Government of Karnataka

DEPARTMENT OF COLLEGIATE AND TECHNICAL EDUCATION

Program	Electronics & Communication Engineering	Semester	5
Course Code	20EC54I	Type of Course L:T:P	104 : 52 : 312
Specialization	E- Mobility	Credits	24
CIE Marks	240	SEE Marks	160

Rationale:

Welcome to the curriculum for the Specialization Pathway E-Mobility. This specialization course is taught in Boot camp mode. Boot camps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur. You will be assisted through the course, with development-based assessments to enable progressive learning. In this course, you'll learn how to develop and exploit Electric Vehicle system in a range of manufacturing and EV applications that are needed for today's job market.

Leading to the successful completion of this boot camp, you shall be equipped to either do an internship in an organization working on E-Mobility or do a capstone project in the related field. After the completion of your Diploma, you shall be ready to take up roles like a Programmer, Supervisor and can rise up to the level of Manager, also can become Entrepreneur in the related field and more

This course will teach you about E-Mobility, Energy storage system, Battery Management System (BMS), EV System Design, EMC/EMT testing, Electric Drive and Power Train, Sensors used in EVs, IOT applications in Electric Vehicles and more. Details of the curriculum is presented in the sections below.

Pre-requisite

Before the start of this specialization course, you will have prerequisite knowledge gained in the first two years on the following subjects:

1st year -Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Electrical and Electronics Engineering, Project Management skills, Digital Electronics

2nd year- Analog Electronics, Logic Design using Verilog, Communication Systems, Electronic Measurements and Testing Techniques, PCB Design & Fabrication, Wireless Communication, Embedded C Programming, Industrial Automation, in this year of study, you shall be applying your previous years learning along with specialized field of study into projects and real-world applications.

Instruction to course coordinator.

1. Each Specialized field of study is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. One faculty from the Core Discipline shall be the Cohort Owner, who for teaching and learning in allied disciplines can work with faculty from other disciplines or industry experts.
3. The course shall be delivered in boot camp mode spanning over 12 weeks of study, weekly developmental assessments and culminating in a mini capstone.
4. The industry session shall be addressed by industry experts (in contact mode/online / recorded video mode) in the discipline only.
5. The cohort owner shall be responsible to identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for industrial/mines/site/showroom/service Centre visits.
7. Cohort owner shall maintain and document the industrial assignments, weekly assessments, practices and mini project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom can augment or use for supplementally teaching on line courses available although reliable and good quality online platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademy, SWAYAM etc.
10. Report should be maintained for industrial/field visit, such report shall be considered as industrial assignment.

Course outcomes: On successful completion of the course, the students will be able to,

CO1	**Identify the type of E- vehicles, components, architecture and its applications.**
CO2	**Analyse the EV - government policies, automobile regulatory bodies functionalities, vehicle dynamics, transmission system.**
CO3	**Demonstrate the working of electric motor drives, sensors and the role of power electronics in EV's.**
CO4	**Analyse the communication protocols, battery management systems, charging systems and demonstrate them.**
CO5	**Model, test & troubleshoot the motors, battery packs, electric vehicle & analyze its performance parameters using the simulation software.**

