Government of Karnataka
DEPARTMENT OF COLLEGIATE and TECHNICAL EDUCATION

Program	**Mechanical Engineering**	**Semester**	**5**
Course Code	**20ME54I**	**Type of Course**	**L: T:P (104:52:312)**
Specialization	**E-Mobility**	**Credits**	**24**
CIE Marks	**240**	**SEE Marks**	**160**

Introduction:

Welcome to the curriculum for the Specialization Pathway - **E-Mobility**. This specialization course is taught in Bootcamp mode. Bootcamps 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.

The automotive industry is already expanding and growing faster than before. With these advancements in place, it is evident that EV is creating ripples, redefining transportation in a new way. While these developments are fascinating, the evolving nature of the sector makes it complex with each passing day, and hence, a complete understanding of the system and in-depth exposure is necessary.

Leading to the successful completion of this bootcamp, you shall be equipped to either do an internship in an organisation 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 design or maintenance assistant and can rise up to the level of a design or maintenance engineer, also can become Entrepreneur in the related field and more

This course will teach you to manage electric vehicle complexity, optimize vehicle performance, and more by using Model-based Systems and better understand the intricate EV architecture.

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 Engineering Materials and Mechanical Workshop
2nd year-Mechanics of Materials, Machine Tool Technology, Manufacturing Process, Fluid Power Engineering, Product Design and Development, Operations Management, CNC Machines and Elements of 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 Pathway is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. Single faculty shall be the Cohort Owner.
3. This course shall be delivered in boot camp mode
4. The industry session shall be addressed by (in contact mode/online / recorded video mode) industry experts only.
5. The cohort owner shall identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for industrial visits.
7. Cohort owner shall maintain and document the industrial assignments and 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, Unacademic, SWAYAM, etc.
10. Cohort owner shall guide the cohort for the execution of mini project

Course Outcomes

After completing the course, the students will be able to:

CO-01	Demonstrate the components, architecture and technologies in electric vehicles
CO-02	Analyze the vehicle dynamics, Transmission system, suspension systems; braking system and steering systems in electric vehicles
CO-03	Analyze the use of different power electronics converters and electrical machines in electric vehicles.
CO-04	Analyze the use of different energy storage systems, charging system, their control techniques, and energy management technology for electric vehicles
CO- 05	Demonstrate the electrical systems, communication protocols and Maintenance in Electric vehicles
CO-06	Model the Electric vehicle and analyze its performance using a simulation software

Detailed course plan

Week	CO	PO	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1		1	**Introduction** • Principles and Trends of e-Mobility • e-Mobility Business Model • Impact of mobility on existing sectors • e-mobility for personal vehicles • e-mobility in public transportation • e- mobility in goods transport • Environmental impact of e-Mobility	4			• Overview on Conventional Vehicles-Components, Working Principle • Overview of EV such as Tesla, Hyundai, TATA, KIA, MG, Mahindra motors etc • Technology and Market Scenario in Indian and global perspective • Merits and demerits of Electric vehicles	3		
	2		2	**Vehicle Dynamics** • Fundamentals of Vehicle Dynamics • Vehicle resistance, Types: Rolling Resistance, gradient resistance, Aerodynamic drag • Tire- Ground Adhesion	4			• Calculating the Rolling Resistance • Calculating the gradient resistance • Calculate the Aerodynamic drag • Calculating the Acceleration Force • Calculate the maximum speed of the vehicle • Calculate the Maximum Tractive Effort and Powertrain Tractive Effort • Find the Total Tractive Force • Calculate the Torque Required on the Drive Wheel	1		**2**
	2		3	• Calculating the Rolling Resistance • Calculating the gradient resistance • Calculate the Aerodynamic drag • Calculating the Acceleration Force • Calculate the maximum speed of the vehicle • Calculate the Maximum Tractive Effort and Powertrain Tractive Effort • Calculate the Torque Required on the Drive Wheel							7

