ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 15
(Syllabi for Electrical and Electronics Engineering & Electric Vehicle Technology Programme Courses)

(Revised on August 2024)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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Regulations 2021

Volume – 15B
(Syllabi for Electric Vehicle Technology Programme Courses)

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Core Course

Regulations 2021

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
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(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EVC201J	Course Name	ELECTROMECHANICAL ENERGY CONVERSION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the basic skills required to understand, develop, and solve various engineering problems in electrostatics, magnetostatics and their applications.*
CLR-2:	*emphasis on the electromagnetic wave concepts for obtaining solution to problems real time applications*
CLR-3:	*analyze the performance of DC machines and transformer at various operating conditions*
CLR-4:	*comprehend the operation and performance of induction and synchronous machines*
CLR-5:	*acquaint with a deep knowledge of PMSM and BLDC*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*solve potential problems within electrostatics field and Magnetostatics in real time scenario*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*familiarize the fundamental of Electromagnetic fields and its applications*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*acquire deep knowledge on performance of DC machine and transformer*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*implement induction and synchronous machines for various operating condition*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*technically analyze and solve the practical challenges in implementing special machines for different applications*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Electrostatic and Magnetostatics	***12 Hour***
Sources and effects of electromagnetic fields, Coordinate Systems- Gradient, Divergence, Curl, Stokes and Divergence theorem, Coulombs Law - Electric field in free space, conductors, dielectrics, Boundary conditions, Poisson's and Laplace's equations in electrostatic field. Magnetic field intensity, Magnetization - Poisson's equations of Magnetic Field - Static and Dynamic Magnetic field, Energy Stored and Energy Density in a Static Electric and magnetic Field. Finite element method (FEM) for magnetostatic field. Laboratory Practice: Finite element analysis of magnetic circuits and Design of Magnetic field in Conductors.	
Unit-2 - Electromagnetic Field	***12 Hour***
Faraday's law of Electromagnetic induction, transformer EMF, Displacement current, conduction current, Maxwell's equation, Applications of Poynting theorem Electromagnetic wave generation and Helmholtz's equations. Wave parameters- velocity, intrinsic impedance- propagation constants, skin effect, Skin depth- Plane wave reflection and refraction, incidence of plane wave at the boundary between two region- Software tools usage for 3D electromagnetic field simulations. Laboratory Practice: Simulation of 3D Electromagnetic Field	
Unit-3 - Transformers and DC Machines	***12 Hour***
Single and three phase transformers construction-operating principle - Transformer on No load and Load – Equivalent circuit –- Three phase transformer connections - Parallel operation of single phase and three phase transformers - Auto transformer. DC Generators, DC Motor: Construction, working principle and Types, characteristics-. Motors starting methods and speed control of DC motors – Plugging, dynamic and regenerative braking- testing of DC machine and efficiency calculation. Output Equation of DC machines - Choice of Specific Electric Loading and Specific Magnetic Loading, Separation of D and L	

Laboratory Practice: Speed control of DC motor, load test on DC motor and transformer, Harmonics and switching transients in transformers, effect of transformer connections, inrush current
Unit-4 - AC Machines ***12 Hour***
Three phase induction motors: Torque slip characteristics - Equivalent circuit – Generating mode, Electric Braking mode – Cogging & Crawling -Starting– Speed control – Slip power recovery scheme. Synchronous Generator-EMF equation - armature reaction – Synchronous reactance-Synchronous motor- Torque and power relations – Starting methods – V curves and inverted V curves – Hunting and suppression methods
Laboratory Practice: No load, blocked rotor tests for determining equivalent circuit and circle diagram and load test of induction motors, Determination of Xd and Xq of salient pole machine, Determination of 'V' and inverted 'V' curves in synchronous motor
Unit-5 - Special Machines ***12 Hour***
Permanent Magnet Synchronous Motor: Construction, Working Principle, and Types - Power Equivalence – Electrometric Torque – Steady State Torque Characteristics -Behaviour Modelling of Flux Linkage. BLDC: Construction, working principle, and Types - Power Equivalence – Electrometric Torque, Switched Reluctance Motor (SRM): Construction, working principle, and Types - Power Equivalence – Electrometric Torque. Ingress Protection (IP) Ratings of motor - motor insulation class – Mounting types in EV motors – Thermal Consideration - Cooling methods for electric motors.
Laboratory Practice: Mathematical modelling software simulation of PMSM, Performance test on BLDC Motor

Learning Resources	1. *Matthew N.O. Sadiku, "Principles of Electromagnetics", Oxford University Press Inc, sixth edition, 2015.* 2. *William H. Hayt, Jr, John A. Buck, Akhtar, "Engineering Electromagnetics", McGraw Hill Education, nineth edition, 2019.* 3. *Kraus and Fleish, "Electromagnetics with Applications", Edition McGraw Hill International Editions, fifth edition, 2017.* 4. *D.P. Kothari, I.J. Nagrath "Electric Machines", McGraw Hill Education, fifth edition, 2017.*	5. *P.C. Sen "Principles of Electric Machines and Power Electronics", John Wiley & Sons, third Edition, 2013.* 6. *Vincent Del Toro, "Basic Electric Machines", Pearson India Education, first edition, 2016.* 7. *Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw Hill Education Pvt. Ltd, fourth edition, 2010.* 8. *Shaahin Filizadeh, "Electric Motors and Drives: Principles, Control, Modeling and Simulation", first edition, CRC Press, 2017.* 9. *K. T. Chau, "Electric Vehicle Machines and Drives: Design, Analysis and Application", Wiley-IEEE Press, first edition, 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Chandrasekhar Konda , Abhinava Rizel Pvt.lt, India	*1. Dr. Arun Kumar Verma, IIT Jammu, India*	*1. Dr.R.Rajarajeswari, SRMIST*
2. Mr.Sandeep, Altair	*2. Dr. B. Chitti Babu, IIITDM Kancheepuram, India*	*2. Dr. Phani Teja Bankupalli, SRMIST*

Course Code	21EVC202J	Course Name	ANALOG AND DIGITAL ELECTRONICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*21EES101T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on various amplifier, oscillator and regulator circuits*
CLR-2:	*correlate different integrated circuits for various applications*
CLR-3:	*design combinational and sequential circuits*
CLR-4:	*understand different programmable logic family and VHDL programming*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the applications of amplifier, oscillator and regulator circuits*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-2:	*analysis different integrated circuit using OPAMP*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-3:	*implement the combinational and sequential circuits using digital IC*	*3*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-4:	*deduce programmable logic to digital circuits and develop VHDL programs*	*3*	*3*	*2*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*