Detailed course plan

Week	CO	PO	Days	1st session (9 am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	**Learning Outcomes**			**1. Introduction to E-mobility.** **2. Government policies related to EV.** **3. Exposure to the automobile regulatory bodies.**							
	1,2	1	1	<< Video Demonstration of E- Mobility>> https://youtu.be/tJfERzrG-D8 E – Mobility – Introduction, Benefits & Future Technologies. Comparison between Internal Combustion Engines (ICE) vehicles & E-Vehicles (EV).	2		2	EV's - Costs and Emissions: Electricity costs, End of Life, CO2 Emissions. Types of different pollutants produced due to IC engine vehicle (ICEV) and their effect on human health. Economic and environmental impacts of using E – Vehicles.	**1**		2
			2	Electric Vehicle – Overview (TATA, Maruthi Suzuki, KIA, TESLA, HYUNDAI, etc), Types, Indian Market Scenario. EV Terminologies & EV Manufacturers.	1		3	EV parameters: weight, size, force, energy & performance parameters. Autonomous cars: Introduction, Google Self driving car, Hacking.	**1**		2
			3	Polices in India – Incentives, PLI (Production Linked Incentive) scheme, battery swapping policy, special E-Mobility zone. Need for regulation, Regulations for EV in India.	1	1	2	Government Policies related to Energy, EV Subsidies and their role in EV adoption.	**1**		2
			4	Automobile regulatory bodies & Societies like ARAI, SAE, CMVR, etc – standards, functions and its importance.	2		2	E – Mobility: Myths, Success Factors & Challenges. The Future of Sustainable Transportation.	**1**		2
			5	Developmental Assessment				Assessment Review and corrective action			3
			6	**Industry class** - E- Mobility	2		2	Weekly Assignment(1PM-2PM)			1

2	**Learning Outcomes**			**1. Explain the different aspects of Vehicle Dynamics. 2. Identify the components of Transmission system: gear train and power train. 3. understand the concepts of regenerative braking, develop simulation models.**								
	1,2	1,4	1	Tutorial (Peer discussion on Industrial assignment)		4		Vehicle Dynamics - Introduction. Types of Vehicle Resistance – Rolling resistance, Grading resistance & Aerodynamic drag. **Practise** Develop a simulation model to analyse the effect of rolling resistance on vehicle range and performance.	1		2
			2	• Calculating the rolling resistance • Calculating the grade resistance • Calculate the Aerodynamic drag • Calculating the Acceleration Force • Calculate the maximum speed of vehicle **Practise** Develop a simulation model to analyse the effect of Aerodynamic drag on vehicle range and performance.	1		3	Transmission System. Introduction to Gear Train & Power train in EV. Explain and Demonstrate the Working principle and components of Gear Trains used in EV.	1		2
			3	EV Power train – Components, Block diagram & it's working principles. Demonstration of its integration. **Practise** Develop a simulation model to analyse the effect of vehicle Mass on vehicle range and performance.	1	1	2	Brakes for EVs: Types. Regenerative Braking – concept, working principle, advantages. **Practise** Develop a simulation model to analyse Electric motor Regenerative braking characteristics for different driving cycles.	1		2

			4	Electronic power assisted steering - Concept, components, working principle, demonstration. power windows - Concept, components, working principle, demonstration.	1		3	Tyre selection factors for EV. Demonstration & comparison of steel wheels & alloy wheels. Demonstration & comparison of tube & tubeless tyres.	1		2
			5	**Developmental Assessment**				Virtual tour on Electric and Hybrid vehicle			3
			6	**Industry Class** on vehicle dynamics.	2		2	Weekly Assignment(1PM-2PM)			1
3	**Learning outcomes**			**1. identify the configurations of battery electric vehicles.** **2. Understand the different components, working principle, performance parameters of electric vehicles.**							
	1,2,3	1,3	1	Tutorial (Peer discussion on Industrial assignment)		4		Configuration of Electric Vehicles, vehicle performance. Concept of Hybrid Electric Drive Trains.	1		2
			2	Battery Electric Vehicles (BEV) – concept, architecture, major components, working principle, performance parameters, merits and demerits with demonstration.	1		3	Hybrid-Electric Vehicles (HEV) - concept, architecture (series drive train, parallel drive train), major components, working principle, performance parameters, merits and demerits with demonstration.	1		2
			3	Plug-in hybrid vehicles (PHEV) - concept, architecture, major components, working principle, performance parameters, merits and demerits with demonstration.	1		3	Fuel cell electric vehicles (FCEV) - concept, architecture, major components, working principle, performance parameters, merits and demerit with demonstration.	1		2
			4	Compare the features of BEV, HEV, PHEV, FCEV type of vehicles Discuss on current adoption status of BEV, HEV, PHEV, FCEV type vehicles.	2		2	four-wheel drive system- concept, block diagram, benefits. Demonstration.	1		2
			5	**CIE 1 – Written and Practice Test**				Assessment Review and corrective action			3
			6	**Industry Class** on Electric & Hybrid electric Vehicles	2		2	Weekly Assignment (1PM-2PM)			1