	2		4	**Suspension system** • Explain and demonstrate the working principle and components of Double Wishbone suspension • Explain and demonstrate the working principle and components of Trailing twist axle suspension • Explain and demonstrate the working principle and components of Macpherson Srut suspension • Explain and demonstrate the working principle and components of electronic adjustable-rate shock absorbers	2		2	**Transmission system** Explain and Demonstrate the Working principle and components of Power transmission system used in EV **Chassis System** • Explain and demonstrate the different Chassis systems in EV	1		2
			5	Weekly developmental Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on vehicle dynamics + Industry Assignment			5				
2	2		1	Tutorial (Peer discussion on Industrial assignment)		4		**Tires and Wheels** • Designation of tires • Explain JATMA, ETRTO standards, • Tire selection considerations for EV • Compare Diagonal vs Radial tires • Compare Tubed vs Tubeless tires	3		
	2		2	**Steering Systems** • Explain the importance of steering geometry (Caster, Camber, Kingpin inclination, Toe-in, Toe-out) • Explain and demonstrate the working principle and	2		2	**Braking System** • Explain and demonstrate the working principle and components of disc and drum brakes. • Explain and demonstrate the working principle and components of hydraulic brakes	2		**1**

				components of electronic power assisted steering				• Calculate Braking Performance and Distribution braking Force				
	2		3	• Explain and demonstrate the working principle and components of Electric brakes • Explain and demonstrate the working principle and components of Electro hydraulic braking (EHB) • Explain and demonstrate the working principle and components of Electronic Parking Brake (EPB)	2		2	• Explain and demonstrate the working principle and components ABS brake system • Explain and Demonstrate Wheel speed sensors, ABS with Electronic Brake force Distribution (EBD) control unit • Explain and Demonstrate Electronic Stability Control (ESC) • Explain and Demonstration on warning & safety device	2		1
	1		4	**Architecture of EV** • Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of all Electric Battery Electric Vehicles (BEV)	2		2	• Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of Hybrid-Electric Vehicles (HEV)	2		1
			5	Weekly developmental Assessment				Assessment Review and corrective action			3	
			6	Industry Class on Steering geometry, transmission system and ABS + Industry Assignment			5					

Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
3	1		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of Plug-in hybrid vehicles (PHEV)	1		2

	1		2	• Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of Fuel cell electric vehicles (FCEV)	2		**2**	• Compare the features of BEV, HEV, PHEV, FCEV type of vehicles • Discuss on current adoption status of BEV, HEV, PHEV, FCEV type vehicles	**3**		
	3		3	**Electric Machines and Drives** • Explain and demonstrate the working principles and components of DC Motor and Brushless DC motors (BLDC)	2		**2**	• Explain and demonstrate the working principles and components of Induction motors	1		**2**
	3		4	• Explain and demonstrate the Working principle and components of Permanent magnet synchronous motor (PMSM)	2		**2**	• Explain and demonstrate the Working principle and components of Switched Reluctance Motor (SRM)	1		2
			5	CIE 1– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on architecture of EV + Industry Assignment			**5**				
4	3		1	Tutorial (Peer discussion on Industrial assignment)		4		• Calculate speed and Torque of motor • Calculate Power consumption of EV • Selection and sizing of Motor			**4**
	3		2	• Calculate speed and Torque of motor • Calculate Power consumption of EV • Selection and sizing of Motor							**7**
	3		3	• Discuss the merits and demerits of DC motors, BLDC motors, Induction motors, PMSM motors and SRM motors • Discuss the type of Electric drives used in EV such as Tesla, Hyundai, TATA, KIA, MG, Mahindra motors	4			• Explain the Principle of Regenerative Braking • Explain the Regenerative Brake cooperative control operation. Riding Modes -Sport and Comfort, Driver Behaviour, Economy mode	**3**		