Unit-1 - Transistor and its Applications	***15 Hour***
Transistor configurations, JFET, MOSFET amplifier, Class A, B and C amplifiers, Isolation Amplifiers, Feedback amplifiers, Oscillators – RC, LC, Crystal oscillators, Voltage regulator – series, switching, UPS, SMPS. Laboratory Practice: FET characteristics, oscillator, voltage regulator.	
Unit-2 - Operational Amplifier	***15 Hour***
Op-Amp basics Applications: Adder, Subtractor, Comparator, Schmitt trigger, Integrator, Differentiator, Instrumentation amplifier, 555 timer – Monostable, Astable Multivibrator, 723 regulator, Filter – Types – Analysis of LPF, HPF, BPF, DAC – R – 2R ladder, ADC – Counter, Successive approximation. Laboratory Practice: Applications of op-amp, 555 timer applications, ADC, DAC.	
Unit-3 - Combinational Circuits	***15 Hour***
K-map - Quine Mckluskey – Adders – Subtractors - Binary adder - BCD adder - Magnitude Comparator – Multiplexers – Demultiplexers - Code converters – Encoders - Parity generator *Laboratory Practice: Design and implementation of code converters, Adders, subtractors, BCD adder, Realization of Boolean expression using MUX*	
Unit-4 - Sequential Circuits	***15 Hour***
Concept of Sequential circuits - Flip flops and types - shift registers - controlled shift registers - ring counter – Counters: asynchronous Counters, synchronous counter, up - down counter, twisted ring counters, Mod counters - Design and analysis of synchronous sequential circuits. Laboratory Practice: Design and implementation of 3-bit synchronous up/down counter - Shift register - Counters	
Unit-5 - Programmable Logic Circuits	***15 Hour***
Characteristics of Digital logic families, Programmable logic devices: PROM, PLA, PAL, Design using PLA, PAL field programmable gate arrays – TTL – PMOS – NMOS - CMOS and ECL - open collector and tristate gates, Introduction of FPGA, VHDL – Introduction to VHDL programming - VHDL design flow: Structural, Behavioural and Data flow Modelling - Simple programmes. *Laboratory Practice: Verification of Combinational logic circuits using FPGA , Simulation using VHDL: CMOS Inverter, NAND and NOR, Implementation of Adder and Subtractor using VHDL program*	

Learning Resources	*1.Jacob Millman, Christos C.Halkias, SatyabrataJit, Millman's, "Electronic Devices and Circuits", Tata McGraw Hill, fourth edition, 2015.* *2.Boylestead, Nashelsky, "Electronic Devices and Circuit Theory", Pearson, eleventh edition, 2015.* *3.David A. Bell, "Electronic Devices and Circuits", Prentice Hall, fifth edition, 2004.*	*4. Roy Choudhary and Shail Jain, "Linear Integrated Circuits", New Age International Publishers, fourth edition, 2014* *5. M. Morris Mano, Michael D. Ciletti, "Digital Design: With an Introduction to Verilog HDL, VHDL and System Verilog", Pearson, sixth edition, 2018,* *6. Thomas L.Floyd, "Digital Fundamentals", Pearson India, eleventh edition, 2014.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Srinivasan Vijayaraghavan, Altair	*1. Dr. Udayakumar. Anna University*	*1. Dr.Uthra.R, SRMIST*
2. Sandeep, Matlab	*2. Dr. Pradyumn Chaturvedi, VNIT Nagpur, India*	*2. Dr.V.Pradeep, SRMIST,*

Course Code	21EVC203T	Course Name	VEHICULAR SENSOR ACTUATORS AND CONTROLS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental theory of sensor and actuator in electric vehicle*
CLR-2:	*acquire knowledge about various sensors used for electric vehicle battery charge control*
CLR-3:	*gain knowledge about the various actuators used for different functions in electric vehicles*
CLR-4:	*understand the various controllers used in electric vehicle applications*
CLR-5:	*understand the concept of controllers in electric vehicle*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the knowledge of functions of sensors used in electric vehicle applications*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*apply the different sensors used in electric vehicle battery charge control*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*2*	-
CO-3:	*analyze the different actuators involvement in electric vehicle applications*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*explore the various control techniques used in electric vehicle applications*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*interpret and implement the integrated sensors actuators and controllers for electric vehicle applications*	*3*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction to Electric Vehicle and Vehicular Sensors	***9 Hour***
Overview of Electric Vehicle, Types of Electric Vehicles, Major Components in Electric Vehicle, Automotive Sensors and Actuator: Types and classifications of sensors and actuators in vehicles, Role of Sensors and Actuators in Vehicle Control Systems, Integration of sensors and actuators in automotive control, Importance in safety, efficiency, and performance. Overview on Signal Processing for Vehicular Sensors, Analog and digital signal processing for sensor data, Filtering, conditioning, and fusion techniques.	
Unit-2 - Sensors for Battery Charging and Control	***9 Hour***
Overview of Battery Charging, Battery Modules, Regenerative Braking, Current Measurement, Voltage Measurement, Battery Management System (BMS) Sensors: State of Charge (SOC), State of Health (SOH), and State of Function (SOF), Torque Sensors, Speed Sensors, Thermistors, onboard thermal sensor, humidity and air quality sensors, Integration of sensors for cabin climate control.	
Unit-3 - Electric Vehicle Actuators	***9 Hour***
Actuators: solenoid actuator, stepper motors, relays, electrohydraulic actuators, Electric Drive Systems: Types of electric motors in EVs, induction motors, permanent magnet motors, Electric Brake Systems: Regenerative braking systems and components, Thermal Management Actuators: Electric cooling pumps and fans for battery and motor cooling, Heating systems for battery and cabin temperature control.	
Unit-4 - Overview of Electric Vehicle Control Systems	***9 Hour***
Current Loop Control, Speed Control Loop Powertrain Control Strategies, Charging Control: Battery balancing and equalization strategies, Charging control for different charging scenarios, Regenerative Braking Control: Regenerative braking algorithms, Real-time control strategies for electric vehicles.	
Unit-5 - Electric Vehicle Control Techniques	***9 Hour***

Architectures of vehicle control systems, Integrated vehicle control systems: electronic stability control, adaptive cruise control, PD Controller, PI Controller, Selecting PI Gain for Speed Controller, PI Controller Design, PI Controller with Reference model, Adaptive and predictive control techniques in automotive systems, Overview of Advanced driver assistance systems (ADAS), Real-world examples of sensor, actuator, and control systems in vehicles, Application-specific case studies: electric vehicles, hybrid vehicles, connected vehicles.