4	**Learning Outcomes**			**1. Identify the various sensors and control systems in EV.** **2. Identification of power electronics components & their role in EV.** **3. Importance of Electronic stability control in vehicles.**									
	1,3	2,4	1	Tutorial (Peer discussion on Industrial assignment)		4		Role of sensors in electric motor systems used in EV.	1		2
			2	Importance of Power electronics in E -Vehicles - switched mode power converters, DC-DC Converters, Rectifiers & Inverters, switch controller, Solid State controllers, electronic controllers – working principle & applications. Battery Monitoring Sensors, State of the Charge Sensing, MEMS Sensors for Engine Management, Hall effect sensors.	1		3	Switching devices– diodes/IGBT's/MOSFETs, Onboard chargers/offboard chargers – working principle & applications. Sensors for Passenger Safety, Sensors for Skidding and Rollover Detection, Tire Pressure Sensors.	1		2
			3	Electronic Stability Control of Vehicles – components, demonstration. Sensors for Antitheft, Vehicle Navigation Sensors. EV sensors of Texas Instruments, STM, NXP, etc.	1		3	Traction control, Body and chassis control, Onboard/Offboard charger control, Battery Management system control, Auxiliary power system and its control.	1		2
			4	Examples of control with MATLAB/open-source Simulink Control Toolbox with explanation.	1		3	Virtual tour on sensors and controls in electric vehicles	1		2
			5	**Developmental Assessment – Poster Presentation of Battery basics and Types**				Assessment Review and corrective action			3
			6	**Industry Class** on sensors & control systems in EV.	2		2	Weekly Assignment (1PM – 2PM)			1
5	**Learning Outcomes**			**1. Exposure to the various communication protocols, architecture & applications.** **2. Using the CANalyser/CANoe software for intuitive operation for analysis and stimulation of network communication.** **3. Advanced Driver Assistance System (ADAS) – components and features.**									
	4	2,3,4	1	Tutorial (Peer discussion on Industrial assignment)		4		Communication Protocols – Need for protocols. Local Interconnect Network (LIN) – Concept, Architecture, Applications & Demonstration.	1		2

			2	Control Area Network (CAN) Protocol– concept, layered architecture, applications & demonstration. FlexRay Protocol - concept, layered architecture, applications & demonstration.	1		3	Demonstration of CANalyser/CANoe software (CAN related software), application areas – analysis, diagnostics, logging, etc.	1		2
			3	Media Oriented Systems Transport (MOST) protocol- Concept, architecture, applications & demonstration. Similarities and differences of LIN, CAN, FlexRay Protocols. AUTOSAR – concept, architecture & features.	1	1	2	Advanced Driver Assistance System (ADAS) – Concept, Architecture & Features. components - Image processing cameras, RADAR (Radio detection & ranging), LIDAR (Light detection & ranging), Ultrasonic sensors, Electromagnetic sensor. adaptive cruise control, etc.	1		2
			4	Role of an ECU, ECU software, types of MCUs: NXP, TI, Infineon – features. STM32 Microcontroller – features, programming, applications.	2		2	Demonstration of STM32CUBE IDE software with simple application programs.			3
			5	**CIE 2 – Written and Practice Test**				Assessment Review and corrective action			3
			6	**Industry Class** on communication protocols.	2		2	Weekly Assignment (1 PM-2PM)			1
6	**Learning Outcomes**			1. **Implementation of Electric drive systems & Power Trains.** 2. **BLDC motor control using Pulse width modulation. (PWM).** 3. **Simple problems to calculate speed, torque, power consumption.**							
	3	3,4	1	Tutorial (Peer discussion on Industrial assignment)		4		**Fundamentals:** General architecture and requirement of EV, load characteristics.	1		2
			2	principle of electromechanical energy conversion. motors and generator – concept, working principle, demonstration. Factors to be considered for selection of motor Types of Electric Drives: DC motors & BLDC motors – concept, components, working principle, demonstration.	1		3	BLDC motor control using Pulse width modulation. (PWM). **Practise Activity**: Perform speed control of BLDC Motors.	1		2