				etc with their specifications from company catalogue								
	3		4	**Control Unit and Control Strategies** • Explain and Demonstrate DC-DC Converters • Explain and Demonstrate DC-AC Converters • Explain and Demonstrate AC-DC Converters • Explain Switch Controller • Explain Solid-State Controller • Explain Electronic Controllers	4			• Explain and Demonstrate AC Controllers • Explain and Demonstrate DC Motor Controller- The Lesson of the Jones Switch • Explain Off-the-Shelf Curtis PWM DC Motor Controller			**3**
			5	Weekly developmental Assessment				Assessment Review and corrective action				**3**
			6	Industry Class on electric drives and their control strategies + Industry Assignment			5					**3**
5	3		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain Zilla Controller • Explain ZAPI Control Strategies • Explain Max. SOC-of-PPS Control Strategy (SOC- State of Charge; PPS- Peak power source)	3			
	3,6		2	Modelling of Electric machines and controllers by using simulation software								7
	3,6		3	Modelling of Electric machines and controllers by using simulation software								**7**
	3,6		4	Modelling of Electric machines and controllers by using simulation software								**7**
			5	CIE 2 – Written and practice test				Assessment Review and corrective action				3
			6	Industry Class on modelling of electric drives and controllers + Industry Assignment			5					
6	4		1	Tutorial (Peer discussion on Industrial assignment)		4		**Energy Storage Solutions (ESS)** • Explain Battery capacity, 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	2		**1**

								• Explain Thermodynamic Voltage, Specific Energy, Specific Power, Energy Efficiency			
	4		2	Classification of Batteries ➢ Primary ➢ Secondary • Li –ion • Na- ion • Mg –ion • K-ion Geometry of Batteries ➢ Coin Cell ➢ Cylindrical Cell ➢ Stack Cell ➢ Pouch Cell Chemistry behind Batteries Battery Materials- Anode, Cathode, Electrolyte, Separator Explain the working principle, of Lead Acid and Lithium-ion (Li-ion) batteries used in electric vehicle	4			• Future developments in Batteries- Na- ion, Mg –ion K-ion, Li air • Discuss Corrosion of Battery Terminals • Discuss Lithium-Ion Batteries Aging Effects • Discuss on Selection and sizing of cells and Handling of Cells • Explain working principle of Ultra capacitors and its features	3		
	4		3	• Explain Cell Charging and Discharging cycles and Discharging Curves • Ragone plot for Batteries • Calculations on Battery charging and discharging • Explain the Temperature impact on cell, Internal resistance • Study the Lifecycle of batteries • Discuss Battery Fabrication Process	4			**Battery Module and Pack Development** • Demonstrate the Battery Pack Module Construction, Configurations, Types and Energy Concepts • Demonstrate the Voltage, Current and Temperature Measurement • Discuss the Battery pack selection criteria	1		2
	4		4	**Battery Management System (BMS)** • Discuss the Need of BMS	4			**EV Thermal Management** • Explain Cooling of Battery Pack, Motor and Inverter	3		

				• Explain L9963 battery management device • Explain the Voltage, Current and Temperature Monitoring, • Demonstrate various sensors installed on BMS • Explain Battery management design considerations (Service life, efficiency, safety, operational parameters) • Discuss Cell Balancing - Types, Active, Passive, SoC Determination, SoC Algorithms				• Explain Active and Passive Cooling • Explain Fluid Based Cooling, Ethylene Glycol, • Explain Forced Air Cooling, Cabin Air Based Cooling			
			5	Weekly developmental Assessment				Assessment Review and corrective action			3
			6	Industry Class on Battery technology and BMS + Industry Assignment			5				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
7	4,6		1	Tutorial (Peer discussion on Industrial assignment)		4		• Modeling of Electric vehicle batteries and battery pack by using simulation software			3
	4,6		2	• Modeling of Electric vehicle batteries and battery pack by using simulation software							7
	4,6		3	• Modeling of Electric vehicle batteries and battery pack by using simulation software							7
	4,6		4	• Modeling of Electric vehicle batteries and battery pack by using simulation software							7
			5	CIE 3– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on modeling of EV batteries + Industry Assignment			5				