Learning Resources	1. *Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, "Electric and Hybrid Vehicles: Technologies, Modelling and Control - A Mechatronic Approach", first edition, April 2014.* 2. *Craig Smith, "Car Hacker's Handbook A Guide for the Penetration Tester", first edition, March 2016.* 3. *Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", CRC press, first edition, 2017.*	4. *Xudong Zhang, "Modelling and Dynamics Control for Distributed Drive Electric Vehicles", Springer, first edition. 2021.* 5. *William B. Ribbens, "Understanding Automotive Electronics", Elsevier Publishing, sixth Edition, 2003* 6. *Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer, second edition, 2005.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Haricharan.radhakrishnan, Volvo trucks India	*1. Dr. Mahajan Sagar Bhaskar, PSU, Saudi Arabia*	*1. Dr. A.Sureshkumar , SRMIST*
2. Mrs.Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China	*2. Dr Hariharan Muthusamy. National Institute of Technology, Uttarakhand, India*	*2. Dr.R.Narayanamoorthi, SRMIST*

Course Code	21EVC204T	Course Name	AUTOMOTIVE ENGINEERING SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the principles and fundamental of automotive transmission*
CLR-2:	*understand the arrangement and functioning of passenger transmission systems*
CLR-3:	*understand the concept of passenger vehicle body*
CLR-4:	*describe the different types of braking systems in an automobile*
CLR-5:	*understand the concept of different suspension systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the key components of automotive transmissions and their performance*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*illustrate the different arrangements of passenger vehicle transmission system*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*categorize different vehicles bodies, layout's and its nomenclature, structural elements and synthesis it to meet vehicle crashworthiness requirements*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*explore information about braking system and its types*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*depict the different suspension systems and demonstrate the vehicle stability.*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Introduction to Automotive Engineering and Mechanics	***9 Hour***
History - Development of vehicles and drive units - Stages in the development of automotive transmissions, Development of gear-tooth systems and other - Transmission components- Basic elements of vehicle and transmission engineering, Need of gearboxes, Functions of vehicle transmissions, Fundamental performance features of vehicle transmissions, Trends in transmission design, Transmission losses and efficiency.	
Unit-2 - Passenger Vehicle Transmission System	***9 Hour***
Arrangement of the transmission in passenger, Commercial, All-Wheel drive passenger cars - Transverse and longitudinal dynamics with all-wheel drive - Transmission formats and designs, Basic gearbox concept - Passenger car transmissions: manual passenger car transmissions - Automated manual passenger car transmissions, Dual clutch passenger car transmissions, Automatic passenger car transmissions, Passenger car hybrid drives, Continuously variable passenger car transmissions - Final drives: axle drives for passenger cars, axle drives for commercial vehicles - Differential gears and locking differentials - Hub drives for commercial vehicles - transfer gearboxes.	
Unit-3 - Passenger Vehicle Body	***9 Hour***
Automobile body - Description of the automobile body Types (space frame, central frame, body-on-frame, monocoque) - Body nomenclature - Body mass benchmarking - Steel used in passenger vehicle - Vehicle layout - Different types of car body style - Automotive body structural elements - Overview of classical beam behaviour - Design of automotive beam sections - Design for crashworthiness: Standardized safety test conditions and requirements - Front barrier - Side impact - Note on rear impact.	
Unit-4 - Braking Systems	***9 Hour***
Type of brakes - Disc and drum brake theory - Constructional details – Advantages - Brake actuating systems – Materials - Braking torque - Factors affecting brake performance - Parking and exhaust brakes - Power-assisted brakes - Antilock braking system - Testing of brakes - Thermal Considerations	

Unit-5 - Suspension Systems	***9 Hour***
Construction of suspension system - Solid axles and independent suspension system - Four-link and multi-link - Trailing arm - Short long arm, MacPherson strut suspension system - Anti-squat, Anti-pitch, and anti-dive suspension system - Roll center and stability Analysis.	

Learning Resources	1. *Harald Naunheimer, Bernd Bertsche, Joachim Ryborz, Wolfgang Novak "Automotive Transmission: Fundamentals, Selection, Design & Application", Springer-Verlag Berlin Heidelberg, second edition, 2011.* 2. *Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, "Creating Autonomous Vehicle Systems", Morgan and Claypool, first edition, 2017.* 3. *Donald E. Malen "Fundamentals of Automobile Body Structure Design" SAE International Publication, second Edition, 2020.*	4. *K. Newton, W.Steeds and T.K.Garret, "The Motor Vehicle", Butterworth Heinemann, India, thirteenth edition, 2004* 5. *Giancarlo Genta, "Automotive Chassis", springer Italy, first edition, 2014.* 6. *W.Steed, "Mechanics of Road Vehicles", Illiffe Books Ltd, London, first edition, 1992.* 7. *Heinz Heisler, "Advanced Vehicle Technology", Butterworth – Heinemann, New York, second edition, 2002.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Santhiya, Tataelxi , Bangalore, India	*1. Dr.Sheldon Williamson Professor, Ontario Tech University, Canada*	*1. . Dr.K. Sivanathan, SRMIST*
2. Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China	*2. Dr Hariharan Muthusamy. National Institute of Technology, Uttarakhand, India*	*2. Dr.K.Saravanan, SRMIST*

Course Code	21EVC205J	Course Name	POWER ELECTRONICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize power semiconductor switches and its advancements*
CLR-2:	*familiarize in selecting controlled rectifier for specific application.*
CLR-3:	*apply the concept of chopper principle and design an isolated/non-isolated DC-DC converter*
CLR-4:	*articulate the DC-AC conversion*
CLR-5:	*understand AC-AC conversion and power electronic circuits for different applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the characteristics of different power devices along with protection methods*	*3*	*2*	*-*	*-*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-2:	*determine various controlled rectifiers for the specific voltage range*	*3*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-3:	*formulate and design DC-DC isolated and non–isolated converters*	*3*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-4:	*design power electronic DC – AC converter*	*3*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-5:	*explore various AC – AC converters for power electronics applications in emerging areas of engineering*	*3*	*2*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*3*	*-*	*-*

Unit-1 - Power Semiconductor Devices	***12 Hour***
Introduction to Power Electronics - Review of power semiconductor switches: Power diodes, SCR, GTO - BJT, MOSFET, IGBT-Static and dynamic characteristics - Wide-band gap semiconductors - Selection of switches - Design of snubber circuits, protection methods, Thermal modelling and design of heat sink. *Laboratory Practice: Design of gate driver circuits.*	
Unit-2 - Design of Controlled Rectifiers	***12 Hour***
Design and analysis of single-phase half-wave and full wave thyristor-controlled rectifiers three phase half-controlled and full-controlled rectifiers, Effect of source inductance on controlled rectifiers, Twelve-pulse Rectifiers, Dual converters, Case Study: Power Factor Correction Using Controller Rectifier. *Laboratory Practice: Design and analysis of single-phase and three-phase fully controlled rectifiers.*	
Unit-3 - Design of DC to DC Converters	***12 Hour***
Introduction, Chopper operation and Control Strategies-Design and analysis of non-isolated converters with continuous, and discontinuous modes - non-ideal switches and converter performance - Design of isolated topologies- Converter selection - Multiport and high voltage gain converters design- Concept of resonant switching - High frequency inductor design for converter application - capacitive filter design. Case Study: DC to DC Power Converters applications. *Laboratory Practice: Design of non-isolated and isolated converters.*	
Unit-4 - Inverters	***12 Hour***
Voltage source inverters- Design of single-phase full-bridge inverter- Three-phase full bridge inverter with 180 and 120 degree modes- Harmonic distortion analysis- Development of pulse-width modulation schemes - Significance of dead time- Current controlled inverter, Concept of Multilevel inverters - Case Study: Inverter for EV Drive	

Laboratory Practice: Design and analysis of single phase, Three phase inverters, and multilevel inverter.
Unit-5 - AC to AC Controllers ***12 Hour***
Types of AC-AC voltage regulation-Design of single-phase AC voltage controller- Analysis of three-phase AC voltage controller - Single phase to single phase cyclo-converters-Matrix converter. Various power electronic applications: Power conditioners, UPS, HVDC, induction heating, speed control of induction motor, EV, and renewable energy integration. Case Study: Power Converters for EV charging. Laboratory Practice: AC-AC voltage regulation- Power electronic interfaces for renewable energy and EV applications.