			3	**Practise** Modelling and simulation of BLDC motor using a open source simulation software.			4	Permanent Magnet Synchronous Motor (PMSM) - concept, components, working principle, demonstration. Switched Reluctance Motors (SRM) – concept, components, working principle, demonstration.	1		2
			4	Induction motors - concept, components, working principle, demonstration. power electronics-based control of electric motors – control strategies: types – direct torque control (DTC), Field oriented control (FOC).	2		2	Calculate speed and torque of motor Calculate Power consumption of EV Selection and sizing of Motor, Example problems.	1		2
			5	**Developmental Assessment**				Assessment Review and corrective action			3
			6	**Industry Class** on electric drives and power trains	2		2	Weekly Assignment (1PM-2PM)			1
7	**Learning Outcomes.**			1. **requirement of Energy Storage Systems & Batteries.** 2. **battery terminologies & specification parameters.** 3. **different types of batteries & its operations.**							
	4	1,2,3	1	Tutorial (Peer discussion on Industrial assignment)		4		**Fundamental:** Energy storage requirements for vehicle applications, types of energy resources, sources of energy, Storage technologies and metrics for comparison, Energy generation, supply, distribution. Introduction to battery cell, battery module, battery pack.	1		2
			2	Energy devices & combinations, Duty Cycles in Indian cities; performance, Sustainability assessment.	1		3	Theory of Ragone Plots. Ragone Plot of a Battery – example. Lead Acid Battery (PbA) – Construction,	1		2

				Battery terminologies: power density, battery efficiency, discharge rate, State of Charge (SOC), State of Health (SOH), State of Energy (SOE) State of Power (SOP), state of discharge (SOD) Depth of discharge (DOD), C -Rate, drive cycle. Battery specifications: Energy density, Specific Energy, Charge Temperature Interval, Charge/discharge inefficiency, cycle durability, Nominal cell voltage. Batteries: Range, Battery Life & Recycling, Types. Basic of Battery – How it is made and concept of batteries, Storage types.				working principles, advantages. Nickel Metal hydride (Ni-MH) battery- Construction, working principles, advantages. Explain the battery specifications of the any 2 Indian EV's. **Practise** Measure normal open circuit voltage charging voltage & current of a battery used in any vehicle.			
			3	Nickel- cadmium (Ni-Cad) battery – construction, working principles, advantages. Lithium- ion (Li-ion) Battery – construction, working principle, advantages. **Practise** Verify Ampere- hour capacity of a battery with any available load.	1	1	2	Sodium–Sulfur (Na–S) Battery - construction & working principle, advantages. Fuel Cells – construction, operation & advantages. Supercapacitors, Flywheels – features & operation.	1		2
			4	Explain Cell Charging and Discharging cycles and Discharging Curves. Calculations on Battery charging and discharging. Explain the Temperature impact on cell, Internal resistance. Video demo on fabrication and process of battery.	2		2	Evolution of batteries. Power Density and Energy Density concepts with basic calculations and examples.	1		2