8	4		1	Tutorial (Peer discussion on Industrial assignment)		4		**Electric Vehicles charging station** • Explain and Demonstrate the Electric Vehicle charging Technology and Charging Equipment's • Draw Basic charging Block Diagram of Charger • Differentiate Slow charger, fast charger and Rapid charger • Explain Slow charger design rating • Explain Fast charger design rating	2		1
	4		2	• Demonstrate AC charging and DC charging methods • Demonstrate Inboard and off board charging methods and specification • Demonstrate Modes of charger-Mode -2, Mode-3 and Mode-4 • Perform EVSE (Electric Vehicle supply Equipment) associated charge time Calculation.			4	**Selection and sizing of fast and slow Charger** • Demonstrate AC Pile Charger • Demonstrate DC Pile Charger • Demonstrate EVSE Power Module selection and technical specification			3
	4		3	• Demonstrate Specification of open charge point protocol (OCCP 1.6/2.0) • Demonstrate Bharat DC001 & AC001 Charger specification • Demonstrate Communication Interface between charger and CMS (central management system)			4	**Selection and sizing of Common types of connectors and applications** • Demonstrate Selection of AC charger type-1, type -2 and type -3 • Demonstrate Communication between charging station and EV			3
	4		4	• Demonstrate Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2 • Demonstrate Communication methodology of DC fast chargers			4	• Demonstrate IS/ IEC/ARAI/ standard of Charging topology, Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2)			3

				• Sizing of Charger connector cable								
			5	Weekly developmental Assessment				Assessment Review and corrective action				3
			6	Industry Class on EV chargers and charging stations + Industry Assignment			5					
9	5		1	Tutorial (Peer discussion on Industrial assignment)				**Trace and Test all Electrical & Electronic components & circuits** • Demonstrate the EV electrical architecture, power supply systems by using service manual				3
	5		2	• Identify the electrical and electronics components in a vehicle • Explain and Demonstrate the Wiring Harness Design, Harness Topology.	2		2	• Hands on removing and fitting basic electrical and electronic components				3
	5		3	**Trace the wiring circuit of lighting system in an EV** • Explain and Demonstrate Headlight & dimmer circuits, Park & taillight circuits, Brake light circuits, turn signal circuit, Cornering lights, Fog lights circuit, interior lights courtesy, reading and instrument panel lights, Smart lighting, Reverse lights circuits	2		2	**HVAC** • Explain and demonstrate the working principle and components of HVAC in EV • Climate Control System in EV				3
	5		4	**Vehicle and Occupants Safety** • Explain and demonstrate the types of safety systems and their functions and applications. - Seat Belt, Child Restraint System (CRS), Air Bag - Supplemental Restraint System (SRS), Cruise Control, Central Lock System			4	**Instrument Cluster** • Explain and demonstrate the electronic instrumentation cluster for battery status, distance to empty, battery temperature, gear position indicator, tire air pressures, cabin temperature, vehicle speed, trip information,				3

				(CTL), Parking electronic System (PTS), power windows, Smart key				Warning and indicator lights, display messages, GPS, fault diagnosis etc			
			5	CIE 4– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on electronic vehicle management system + Industry Assignment			5				
10	5		1	Tutorial (Peer discussion on Industrial assignment)				**Communication protocols** • Explain and Demonstrate the Application of Automotive bus system-CAN (Control Area Network)	3		
	5		2	• Explain and Demonstrate the Application of Automotive bus system- LIN (Local Interconnect Network)	4			• Explain and Demonstrate the Application of Automotive bus system- FlexRay™ and MOST (Media Oriented Systems Transport).	3		
	5		3	**Vehicle Telematics** • Explain Integrated communications, Global positioning satellites, Triangulation/ trilateration, Telematics	4			• Explain Integrated communications, Global positioning satellites, Triangulation/ trilateration, Telematics	3		
	5		4	**Advancement in EV technology** • Explain the Advanced Driver Assist vehicle system architecture (ADAS) • Explain the ADAS system components- LIDAR, AI cameras, collision detection, object detection, Adaptive Cruise Control,	4			• Intelligent Speed Adaptation, Driver Monitoring System, Drowsy Driver Warning, Driver Fatigue Warning, Blind Spot Detection, Lane Keeping Assist, Lane Departure Warning, etc	3		