Learning Resources	*1 Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics - Converters, Applications and Design", Wiley India, third edition, 2022.* *2. Rashid M H, "Power Electronics: Circuits, Devices and Applications", Pearson Education, India, fourth edition, 2017.* *3. P.S.Bimbhra P.S., "Power Electronics", Khanna Publishers, sixth edition, 2018*	*4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, first edition, 2009.* *5. Robert W. Erickson, Dragon Maksimovic, "Fundamentals of Power Electronics", Springer, third edition, 2020.* *6. Daniel W.Hart, "Power Electronics", McGraw Hill Higher Education, third edition, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Bhaskarsahu, Schneider Electric Ltd, India	*1. Dr. K. S. Swarup, IIT Madres, India*	*1. Dr. Ravi Eswar K M, SRMIST*
2. Dr. B. Hariram Satheesh - Principal Scientist – ABB, India	*2. Dr. Bradley Lehman, Northeastern University, USA*	*2. Dr. C. Bharatiraja, SRMIST*

Course Code	21EVC206T	Course Name	ELECTRIC VEHICLE ARCHITECTURE	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the structure of Electric Vehicles*
CLR-2:	*familiarize on the concept of vehicle mechanics*
CLR-3:	*enrich the knowledge on the component of hybrid electric vehicle*
CLR-4:	*familiarize the concepts of Hybrid Electric Vehicle Control Strategy*
CLR-5:	*discover the concepts of Plug-in Hybrid Electric Vehicle*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the History and Evolution of EVs, Hybrid and Plug-In Hybrid EVs*	*3*	*2*	-	-		-	-	-	-	-	-	-	*2*	-	-
CO-2:	*understand the mechanics of vehicle*	*3*	*3*	*2*	-		-	-	-	-	-	-	-	*2*	*1*	-
CO-3:	*illustrate the working of the component of Hybrid Electric Vehicles*	*3*	*3*	*2*	-		-	-	-	-	-	-	-	*2*	*1*	-
CO-4:	*describe the hybrid vehicle control strategy*	*3*	*3*	-	-		-	-	-	-	-	-	-	*2*	*1*	-
CO-5:	*interpret the concepts related to the Plug-In Hybrid Electric Vehicles*	*3*	-	-	-		-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Vehicle Architecture and Sizing	***9 Hour***
Introduction to Electric Vehicle - History of Electric Vehicle - Comparison of EV with ICE based Vehicle - Benefits and Challenges in Electric Vehicle - Electric Vehicle Classification based on their Level of Electrification - Series, Parallel and Series parallel Architecture (torque and speed coupling) - Comparison between Different Types of Electric Vehicles - Mountain Bike - Motorcycle- Electric Cars and Heavy Duty EVs - Details and Specifications.	
Unit-2 - Vehicle Mechanics	***9 Hour***
General description of vehicle movement, vehicle resistance, vehicle dynamic equation – Tire and ground adhesion – Traction force – Traction torque – Traction power - Vehicle performance (maximum speed of a vehicle, gradeability and acceleration performance) – Tractive Effort in Normal Driving - Energy Consumption.	
Unit-3 - Power Components and Brakes	***9 Hour***
Major components of HEV – Engine – Battery – Power converter assembly –Gears, clutches, differential, transmission system - Brake system – Electric power steering – Vehicle stability control - EV power train sizing.	
Unit-4 - Hybrid Vehicle Control Strategy	***9 Hour***
Vehicle supervisory control – Max SOC of PPS – Engine on-off – Constrained engine on-off – Fuzzy logic control – Dynamic programming – Mild hybrid electric drive train operating modes and control strategy – Optimal braking control – Optimal energy recovery control.	
Unit-5 - Plug-In Hybrid Electric Vehicle	***9 Hour***
Introduction-History - Construction and working of PHEV- Energy management control strategy – AER focused control – Blended control – Energy storage systems - Design -Charging mechanisms-Advantages of PHEVs.	

Learning Resources	1. *A. Emadi, M. Ehsani and John M. Miller, "Vehicular Power Systems", Marcel Dekker, New York, first edition, 2004.* 2. *Ion Boldea and S.A Nasar, "Electric drives", CRC Press, second edition, 2005.* 3. *Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, first edition, 2002.*	4. *Chris Mi, M. Abul Masrur, David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", Wiley, second edition, 2011.* 5. *Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, second Edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Shekhar Malani, Devise Electronics, Pune,India	*1. Dr. Rajesh Verma, King Khalid University, Saudi Arabia*	*1. Dr. C.Bharatiraja, SRMIST*
2. Mr.Venkata Karthik, ZF India	*2. Dr Hariharan Muthusamy. Associate Professor; National Institute of Technology, Uttarakhand.*	*2. Dr.K.Sivanathan, SRMIST*

Course Code	21EVC207T	Course Name	EMBEDDED SYSTEM AND COMMUNICATION PROTOCOLS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand embedded system hardware and processor design*
CLR-2:	*gain skills in advanced embedded C programming*
CLR-3:	*learn fundamentals and applications of Real-Time Operating Systems*
CLR-4:	*familiar with embedded system verification and debugging using LDRA tool integration*
CLR-5:	*understand automotive embedded communication protocols*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*know the features of embedded system hardware and processor design*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*demonstrate advanced embedded C programming skills*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*explore the real-time operating systems principles*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*interpret embedded systems using LDRA for verification and debugging.*	*3*	*2*	-	-	-	-	-	*1*	-	-	-	-	*3*	-	-
CO-5:	*learn the automotive communication protocols.*	*3*	-	-	-	-	-	-	*2*	-	-	-	-	*3*	-	-

Unit-1 - Fundamentals of Embedded System Hardware	***9 Hour***
Embedded system evolution trends - Custom single purpose processors: Hardware - Timing diagram - Memory -Paging- Direct memory access- buses – Interrupts - Built interrupts - Interrupt latency - Combination Sequence- Shared data problems -Processor design –Case study on RT level design	
Unit-2 - Advanced Embedded Programming	***9 Hour***
Embedded software Design methodologies and development tools – Emulators and debuggers -Embedded C Programming - Looping structures – Register allocation – Function calls – Pointer aliasing – structure arrangement – bit fields – unaligned data and endianness – inline functions and inline assembly – portability issues– Case studies on Battery monitoring system.	
Unit-3 – Real Time Operating System Design	***9 Hour***
Operating systems and its internals - Multitasking and Real time Operating Systems – Task Swapping Methods – Scheduler Algorithms – Priority Inversion – Task, Thread and Process – Choosing Operating System – Commercial Operating Systems- Basics of Embedded Linux- Linux Kernel- Device Driver-Data Acquisition- case study on real time application on RT Linux.	
Unit-4 - Verification and Validation in Embedded Systems	***9 Hour***
Equivalence Checking -Types: QMDD, SAT based Equivalence Checking -Automated Debugging and Fixing -The Debugging Problem -Determining Error Candidates –Determining Error Locations -Fixing Erroneous Circuits - LDRA Tool Suite Integration-Case study on static and dynamic analysis using LDRA.	
Unit-5 - Embedded Communication and Protocols	***9 Hour***
Serial Communication - UART, SPI, I2C - Introduction to CAN and LIN: Data Frame Structure, Master Slave Architecture-Error Detection and Handling-Integration with Vehicular Network – Protocol Stacks- Security and Data Encryption Protocols- Case study on role of CAN and LIN in sensor data aggregation and actuator control for ADAS application.	