			5	**CIE 3 – Written and Practice Test**				Assessment Review and corrective action			3
			6	**Industry Class** on energy storage systems and batteries.	2		2	Weekly Assignment (1 PM-2PM)			1
8	**Learning Outcomes.**			**1. Importance of Battery management systems & its functionalities.** **2. Battery pack configurations & factors affecting battery performance.** 3. **Modelling of electric vehicle batteries and battery pack by using simulation software.**							
	2,4,5	1,3,7	1	Tutorial (Peer discussion on Industrial assignment)		4		Battery Management system- components, block diagram, functionalities, importance, benefits. Explain battery management design considerations (Service life, efficiency, safety, operational parameters, etc.).	1		2
			2	Battery Pack Module: Types, procedure, Configurations, demonstration. Criteria for battery selection pack, Cost reduction of the overall battery pack for EV. **Practise** Design a battery pack rated capacity 25Ah in a simulation software with C rate calculation.	1		3	Battery working temperature – temperature list for all type of batteries. Different types of electrolytes and additives used in batteries. Factors affecting Battery Performance- electrolyte used, chemical reaction, packing of cell, high current ratings, safety, cost, aging, etc. Causes of battery explosion	1		2
			3	Modelling of Electric vehicle batteries and battery pack by using simulation software	1	1	2	Modelling of Electric vehicle batteries and battery pack by using simulation software	1		2
			4	Modelling of Electric vehicle batteries and battery pack by using simulation software	2		2	Modelling of Electric vehicle batteries and battery pack by using simulation software	1		2
			5	**Developmental Assessment**				Assessment Review and corrective action			3

			6	**Industry Class** on battery management systems	2		2	Weekly Assignment (1PM – 2PM			1
9	**Learning Outcomes.**			**1. Fabrication of batteries and battery testing methods.** **2. Importance of thermal management systems & cooling operations.** 3. **Process EV charging, components & charging station.**							
	4	1,3,7	1	Tutorial (Peer discussion on Industrial assignment).		4		Gas formation inside the battery – Reason and Solution to avoid gas formation - concept, demonstration, working principle. High current rate performance along with Stability and Recycling Importance and process.	1		2
			2	Fabrication of battery which is completely non-flammable – concept, demonstration, working principle, advantages.	1		3	Battery testing- methods, disposal and secondary use of batteries. Demonstrate the car battery testing procedure.	1		2
			3	Thermal runaway. EV Thermal Management Systems (TMS) - Need, significance. Explain Cooling of Battery Pack, Motor and Inverter, types, advantages. Explain Active and Passive Cooling. Demonstration of Thermal Management systems and it use in system level algorithms and communications.	1	1	2	EV Charger: components, types, block diagram, charging methods, charging standards.	1		2

			4	Design rating & difference between slow charger and fast charger. Charging plugs – Types with specifications. vehicle to grid technology(V2G), grid to vehicle technology(G2V), vehicle to building(V2B), vehicle to home (V2H), smart charging- concept, applications. Tesla Powerwall – concept & applications.	2		2	Wireless power transfer. EV Charging station – components, block diagram. How to make EV charging sustainable? Demonstration.	1		2
			5	**CIE 4 – Written and Practice Test**				Assessment Review and corrective action			3
			6	**Industry Class** on thermal management systems.	2		2	Weekly Assignment (1PM-2PM)			1
10	**Learning Outcomes**			1. **Types of charging protocols.** 2. **Case studies.** 3. **Hazard management & on-board diagnostics (OBD).**							
	4	1,5,7	1	Tutorial (Peer discussion on Industrial assignment)		4		Charging protocols: Open Charge Point Protocol (OCPP), Open Smart Charging Protocol (OSCP), Demonstration.	1		2
			2	Charging protocols: Open Charge Point Interface (OCPI), ISO 15118 – concept & features. Roadmap for EV testing & validation, testing & validation standards.	1		3	Vehicle Navigation Based on MEMS-types of navigation system, MEMS vehicle positioning method. Demonstration.	1		2
			3	Electric vehicle charging systems demo video/hands on. Demonstration with explanation.	1	1	2	Electrification challenges. Diagnosis and remedy	1		2