			5	Weekly developmental Assessment				Assessment Review and corrective action				3
			6	Industry Class on EV communication protocol + Industry Assignment			5					
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**	
11	6		1	Tutorial (Peer discussion on Industrial assignment)		4		Model the Electric vehicle by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance travelled, 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				3
	6		2	Model the Electric vehicle 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
	6		3	Model the Electric vehicle 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
	6		4	Model the Electric vehicle by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance travelled, 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	CIE 5– Written and practice test				Assessment Review and corrective action				3
			6	Industry Class on modeling of EV + Industry Assignment			5					
12	5		1	Tutorial (Peer discussion on Industrial assignment)				Precaution to be taken care while handling the electric vehicle. • Things to know while handling EVs	2			1

								• Importance of Practicing Battery Safety for Electric Vehicles			
	5		2	Safety of e- vehicle batteries- • Electric system safety - Protection against electric shocks, Protection against direct contact, Protection against indirect contact • Functional system safety - System activation warning, Power on procedure, driving backwards: Prevention of fierce reverse braking, Emergency disconnect device, Fail-safe operation- Power surge prevention, Fail-safe operation - Frame faults, Fail-safe operation - Electromagnetic compatibility, The auxiliary network, • Battery charging safety- electrical aspect, mechanical aspect, chemical aspect, explosion hazard	2		2	Maintenance in EV • First-line maintenance: by the user • Second-line maintenance: in the Authorised service centre. • Maintenance for safe operation	1		2
	5		3	Visit an EV authorized service station and observe the following • Observe the Safety Precaution practices followed while handling EV's • Study the job card and case history of the vehicles • Study the owner's instruction manual for periodic maintenance • Interact with the Service execute while Vehicle Inspection form is recorded • Observe the use of Diagnostics software • Observe the Periodic maintenance and repair performed on EV's							7
	5		4	Visit an EV authorized service station and observe the following • Observe the Safety Precaution practices followed while handling EV's • Study the job card and case history of the vehicles • Study the owner's instruction manual for periodic maintenance • Interact with the Service execute while Vehicle Inspection form is recorded							7

				• Observe the use of Diagnostics software • Observe the Periodic maintenance and repair performed on EV's								
			5	Weekly developmental Assessment				Assessment Review and corrective action				3
			6	Industry Class on modeling of EV + Industry Assignment			5					
13			1	**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** **Internship/Project Total = 40Hrs** **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.**			

References:

1. Iqbal Husain, Electric and Hybrid Vehicles –Design Fundamentals, CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Celll vehicles-Fundamentals - Theory and Design", CRC Press
3. Energy Storage by Robert A. Huggins, Springer Publication
4. Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.
5. Energy storage (A new approach) by Ralph Zito Wiley Publication
6. Energy Management Handbook, Wayne C. Turner, The Fairmont Press Inc., 5th Edition,Georgia
7. Energy Storage Systems, Alfred Rufer, CRC Press
8. Chang Liang Xia,"Permanent Magnet Brushless Dc Motor Drives and Controls" Wiley 2012.
9. Bimal K Bose, " Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003
10. Miller. T. J. E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989
11. Kenjo. T and Nagamori. S, "Permanent Magnet and Brushless DC Motors", Clarendon Press, Oxford, 1989.
12. Robert .L.Boylsted,and Louis Nashelsky, "Electronic Devices and Circuit Theory", Pearson Education,9th edition,2009
13. David A Bell, "Fundamentals of Electronic Devices and Circuits", Oxford University Press, 2009.
14. Albert D Halfride & William D Cooper, "Modern Electronic instrumentation and Measurement techniques", Prentice Hall of India Pvt Ltd., 2007.
15. Rajendra Prasad, "Electrical Measurements & Measuring instruments", C Publishers, 4th Edition, 2004