Learning Resources	*1. Lyla b das, "Embedded Systems- An integrated approach", Pearson education, first edition, 2013.* *2. Rajkamal, "Embedded Systems- Architecture, Programming, and Design", McGraw Hill Education, third edition, 2017.* *3. John Pratt "Real-Time Embedded Components and Systems with Linux and RTOS", Mercury Learning and Information, second edition, 2016.*	*4. Frank Vasquez, "Mastering Embedded Linux Programming", Packt Publishing, first edition, 2021.* *5 Abhik Roychoudhury, "Embedded Systems and Software Validation", Morgan Kaufmann, first edition, 2009.* *6. Olaf P.Feiffer, Andrew Ayre and Christian Keyold, "Embedded Networking with CAN and CAN open", Copperhill Media Corporation, second edition, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.V.Ashwin, Qualcomm	*1. Dr.K.Vijayakumar, IIITDM*	*1. Dr.R.Narayanamoorthi, SRMIST*
2. Mr. Sathish Arvind M, Schneider Electric	*2. Dr. S.Pappa, MIT, Anna University*	*2. Mr. V. Manoj Kumar, SRMIST*

Course Code	21EVC208J	Course Name	ELECTRIC VEHICLE DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the different types of frames and loads*
CLR-2:	*design the steering system and its components*
CLR-3:	*understand the components and function of braking system*
CLR-4:	*understand the different types of suspension systems*
CLR-5:	*gain knowledge about tire and its performance characteristics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design the chassis and its components*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-
CO-2:	*interpret different steering and braking system components*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-
CO-3:	*design the components of braking system*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-
CO-4:	*classify and design different suspension system and its components*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-
CO-5:	*infer about tires and their performance characteristics*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-

Unit-1 - Design of Frames	***15 Hour***
Study of loads - Bending case - Torsion case - Combined bending and torsion - Lateral loading - Fore and aft loading - Frame materials - Design of frames - Moment of inertia of rectangular section - Moment of Inertia of a Hollow Rectangular Section - Moment of Inertia of a Hollow Rectangular Section - Moment of Inertia of a Circular Section - Chassis types, introduction -Ladder frames - Cruciform frames - Torque tube backbone frames- Space frames - Integral structures - Underbody, Sub-frame - Industrial vehicle frames - Structural tasks Structural design - Structural testing. *Laboratory Practice: Study and measurement of various types of two and four-wheeler vehicle frames; Study of different types of front and rear axles and final drives. Calculation of final drive ratio.*	
Unit-2 - Design of Steering Systems	***15 Hour***
Introduction Steering mechanism - Steering mechanism and applications - Rack and pinion steering box - Screw and sector steering box - Design Steering column - Design Steering column - Steering column calculations - Recirculation ball steering diagnosis and service - Principles of conventional column - Tilt column systems - Collapsible steering column - Conventional steering linkage mechanism - Rack and pinion steering linkage mechanism – Manual and Power Steering Theory - Manual steering - Power steering - Power steering pump operation - Rack and pinion - steering diagnosis and service. *Laboratory Practice: Dismantling, study, and assembling of different automobile steering systems, automobile driveline and differential mechanism.*	
Unit-3 - Design of Brakes	***15 Hour***
Weight transfer during braking and effect of vehicle parameters – Design of mechanical, hydraulic, air, parking and brake systems: components and configurations - Brake Friction materials – Brake pads and Brake Liner Composition and friction - Thermal effects in friction brakes - Wheel lock and vehicle stability during braking - Electronic braking system - Brake system legislation - Brake testing - Brake NVH - Stopping distance calculation - Brake factor calculation for a drum brake and Disc brake - Brake torque calculation in a hydraulic system. *Laboratory Practice: Dismantling, studying, and assembling of different automobile braking systems and performing brake bleeding operation.*	
Unit-4 - Design of Suspension System	***15 Hour***

Design of leaf, Helical Springs - Helical springs in series and parallel - Design of torsion bar - Independent suspensions- McPherson suspensions for rear axle - Double wishbone suspension - Virtual centres suspensions - Trailing arm suspensions- Semi- trailing arms suspension - Multilink suspensions Semi-independent suspensions - Twist beam suspension - Rigid axle suspensions - Rigid axles with leaf springs - Rigid guided axles - Industrial vehicles suspensions - Pneumatic springs - Front suspension Rear suspensions - Design and testing *Laboratory Practice: Dismantling, study, and assembling of the automobile suspension system and automobile clutches.*
Unit-5 - Design of Wheels ***15 Hour***
Description Rim characteristics - Tire characteristics Wheel reference system - Tire operation - On-road driving - Off-road driving - Rolling radius - Rolling resistance Effect of speed, material nature and structure, tread wear - Effect of operating temperature, inflation pressure and vertical load, tire size, road - wheel sideslip angle - Static Forces - Longitudinal Force - Cornering forces - Interaction between longitudinal and side forces - Outline on dynamic behavior - Testing of tires. *Laboratory Practice: Dismantling, gear ratio calculation, and assembling of an automobile transmission, Study of different types of rims, wheels and tires*

Learning Resources	*1. Genta, Giancarlo, Morello, L, "The Automotive Chassis Volume 1: Components Design", Springer, Netherlands, second edition, 2009.* *2. Julian Happian-Smith, "Introduction to Modern Vehicle Design", Butterworth- Heineman, first edition, 2001.*	*3. Beer, Johnston, "Vector Mechanics for Engineers: Statics and Dynamics", McGraw Hill Education, tenth edition, 2017.* *4. Heinz Heisler, "Advanced Vehicle Technology", Butterworth-Heinemann, second edition, 2002.* *5. Kenneth Newton, T.K. Garrett, W. Steeds, "The Motor Vehicle", Butterworth -Heinemann, twelfth edition, 1997*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Haricharan.radhakrishnan, Volvo trucks India	*1. Dr.K.Arunachalam, MIT, Anna University*	*1. Dr. Shubhabrata Datta, SRMIST*
2. Sandeep, Matlab	*2. Dr.S.Raghu, CSIR, Durgapur, India*	*2. Dr.C.Bharatiraja, SRMIST*