				Demonstrate Communication Interface between charger and CMS (central management system) Demonstrate communication between charger and EV.				a) for charger not responding, b) charger not delivering expected current.				
			4	Fire in EV 's - possible causes & solution – case study. (Any two) Risks of working with EV's. Protection devices against high voltages.	1		3	On –board diagnostics (OBD) – concept, usage, demonstration. List the tools and Equipment's for safety & hazard management of EV's.	1		2
			5	**Developmental Assessment**				Assessment Review and corrective action			3
			6	**Industry Class** on hazard management & diagnostics	2		2	Weekly Assignment(1PM-2PM)			1
	Learning Outcomes			**1. EMC/EMT testing standards of electric vehicles.** **2. Electronic instrumentation cluster options and messages.** **3. Troubleshooting with Measuring equipment's.**							
11	5	1,3,4,5,7	1	Tutorial (Peer discussion on Industrial assignment)		4		EMC/EMT testing standards of electric vehicles, ISO 26262 Functional safety standards In-Vehicle Communication Challenges.	1		2
			2	Explain & demonstrate the electronic instrumentation cluster for battery status, distance to empty, battery temperature, gear position indicator, tyre air pressures, cabin temperature, vehicle speed, trip information, Warning and indicator lights, display messages, GPS, fault diagnosis, fuel information, etc – features, warning signals, actions to be taken when the respective	2		2	Battery cell balancing and other Electronics circuits design in an EV.	2		1

				lights are blinking.								
			3	**EV authorized service station – visit**, to learn about the practical aspects like, ➢ Procedure followed in the service station, from entry to exit. ➢ Historical Data analysis of E-vehicles. ➢ Safety tools & practices that are followed. ➢ Common faced issues and their solutions. ➢ Importance of predictive maintenance and following the maintenance schedules. ➢ On – Board Diagnostic (OBD) generally used and their inferences. ➢ Better efficient type of E- vehicle. ➢ Location of the battery and its assembly connections. Prepare a detailed report. & demonstrate in the class.							7
			4	Measuring Equipment's: Power analyser, digital storage oscilloscope (DSO)– working principle, applications. Demonstrate/perform the testing of power electronic devices / inverters/motors drives/lighting/home appliances/power supplies/industrial machineries using power analyser & DSO.	1	1	2	Management of EV systems – general safety precautions., Vehicle modelling/Simulation tools (SIMPLEV, MARVEL V-Elph, Others: PSAT, CarSim, OSUHEVSim, Hybrid Vehicle Evaluation code (HVEC) – explore any 2 simulation tools for simulation purpose.	1		2
			5	CIE 5– Written and Practice Test				Assessment Review and corrective action				3
			6	**Industry Class** on testing standards.	2		2	Weekly Assignment (1PM-2PM)				1
12	**Learning Outcomes.**			**Performing Vehicle integration using simulation software.**								
	5	2,3,6,7	1	Tutorial (Peer discussion on Industrial assignment)		4		Modelling of E – vehicle using simulation software.				3

			2	Model the Electric Vehicle Integration by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance traveled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance.							7
			3	Model the Electric Vehicle Integration by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance traveled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance.							7
			4	Model the Electric Vehicle Integration by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance traveled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance.							7
			5	**Developmental Assessment**				Assessment Review and corrective action			3
			6	**Industry Class** on modelling of EV integration and analysis of performance parameters.			4	Weekly Assignment(1PM-2PM)			1
13				***Internship*** **a) Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work interest and develop an internship plan that clearly highlights expectations from the industry during the internship.** **b) Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.** **c)Prepare for an internship interview to highlight your interests, areas of study, career aspirations and personnel competence – including the areas of learning you expect to learn during internship**				***Project*** **a) Identification of the problem statement (from at least 3 known problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.** **b) Design and develop the project solution or methodology to be used to solve at least one of the problems identified.** **c)Prepare a project plan that will include a schedule, WBS, Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome**			40

REFERENCES:

