimization based strategies, control of battery management systems, case studies.

Recommended Books:

1. Design of Feedback Control Systems by Raymond T. Stefani, Bahram Shahian, Cornelius J. Savant, Gene H. Hostetter, Oxford University Press (2002)
2. Electric Vehicle Powertrains: Design Fundamentals, Components, and Applications by B. Ashok, V. Indragandhi, Elsevier (2026)
3. Electric and Hybrid Vehicles: Technologies, Modeling and Control – A Mechatronic Approach by Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, Wiley (2014)
4. Power Electronics: Essentials and Applications by L. Umanand, Wiley (2009)

Subject name: Battery thermal management systems
Subject code: ID6L306
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Review of Heat Transfer Fundamentals : Steady and Transient Conduction heat transfer with heat generation, Forced and natural convection heat transfer, Dimensionless parameters governing the conduction and convection heat transfer, Empirical correlations for forced and natural convection.

Battery Management Systems: Battery States Estimation, State of Charge (SOC), Depth of Discharge (DOD), Battery Characteristics, Safety Management/Fault Diagnosis, Thermal Management, Joule heat and entropic heat effect in Battery thermal Management System

Need of Thermal Management in EV Batteries: Heat generation in EV batteries, Battery Heat Transfer Analysis, Battery Temperature Distribution, Battery Temperature Uniformity, Thermal runaway in Li-ion batteries.

Battery Thermal Management Systems : Design of battery thermal management systems, Categories of battery thermal management systems, Air-based battery thermal management systems, Liquid-based battery thermal management systems, Phase change material (PCM)-based battery thermal management systems, Liquid-vapor phase change-based battery thermal management systems, Recent developments in battery thermal management systems.

Case Studies: Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic/Cylindrical Lithium-Ion Battery, Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles, Heat Transfer and Thermal Management of Electric Vehicle Batteries with Phase Change Materials / Immersion Cooling.

Recommended Books:

1. Thermal Management of Electric Vehicle Battery Systems, Ibrahim Dinner, Halil S. Hamut, and Nader Javani, Wiley. (2017)
2. Battery Management Systems for Large Lithium-Ion Battery Packs, Davide Andrea, ARTECH House. (2010)
3. Fundamentals and applications of Lithium-Ion batteries in Electric Drive Vehicles, Jiuchun Jiang and Caiping Zhang, Wiley. (2015)
4. Vehicle thermal Management Systems Conference Proceedings, Coventry Techno centre, UK, 1st Edition (2013)
5. Thermal Management in Automotive applications, 2015, SAE International, T. Yomi Obidi (2015)

Subject name: Vehicle Dynamics
Subject code: ID6L307
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Introduction to the automobile; understanding subsystems responsible for ensuring satisfactory longitudinal, lateral, and vertical dynamics performance of vehicles.

Suspension kinematics and compliance; brake design and force portioning; pneumatic and hydraulic braking systems; antilock braking system (ABS); electronic brake force distribution (EBD) and traction control; vehicle stability and tire friction ellipse; different types of vehicle transmission systems; steering and handling; ride quality and suspension control; introduction to hybrid and electric vehicles.

ePowertrain architectures; vehicle longitudinal dynamics (1 & 2 wheel models); key performance attributes (starting from rest and initial vehicle movement, acceleration and deceleration, energy efficiency, energy density and range, etc.).

Vehicle control: longitudinal acceleration control; yaw rate control; lateral positioning; path planning/tracking; adaptive cruise control; automatic vehicle following and convoys.

Testing of vehicle performance and handling; lab-based and field-testing approaches; different sophistications of lab-based vehicle testing: MIL, SIL, and HIL.

Recommended Books:

1. Jazar, Reza N. Vehicle dynamics. Vol. 1. New York: Springer (2008)
2. Gillespie, Thomas D. Fundamentals of vehicle dynamics. Vol. 114. SAE Technical Paper (1992)
3. Rajamani, Rajesh. Vehicle dynamics and control. Springer Science & Business Media. (2011)
4. Pacejka, Hans. Tire and vehicle dynamics. Elsevier (2005)
5. Borgnakke, C and Sonntag, R.E., Fundamentals of Thermodynamics, 10th edition, Wiley (2019)
6. Mi, C and Masrur, MA, Hybrid electric vehicles: principles and applications with practical perspectives, 2nd edition, Wiley (2017)
7. Miller, J, Propulsion Systems for Hybrid Vehicles, IET (2010)
8. Emadi, A, Advanced Electric Drive Vehicles, 1st edition, CRC Press (2014)

Subject name: Charging Infrastructure
Subject code: ID6L308
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Basics of Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power. Neutral Grounding. Lightning and Switching Surges. Protection against Overvoltage.

Basics of EV charging and working principles, Charging levels (Level 1, Level 2, DC fast charging), Connector types and standards (Type 1, Type 2, CCS, CHAdeMO), EV charging station components and overall system architecture, and communication (OCPP basics), Charging control, CCCV (Constant-Current-Constant-Voltage) charging, Pulse-Burp charging.

Smart charging and grid distribution system; Network impact of EVs on distribution and transmission levels such as over-voltage, power quality issues etc.; Communication interface between EV and the electric power network; Mitigation techniques to overcome EV Impacts on grid/distribution network; Interdependency of EV and Renewable Energy Penetrations; Role of business models for charging and discharging; Insights on Vehicle to home and V2G applications of EVs.

Recommended Books:

1. Electric Vehicle Charging Infrastructure by J. Larminie & J. Lowry, Wiley (2019)
2. Electric Vehicle Integration via Smart Charging: Technology, Standards, Implementation, and Applications by Vahid Vahidinasab & Behnam Mohammadi Ivatloo, Springer (2022)
3. Modern Power System Analysis by D. P. Kothari and I. J. Nagrath, McGraw Hill Education (2003)

Subject name: Maintenance, Diagnostics and Prognostics for Electric Vehicles
Subject code: ID6L309
L-T-P-C: 3-0-0-3
Pre-requisites: None

Detailed Syllabus:
Overview of EV subsystems: battery, motor, inverter, BMS, Differences between ICE and EV maintenance, Failure modes in EV systems, Basics of condition monitoring, Electrical safety in high-voltage systems, Thermal hazards and battery safety, Preventive and predictive maintenance strategies, Standard operating procedures (SOPs), Maintenance scheduling and lifecycle management.

Fault classification: electrical, thermal, mechanical, Diagnostic techniques, Signal-based diagnostics, Model-based diagnostics, Fault detection in Battery systems (SoC, SoH issues), Motor and inverter systems, Use of onboard diagnostics and fault codes, Sensors used in EV diagnostics, Data acquisition systems, CAN bus and vehicle communication protocols.

IoT architecture for connected EVs, Remote diagnostics and cloud-based monitoring, Concept of prognostics and remaining useful life (RUL). Degradation modeling of batteries. End-of-life EV considerations, Battery reuse and second-life applications, Recycling technologies for lithium-ion batteries, Environmental and regulatory aspects, Circular economy in EV ecosystem.

Recommended Books:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 3rd Ed. (2018)
2. Kai Goebel, Neil Eklund, Abhinav Saxena, Prognostics and Health Management of Electronics, Wiley-IEEE Press, 2nd Ed. (2018)
3. Xiaosong Hu, Languang Lu, Xuebing Han, Battery Lifetime Prognostics, Frontiers Media SA (2020)
4. Isidor Buchmann, Batteries in a Portable World: A Handbook on Rechargeable Batteries for Non-Engineers, Cadex Electronics, 4th Ed. (2016)