Course Code	21EVC301J	Course Name	KINEMATICS AND DYNAMICS OF AUTOMOBILE	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*utilise kinematic analysis concepts to familiarise oneself with the operational principles of machine tools*
CLR-2:	*acquaint the valve and port mechanism of the internal combustion engine and build the gear-box for power transmission systems.*
CLR-3:	*utilise the principles of static and dynamic forces in internal combustion engines and flywheels.*
CLR-4:	*familiarise with the equilibrium of forces and torques in rotor bearings, ships, and aeroplanes.*
CLR-5:	*familiarise with the basic principles of vibrations in systems with a single degree of freedom.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the principles of the theory of mechanisms to conduct a kinematic analysis.*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*examine the motion characteristics of cam and follower systems, as well as gear trains.*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*accomplish the static and dynamic force analysis of mechanisms*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*examine the impact of asymmetrical forces and gyroscopic effects on machinery.*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*derive the governing equations and find solutions for single degree of freedom systems.*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Kinematics of Mechanisms	***15 Hour***
Introduction to mechanism: Link, pair, kinematic chain, mechanism and machine - Degrees of Freedom - Mobility - Four Bar Chain, Grashof's law, Kutzback's and Grubler's criterion for planar mechanisms - Kinematic Inversions of kinematic chain, Kinematic Analysis: Velocity and acceleration analysis of Four bar and single slider crank mechanism by graphical method - Instantaneous center method, Kennedy's theorem, Velocity analysis of Four bar and single slider crank mechanism by Instantaneous center method. *Laboratory Practice: Inversions of Four Bar Mechanisms*	
Unit-2 - Kinematic Analysis of Machine Elements	***15 Hour***
Cams and Followers: Cam terminology, types of cams and followers, Types of follower motion - Kinematics of follower for parabolic, simple harmonic, and cycloidal motions - construction of cam profile for radial and offset followers with different follower motions. Gears: Gear terminology, types of gears - law of gearing - path of contact, arc of contact, sliding velocity - interference and undercutting of gears – Gear trains: types and applications - velocity ratio calculations in simple, compound and epicyclic gear train. *Laboratory Practice: Demo of Cam and Follower Types, Demo of Follower motion, Demo of Types of Gears and Gear Train, Cam and Follower Analysis - Cam Profile and Jump speed, Dynamic analysis of epicyclic gear train.*	
Unit-3 - Force Analysis	***15 Hour***
Applied and Constrained Forces – Free body diagrams – Static Equilibrium conditions – Two, Three and four force members – Static Force analysis in simple machine members – Dynamic Force Analysis – Inertia Forces and Inertia Torque – D'Alembert's principle – superposition principle – dynamic force Analysis in reciprocating engines - Turning moment diagrams - flywheels- Case study on four bar mechanism.	

Laboratory Practice: Lami's theorem of forces, Mass Moment of Inertia of a flywheel
Unit-4 - Balancing and Gyroscope ***15 Hour***
Balancing of rotating masses: Static and dynamic balancing of several masses rotating in same and different planes by analytical and graphical methods - Balancing of reciprocating masses by graphical method. Gyroscope: Gyroscopic forces, couple, precessional angular motion, Gyroscopic effects on automobiles, trains, aeroplane and ship *Laboratory Practice: Dynamic balancing of rotating masses, Dynamic force analysis in reciprocating masses, Dynamic analysis of a gyroscope*
Unit-5 - Fundamentals of Vibrations ***15 Hour***
Basics of vibrations - Terminology and types of vibrations - Governing equations for free undamped and damped vibrations of single degree of freedom system - logarithmic decrement. Forced vibration: Types of - of forced vibration single degree of freedom system under harmonic excitation. *Laboratory Practice: Demo of single Degree of Freedom. spring mass system (Helical spring), Torsional vibration of single rotor system with and without viscous damping* *Free and Forced vibration of equivalent spring mass system, Free vibration of cantilever beam using Data Acquisition System, forced vibration of cantilever beam using Modal MRV*

Learning Resources	*1. Rattan S.S., "Theory of Machines ", McGraw Hill Education, fourth edition, 2015.* *2. Thomas Bevan, "Theory of Machines", P3. Education Limited, third edition, 2005.*	*3. Robert L. Norton, "Kinematics and Dynamics of Machinery", McGraw Hill, second edition, 2013.* *4. Rao SS, "Mechanical Vibrations", Prentice Hall, fifth edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Srinivasan Vijayaraghavan, Altair	*1. Dr. Deevesh Sharma, CSIR Durgapur, India*	*1. Dr.M.Leenus Jesu Martin, SRMIST*
2. Sandeep, Matlab	*2. Dr. Sethuraman Sankararaman - IIT Madras, India*	*2. Dr.C.Bharatiraja, SRMIST*

Course Code	21EVC302J	Course Name	ELECTRICAL DRIVES AND CONTROL	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21EES101T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of basic Electrical drives*
CLR-2:	*study the speed control of DC drives*
CLR-3:	*understand the operation of induction motor drives and their control*
CLR-4:	*control of synchronous motor drive*
CLR-5:	*inherit various control method for BLDC and SRM drives*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the essential knowledge of the electric drive concepts*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*comprehend the control of DC motor drives*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*familiarize the induction motor drive and their control techniques*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*examine various control techniques of synchronous motor drive*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*interpret the BLDC drive and SRM drive control techniques*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-

Unit-1 – Introduction to Electrical Drives	***12 Hour***
Electrical Drives - Advantages of Electrical Drives - Dynamics of Electric drives - Fundamental torque equations – Speed torque conventions and multi-quadrant operation - Equivalent values of drive parameters - Components of load torques - Selection of motor power rating - Thermal model of motor for heating and cooling - Classes of motor duty - Determination of motor rating - Control of Electric drives - Modes of operation - Speed control and drive classifications - Closed loop control of drives. *Laboratory Practice: Position control of Servo motor drive*	
Unit-2 - DC Motor Drives and Control	***12 Hour***
DC Motor Drives - DC motors and their performance - Starting - Braking - Transient analysis - Separately excited motor with armature and field control - Ward Leonard drives - Transformer and uncontrolled rectifier control - Controlled rectifier fed DC drives - Chopper controlled DC drives - Single, two and four quadrant operations - Closed loop control - Speed control and current control *Laboratory Practice: DC motor speed control, Braking of DC motor*	
Unit-3 - Induction Motor Drives and Control	***12 Hour***
Induction Motor Drives - Stator control - Stator voltage and frequency control - VSI and CSI fed induction motor drives-principles of V/f control - Closed loop variable frequency PWM inverter with dynamic braking - Cyclo converter fed induction motor drives - Rotor control - Static rotor resistance control and slip power recovery schemes - Static Scherbius drives - Power factor considerations– Modified Kramer drives - Principle of vector control, Field-oriented control (FOC), Direct, torque control (DTC), and Field Weakening Control.. *Laboratory Practice: V/f control of three phase induction motor, Rotor resistance control of three phase slip-ring induction motor*	
Unit-4 - Synchronous Motor Drives and Control	***12 Hour***