Sl. No	Description
1	Electric Vehicle Technology Explained By James Larminie and John Lowry , Wiley Publications.
2	Electric and Hybrid Vehicles by Tom Denton. (Institute of the Motor Industry)
3	Electric power train: Energy Systems ,Power Electronics and Drives for Hybrid, Electric and fuel cell vehicles by John G Hayes , G Abas Goodarzi, Wiley Publications.
4	Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, by Sebastian, Yimin Gao , CRC Press publications.
5	Advanced Electric Drive Vehicles by Ali Emadi , CRC Press publications.
6	Lithium Batteries:: Research, Technology and Applications by Greger R. Dahlin , Nova Science publishers.
7	Fundamentals and Application of Lithium-ion Batteries in Electric Drive Vehicles by Jiuchun Jiang & Caiping Zhang , Wiley Publications.
8	S. Dhameja, "Electric Vehicle Battery Systems, Newnes", 1st edition, 2001.
9	W. Liu, "Hybrid Electric Vehicle System Modeling and Control", 2nd edition, Willey, 2017
10	K. T. Chau, "Energy Systems for Electric and Hybrid Vehicles", The Institution of Engineering and Technology, 2016
11	B. Scrosati, J. Garche and W. Tillmetz, "Advances in Battery Technologies for Electric Vehicle", Woodhead, 1st edition, 2015.
12	V. Pop, H.J. Bergveld, D. Danilov, P.P.L. Regtien, P.H.L Notten, "Battery management systems: Accurate state-of-charge indication for battery-powered applications" Springer Science & Business Media, Vol. 9. 2008.
13	https://youtu.be/ih0UyVc6sJA Electric Vehicle Simulation in Simulink | MATLAB Helper Blog
14	https://youtu.be/5ZTQE-ptxYM Modelling an Electric Vehicle using MATLAB & Simulink (Part - 1)
15	https://youtu.be/oVk9180a8Qs Modelling an Electric Vehicle using MATLAB & Simulink (Part - 2)
16	https://youtu.be/ugnRnVBs_BI Modelling an Electric Vehicle using MATLAB & Simulink (Part - 3)
17	https://youtu.be/eQX-iobIYmw Modeling Batteries Using Simulink and Simscape
18	https://youtu.be/d7L_gv344lc How to design battery pack in MATLAB Simulink With C Rate Calculation
19	https://youtu.be/rCstGDb4R3M Design BLDC Motor Speed Controller in Simulink

CIE and SEE Assessment Methodologies

CIE Assessment	Assessment Mode	Duration In hours	Max Marks
Week 3	CIE 1– Written and practice test	4	30
Week 5	CIE 2– Written and practice test	4	30
Week 7	CIE 3– Written and practice test	4	30
Week 9	CIE 4– Written and practice test	4	30
Week 11	CIE 5– Written and practice test	4	30
	On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard)		40
	Profile building for Internship / Submission of Synopsys for project work		20
Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) *			30
TOTAL CIE MARKS (A)			**240**
SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks		**3**	**60**
SEE 2 – Practical		**3**	**100**
TOTAL SEE MARKS (B)			**160**
TOTAL MARKS (A+B)			**400**

* The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

Assessment framework for CIE (1 to 5)

Note : Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours

Sample Questions For CIE-4

Programme	**Electronics & Communication Engineering**	**Semester**		**V**	
Course	**E- Mobility**	**Max Marks**		**30**	
Course Code	**20EC541**	**Duration**		**4 hours**	
Name of the course coordinator					
Note: Answer one full question from each section.					
Qn.No	**Question**	**CL L3/L4**	**CO**	**PO**	**Marks**
	Section-1 (Theory) – 10 marks				
1.a)	"The batteries take up a lot of space in the EV car". Is this statement true or false. Justify your answer. How Batteries packs are placed in EV, Explain with neat sketch.	L3	2	1,3,7	5
b)	Explain why a Li-ion battery always produces 3.6V?	L4	4	1,3,7	5
2.a)	The customer is having 3-wheeler vehicle and found 2-wheeler charger when his EVs battery voltage is less, can he use the available charge? if yes what are the factors on which the charging process depends upon.	L4	2	1,3,7	5
b)	Recently many cases have been reported regarding catching of fire among various electric vehicles across the nation. Why is this scenario taking place, which part of the E -vehicle is causing thus mishap, how can this be controlled.	L3	4	1,3,7	5
	Section-2 (Practical) - 20 marks				
3)	Modelling of Electric vehicle batteries and battery pack by using simulation software.	L4	5	1,3,7	20
4)	Design a battery pack rated capacity 25Ah in a simulation software with C rate calculation.	L3	2,4	1,3,7	20

Note : Theory questions shall be aligned to practical questions

Assessment framework for SEE 1 (Theory)

Programme	**: Electronics & Communication Engineering**		
Semester	**: V**		
Course	**: E- Mobility.**	**Max Marks**	**: 100**
Course Code	**: 20EC54I**	**Duration**	**: 3 Hrs**

Instruction to the Candidate: Answer one full question from each section.