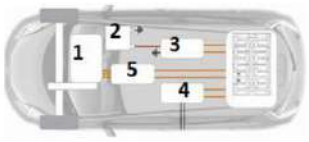
CIE and SEE Assessment Methodologies

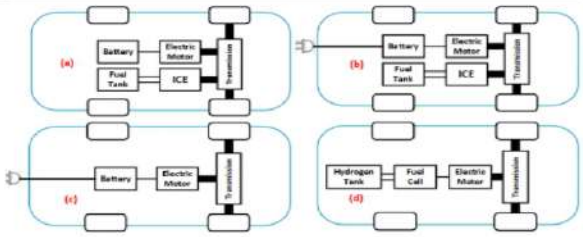
CIE Assessment	Assessment Mode	Duration In hours	Max Marks
Week 3	CIE 1– Written and practice test	4	30
Week 5	CIE 2– Written and practice test	4	30
Week 7	CIE 3– Written and practice test	4	30
Week 9	CIE 4– Written and practice test	4	30
Week 11	CIE 5– Written and practice test	4	30
	On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard)		40
	Submission of Profile building for Internship / 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)
CIE 1 - Model question paper

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

Programme	**Mechanical Engineering**	**Semester**	**V**		
Course	**E- Mobility**	**Max Marks**	**30**		
Course Code	**20ME54I**	**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 Architecture of an Electric Vehicle is as shown in the Diagram. Identify the different components? 	L3	01		02
b)	Electric vehicle is now becoming a need of the current era, to meet the environmental target of zero emission. EV's must be sustainable for society and that will be achieved by the Electric vehicle architecture. Vehicle architecture needs to be flexible so that they can adopt drivetrain electrification. Illustrate how the Architecture of battery electric vehicle is different from Conventional Vehicle?	L4	01		08
2.a)	Identify the types of Electric Vehicles shown in (a), (b), (c), (d).	L3	01		03

					
b)	Development and evolution of the electric vehicles have undergone a great growth, especially in the last 5 years. Technological developments are providing enhanced solutions for EV. What are the technological developments that have surfaced in EV's? Discuss with Illustration	L4	01		07
	Section-2 (Practice) - 20 marks				
3)	Demonstrate the Working principle and components of BLDC motor used in EV	L4	03		20
4)	Demonstrate the working principles and components of Induction motor used in EV	L4	03		20

Note : Theory questions shall be aligned to practical questions

Scheme of Evaluation for Practical question- Section 2

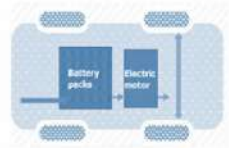
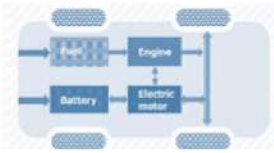
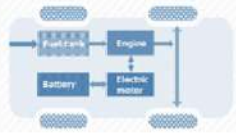
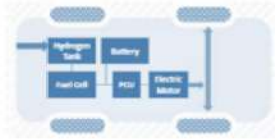
Sl. No	Description	Marks: 20
1	Identify the components of BLDC motor/Induction motor	05
2	Functions of each component	05
3	Working of the BLDC motor /Induction Motor	07
4	Suggest any innovating changes that can be incorporated	03