Synchronous Motor Drives - Open loop VSI fed drive and its characteristics– Principles of Separate and Self-control - Torque angle control – Power factor control - Voltage and Current source inverter fed synchronous motor drive – Cyclo-converter fed synchronous motor drive – PMSM Drive – Field-oriented control of PMSM, Flux-weakening control of PMSM, Position sensor-less control of PMSM, and Model predictive control of PMSM. *Laboratory Practice: Three phase VSI fed synchronous motor, Field-oriented control of PMSM drive.*
Unit-5 - BLDC and SRM Drives ***12 Hour***
BLDC Drive – Basic principles of BLDC Motor, motor construction, types of BLDC motors, characteristic curves, sizing equation, trapezoidal back EMF BLDC motor control; sensor control, sensor less control, field-oriented control for BLDC - Switched Reluctance Motor (SRM) - Basic construction details, working principles of SRM machine, types of SRM, characteristic curves - Torque controlled SRM - Block diagram of Instantaneous Torque control using current controllers and flux controllers. *Laboratory Practice: Sensorless control for BLDC drive; SRM drive control*

Learning Resources	1. *Gopal K D, "Fundamentals of Electric Drives", Narosa Publishing House Pvt. Ltd, first edition, 2011.* 2. *Bimal K Bose, "Modern Power Electronics and Drives", Elsevier publishers, Butterworth Hinnemann, second edition, 2012.* 3. *Krishnan R, "Permanent Magnet synchronous and Brushless DC Motor Drives", CRC Publishers, first edition, 2010.*	4. *Austin Hughes, Bill Drury, "Electric Motors and Drives Fundamentals, Types and Applications", Newnes , fifth Edition, 2019.* 5. *Krishnan R, "Switched Reluctance Motor Drives: Modelling, Simulation, Analysis, Design and Applications", CRC publication, 2001* 6. *K Wang Hee Nam, "AC Motor Control & Electrical Vehicle Application", CR Press Taylor & Francis Group, second edition, 2018*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 . Dr. B. Hariram Satheesh - Principal Scientist – ABB, India	*1. Dr. Siva Kumar K, IIT Hyderabad , India*	*1. Dr. C. Bharatiraja, SRMIST*
2. Mr. Manikandan, Ola Electric, India	*2. Dr. Mahesh Krishnamurthy, Illinois Institute of Technology, Chicago, USA*	*2. Dr. Mohanraj K, SRMIST*

Course Code	21EVC303T	Course Name	ELECTRIC VEHICLE CHARGING TECHNOLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the EV and charging system and basic standards for EV*
CLR-2:	*cognize the fundamentals of electric vehicles chargers*
CLR-3:	*enrich the knowledge of developing advanced EV changers and controls*
CLR-4:	*understand the bidirectional changers and EV communications*
CLR-5:	*familiarize the concept of EV EMI and noise reductions*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the basics of the of electric vehicles standards*	*3*	-	-	-	-	-	-	*2*	-	-	-	-	*2*	-	*2*
CO-2:	*acquire knowledge on electric vehicles chargers and power factor controls*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*development of electric vehicles AC and DC Chargers*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*1*	-
CO-4:	*enrich the modeling of bidirectional changers and communications*	*3*	-	-	-	-	-	*2*	*2*	-	-	-	-	*2*	*1*	*2*
CO-5:	*study the electric vehicles case studies and noise reduction techniques*	*3*	-	-	-	-	-	-	*1*	-	-	-	-	*2*	-	*1*

Unit-1 - EV Charging System	***9 Hour***
Need of charging battery charging modes, types of EV supply equipment, components of EV battery chargers, charging infrastructure challenges, classification based on charging levels (region-wise), modes, plug types, standards related to connectors, communication, supply equipment, EMI/EMC. Introduction to Electric Vehicle Standards, Overview of international standards (ISO, IEC), National standards in India, global standards (SAE, CHAdeMO, CCS).	
Unit-2 - On Board and Off Board Chargers	***9 Hour***
Basics of onboard charging systems, types of AC-DC converters; working principles, modulation, design, and closed loop control of power factor correction converters (PFC): Boost type PFC, Totem-pole PFC, active front-end converter, three-phase PFCs; working principles, modulation, design, and closed loop control of single-stage AC-DC converters Techniques for power factor correction in EV chargers, Types of Chargers: AC chargers, DC chargers, and fast chargers, Charging protocols.	
Unit-3 - Conductive and Wireless Chargers	***9 Hour***
Role of Power Electronics in Charging Systems, turn-on and turn-off characteristics; Types of DC-DC converter used for EV chargers; working principles, modulation, design, modeling and closed loop control of the LLC converter, high-frequency magnetics, soft-switching criteria, Wireless Power Transfer: Basics of WPT technology, Inductive and resonant WPT systems, Static and dynamic operation of WPT.	
Unit-4 - Vehicle-To-Grid, Vehicle-To Vehicle and Grid Charging	***9 Hour***
Vehicle-to-Grid and Vehicle-to-Vehicle Technology: Understanding concepts and Operation of V2V and V2G applications, Benefits and challenges of V2G and V2V integration, modeling and control of bi-directional converter, Grid Standards for EV Charging: Overview of electrical grid standards for EV charging, Smart grid technologies and their impact on EV charging, Vehicle-to-Grid and Vehicle-to-Vehicle, Case Study: Examining successful implementations of V2G and V2V operation.	

Unit-5 – Communication and EMI/EMC Considerations	***9 Hour***
Communication: Introduction to V2G and V2V communication in EVs, Applications and benefits of V2G communication, Open charge points protocol (OCPP), Open System Interconnection-Layer-Model (OSI), adapted PWM signal-based low-level communication, PLC-based high-level communication, CAN communication, testing methodology for EV battery chargers and EVSE, sources of EMI, differential mode noise, common mode noise, LISN, measuring of EMI/EMC spectrum, design of DM filters, CM filters, Case Study: Latest EV reports released by Government of India.	