Q.No	Question	CL	CO	Marks
	Section-1			
1.a)	There are different drive train configurations in EV, with neat sketch explain any 2 types.	L3	1	10
b)	Analyse the economic and environmental impacts of using E – Vehicles in the modern-day society. Explain the role of EV's in reducing Greenhouse effect.	L4		10
2.a)	Compare, Draw and explain the ideal traction power plant characteristics in EV and IC vehicles.	L3		10
b)	A person sees a car which is being driven without a driver. Can this be possible? what is the technology involved. Explain in detail.	L3		10
	Section-2			
3.a)	Justify how rolling resistance effect the tire road contact in EV system.	L4	2	10
b)	The high voltage battery can be recharged when the brakes are applied in an EV. How is this energy transformation taking place. Explain the technology involved.	L4		10
4.a)	An EV owner while driving the vehicle observes that suddenly the steering system has lost its power feature and is very hard to operate. Explain the causes for the failure of the system and its solution.	L3		10
b)	While driving on a wet road, the E- vehicle is not stable, it goes to left direction, it goes to right direction, it drags, it skids. Driver is confused as to what is happening and how he can control the situation. Explain the concept & control system that needs to be used in this case and help the driver to gain control of the vehicle.	L3		10
	Section- 3			
5.a)	What are the parameters to be considered while designing the drivetrain of HEVs? Explain.	L3	3	10
b)	When you're driving and the air suddenly goes from comfortably cool to horribly hot, what might be the problem and how to solve this.	L4		10
6.a)	The range of an EV Vehicle is about 250km. The owner wants to increase the range as he is going on a family trip. How the range can be extended in an E- vehicle, explain the concept involved.	L3		10

b)	Power electronics plays a very important role in EV. Do you agree? If yes list all the components and technologies involved. justify your answer.	L3		10
	Section-4			
7.a)	Can a super capacitor replace a battery? In what way it can be used in electric vehicles?	L3	4	10
b)	Why aren't the Metal air batteries are not used widely in spite of having many benefits. Analyse the possible causes.	L4		10
8.a)	What are the challenges for electrification of mobility in terms of charging infrastructure. Also discuss the load on the grid and how it has to be overcome.	L3		10
b)	In spite of hydrogen having high energy density, why hydrogen fuel cell is still not the preferred source of electric power and battery electric vehicles continue to dominate the EV market. Substantiate with statistics related to efficiencies.	L4		10
	Section-5			
9.a)	In the car, the AC has kept ON but the driver notices that no air coming from the vent, what might be the problem and how to solve it.	L4	5	10
b)	Suppose a EV car owner is going for a drive and the car switches OFF abruptly. List the possible causes and analyse the solutions.	L3		10
10.a)	The battery charging process for an EV in a charging station is taking too long. List the parameters on which the charging process depends on. How can the charging process duration be minimized.	L4		10
b)	Energy management system improves the fuel economy and optimize the performance of HEV, is this statement true? Elaborate energy management system and issues of energy management strategies of EHV	L4		10

Scheme of Evaluation for SEE 2

Sl. No	Description	Marks
Problem Statement	Model an Electric vehicle by using simulation software and analyze the EV performance parameters such as a) speed, Torque, Top speed reached, SOC. b) Vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance	100
1	Modelling using Simulation software with integration of all the components/parts of an EV.	40
2	analyzing the integration process – logical flow of design, connections, etc	20
3	troubleshooting	20
4	Output	10
5	Viva voce	10
Total		**100**

Equipment / Software List with specification for a batch of 20 students

Sl No	Equipment's	Specification	Quantity
1	MAT LAB Simulink Software	as per industry standards.	1
2	Diagnostic Software for EV's	as per industry standards.	1