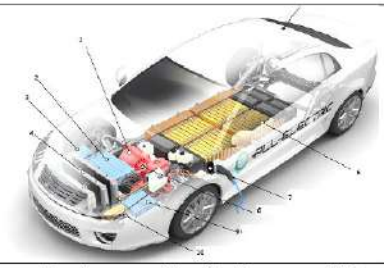
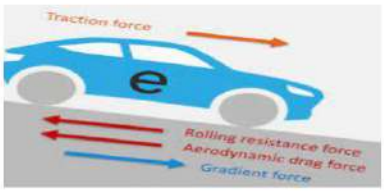
		Total	**20**

Assessment framework for SEE 1 (Theory)

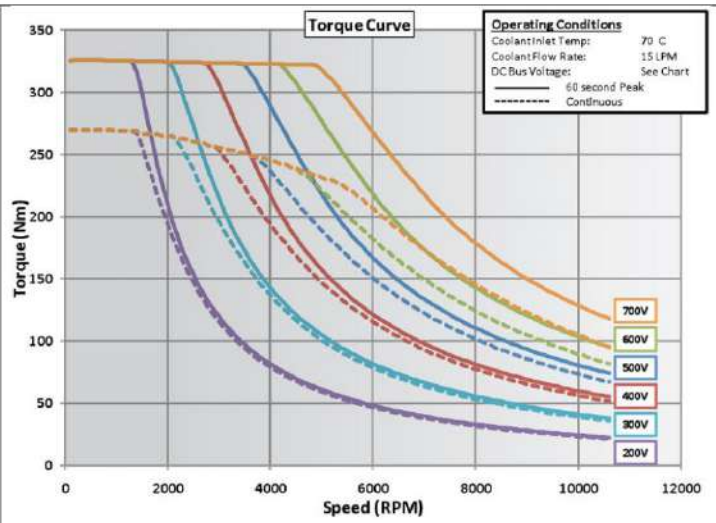
Programme	:	**Mechanical Engineering**	**Semester**	:	**V**
Course	:	**E- Mobility**	**Max Marks**	:	**100**
Course Code	:	**20ME541**	**Duration**	:	**3 Hrs**

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

Q.No	Question	CL (L3/L4)	CO	Marks
	Section-1			
1.a)	 (a)  (c)  (b)  (e) The above sketches represent different types of Electric vehicles. Identify them and prepare a comparison statement on different types of EV's. Suggest the best EV which will provide Zero emission.	L3	1	10

b)	It is debatable whether hydrogen EVs will dethrone battery-electric vehicles as the cars of the future, but it is an interesting technology with wide-ranging potential. In what way is the architecture of fuel cell electric vehicle (FCEV) different from Battery Electric vehicle.? Illustrate the working of FCEV.		L4		
2.a)		Identify the different components of an electric car: What is the role played by these components in EV?	L3		10
b)	According to a report by the European Union, the transport sector is responsible for nearly 28% of the total carbon dioxide (CO2) emissions, while the road transport is accountable for over 70% of the transport sector emissions. Therefore, the authorities of most developed countries are encouraging the use of Electric Vehicles (EVs). Do you think electric vehicles will provide solution to this problem? How do these electric vehicles work when compare to conventional vehicles		L4		10
	Section-2				
3.a)	Analyse the diagram shown. How are these forces determined? What are the effects of these forces on Vehicle movement? How does power and torque overcome these resistances? 		L3	2	10

b)	When selecting drive wheel motors for e- vehicles, several factors must be considered to determine the maximum torque required. The following example presents vehicle design criteria: ▪ Gross vehicle weight (GVW): 35 lb ▪ Weight on each drive wheel (WW): 10 lb ▪ Radius of wheel/tire (Rw): 4 in ▪ Desired top speed (Vmax): 1.5 ft/sec ▪ Desired acceleration time (ta): 1 sec ▪ Maximum incline angle (α): 2 degrees ▪ Worst working surface: concrete (good) Choose the motors capable of producing enough torque to propel the above example vehicle, by considering the total tractive effort (TTE) requirement for the vehicle	L4		10
4.a)	How Power gets transmitted from Motor to wheels in Electric vehicles? Illustrate the working of the transmission system used electric vehicles.	L3		10
b)	The main objective of a vehicle suspension system is to reduce the discomfort sensed by passengers which arises from road roughness and to increase the ride handling associated with the pitching and rolling movements. Different suspension systems are available. Compare these suspension systems provided in EV's? Which transmission system do you think is more effective and why?	L4		10
	Section- 3			
5.a)	A company is interested in converting the Internal Combustion Engine Vehicle to EV? They are in a dilemma of selecting a right type of electric motor. Compare different electric motors used in EV. From your comparison, Suggest a best Electric motor with justification	L4	3	10
b)	Conventional vehicle is propelled by a combustion engine that can only be fuelled by gasoline. This technology is well-established, and reliable, but consumes large amounts of gasoline—which can be costly in many ways. Also, releases large amount of exhaust gases. Which component in electric vehicle helps in overcoming this problem? Analyse the working of this component in electric cars?	L4		10

6.a)	 The Torque and Speed characteristics of an electric motor is shown in the figure, interpret the graph and analyse how it is suitable for e -vehicles	L4		10
b)	The motor control solution consists of the communication, diagnostics, and features like regenerative breaking and power management capabilities. Analyse how the motor controller in EV controls the electric motors such as BLDC, induction motors, PMSM and Reluctance motors as per the requirements of a drive cycle.	L4		10
	Section-4			
7.a)	The lithium-ion battery has established itself as the technology of reference in the world of electric cars. Compare the working principle of this battery with a lead acid battery with respect to material used for anode, cathode, electrolyte, and separator	L4	4	10
b)	"Lithium-ion batteries are preferred in EV due to their high energy per unit mass compared to other batteries. They also have the advantages of a high power-to-weight ratio, energy	L4		10

	efficiency, high-temperature performance, and low self-discharge. Present an argument to support this statement			
8.a)	The performance of an EV mainly depends on the health of a battery. Presently researchers are focusing on safety and enhanced performance of the battery. But one of the major issues is the corrosion of the battery terminals. What may be the reason for this? How can battery terminal corrosion be prevented?	L4		10
b)	Battery management systems (BMS) is used in electric vehicle to monitor health of the batteries which makes the operation more economical. Battery management system keeps the battery safe, reliable and increases the senility without entering damaging state. Analyse how BMS will maintain the state of the battery, voltage, current, ambient temperature in safe range	L4		10
	Section-5			
9.a)	Assuming you are executing the project of installing the e vehicle charging stations in a metro city having considerable e vehicle density. Discuss the fundamentals you need to consider before installing EV charging stations?	L3	5	10
b)	Draw Basic charging Block Diagram of Charger and discuss the salient features of Slow charger, fast charger, and Rapid charger	L3		10
10.a)	In the old days, automotive systems were concentrated on a few nodes. Now, they're continuously evolving. 45 to 70 or 80 subsystems can exist in a car carrying out multiple functionalities. Communication between all these subsystems (for example ADAs, or telematics units) is essential for the overall implementation of the vehicle's features. Right from vehicle start-up till the driver leaves the car, all the subsystems continuously transmit their status to, as well as receive data from, other subsystems necessary to perform a task. In view of the above developments in EV technology, discuss the most widely used communication protocols in EV	L3		10
b)	Charge point operators and e-mobility service providers are facing challenges expanding internationally especially in dealing with different protocols, regulations, and multi-currencies, and integrating roaming capabilities into their networks. Provide an overview on EV Charging Industry Protocols so that right protocols are selected and adopted?	L3		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, distance travelled b) Current, voltage for different drive cycles c) Vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance	**100**
1	Modelling an EV on Simulation software	40
2	Analyze EV performance parameters and write inference	25
3	Analyze Impact of vehicle dynamics on EV performance and write inference	25
4	Innovative changes in the Model	10
Total		**100**