Learning Resources	1. *James Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, fourth Edition, 2003.* 2. *Tom Denton, "Automotive Electrical and Electronic Systems", Pearson Publication, fifth Edition, 2016* 3. *RoutledgeS. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, first edition, 2015.* 4. *Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, third edition, 2021.*	5. *Robert W. Erickson, and Dragan Maksimovic "Fundamentals of Power Electronics", Springer, third edition,.2020* 6. *L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, first edition, 2012* 7. *Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design", Wiley India, third edition, 2007.* 8. *Wolfhard Lawrenz, "CAN System Engineering: From Theory to Practical Applications", Springer, second edition, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Hariram Satheesh. ABB Limited	*1. Dr.Sheldon Williamson, Professor , Ontario Tech University, Canada*	*1. Dr. C.Bharatiraja, SRMIST*
2. Dr Govindaraj Mahindra Electric	*2. Ragavan K - IIT Gandhinagar*	*2. Dr. B.Vinothkumar, SRMIST*

Course Code	21EVC304J	Course Name	AUTONOMOUS AND CONNECTED VEHICLES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the requirements of autonomous and connected vehicles*
CLR-2:	*provide knowledge on the concepts of automotive electronics*
CLR-3:	*explain the concept of controllers in autonomous and connected vehicles*
CLR-4:	*understand the types of sensors, sensory data fusion and wireless networks*
CLR-5:	*gain knowledge on AI and ML in autonomous and connected vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*know the concept and requirements of autonomous and connected vehicles*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*apply automotive ECUs in autonomous vehicle*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyze the role of control system in automated and connected vehicle and ADAS*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*comprehend the sensor technology and wireless networks for advanced driver assistance systems*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*familiarize with the concept of AI and ML in fully autonomous and connected vehicles*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-

Unit-1 – Automated and Connected Vehicles ***15 Hour***

Overview of Autonomous vehicles - Typical requirements for autonomous vehicles - Advantages of autonomous over driver assistance vehicles - Technical and security issues - Main components of self-driving software systems - Safety frameworks - Advanced Driver Assistance System Technology - autonomous systems overview - Autonomous Operation modules

Laboratory Practice: Self driving software - Operations in autonomous vehicles

Unit-2 - Automotive Electronics in Autonomous Vehicles ***15 Hour***

Overview of Automotive Electronics: Infotainment, Body, Chassis, and Power-Train Electronics - Automotive Electronic Systems - Monitoring of Vehicle Components - Advanced driver assistance electronic systems - Connected Car Technology - Navigation in vehicles - Vehicle-to-Vehicle Technology and Applications - Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications

Laboratory Practice: Design of automotive electronic components in autonomous vehicles, Navigation using sensors

Unit-3 - Advanced Driver Assistance Systems and Control System in Autonomous Vehicles ***15 Hour***

Integration of Advanced Driver Assistance System Technology into Vehicle Electronics - Fundamentals of electronic control systems - Basic Cyber-Physical System Theory and Autonomous Vehicles - Usage of controller in used in autonomous driving techniques, Path planning - Control and trajectory tracking for Autonomous Vehicles, Lane keeping, collision avoidance - automatic emergency braking - Troubleshooting and Maintenance of Advanced Driver Assistance

Laboratory Practice: simulation of Controllers for autonomous systems - Electronics control system design for Autonomous vehicles

Unit-4 - Sensors and Wireless Networks in Autonomous and Connected Vehicles ***15 Hour***

Role of sensor in Autonomous Vehicles - Sensor Fusion in self-driving car - Role of Surroundings Sensing Systems and Autonomy - Use of Sensor Data Fusion, Remote Sensing Technology - Ultrasonic sonar system - Basics of Radar Technology and Systems - LiDAR Sensor Technology and Systems - Integration of Sensor Data to On-Board Control Systems - Object recognition and tracking, Satellite based augmentation systems - Distributed computing framework in connected vehicles - IoT for vehicle tracking and monitoring - System block diagram of wireless networks in vehicles
Laboratory Practice: Sensor data acquisition from vehicles - IoT platform for vehicle monitoring - Remote sensing using ultrasonic sensors
Unit-5 - AI And ML in Autonomous and Connected Vehicles ***15 Hour***
CNN based object detection, Deep learning for vehicle tracking - Autonomous vehicle localization using AI - Depth detection using ML - Semantic segmentation - Weighted directed graph for routing - Markov decision process for behavioral decisions - ML based Speed planning - Reinforcement learning in behavioral decisions - Operating system for autonomous driving - AI based Safety and security strategies
Laboratory Practice: ANN for object detection - Reinforcement learning for decision making - Deep learning for vehicle tracking

Learning Resources	*1. Shaoshan Liu, Jean-Luc Gaudiot, Liyun Li, Jie Tang, "Creating Autonomous Vehicle Systems", Springer International Publishing AG, second edition,2020,* *2. Cheng, Hong, Autonomous intelligent vehicles, Theory, Algorithms, and Implementation, Springer, first edition, 2011.*	*3. William B.Ribbens, "Understanding Automotive Electronics", Elsevier Publishing, sixth Edition, 2002.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Santhiya, Tataelxi , Bangalore, India	*1. Dr.Sheldon Williamson Professor , Ontario Tech University, Canada*	*1. Dr.K.Sivanathan, SRMIST*
2. Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China	*2. Dr Hariharan Muthusamy. Associate Professor; National Institute of Technology, Uttarakhand.*	*2. Dr. P. Sandeep Kumar , SRMIST*

Course Code	21EVC305J	Course Name	VEHICLE INTEGRATION AND TESTING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand of the key elements of electric vehicles*
CLR-2:	*impart advanced automotive technologies, focusing on powertrain configurations and braking systems*
CLR-3:	*understand modelling of electrical sub systems in EV*
CLR-4:	*deduce the evolving field of advanced vehicle development, addressing the complex challenges associated with modern automotive technologies*
CLR-5:	*outline the standards, charging policies and incentives in real-world scenarios*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend electric vehicle architectures*	*3*	*3*	-	-	-	-	-	*2*	-	-	-	-	*2*	-	-
CO-2:	*demonstrate a deep understanding of various powertrain configurations and braking system*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*explore modelling of electrical sub systems in EV*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*interpret the vehicle development process, focusing on the integration of various components and systems to meet performance, efficiency, and safety requirements*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*extrapolate communication standards, protocols, and architectures associated with charging systems for electric vehicles*	*3*	*3*	-	-	-	-	-	*2*	-	-	-	-	*2*	-	*2*

Unit-1 – Introduction	***12 Hour***
Introduction to EV technologies - Types of EV architecture - Electric vehicle and environment - Vehicle classification - Usage pattern for electric vehicles - Standardization in e-mobility - Government policies: standards and regulation - Design aerodynamics - Chassis model for battery operated vehicles - BMS Design Considerations - Electromagnetic compatibility testing - Efficiency and emissions testing - On-road electric vehicles testing - Battery Electric vehicle safety and crashworthiness. *Laboratory Practice: Performance Evaluation of an Electric Two-Wheeler Using Dynamometer; Performance Evaluation of an Electric Four-Wheeler Using Chassis Dynamometer; BMS Design Practices.*	
Unit-2 - Powertrain and Brakes	***12 Hour***
Power train configurations and components - hub motor direct drive configuration - centrally mounted configuration - differential- classification and types. Drum brakes, disc brakes, hydraulic brakes, power-assisted brake, air brakes, electric brakes, anti-lock braking system, electronic brake force distribution system, regenerative braking, brake assist system. Regenerative Braking - Real-world energy	

storage requirements and driver behavior assessment. - Brake feel and customer acceptance - Mechanical System Design: New transmission options including split path design approaches and systems (planetary, CVT, dual clutch). Top down and bottom up systems thinking for Engineering & Integration; System Engineering for xEVs: Crucial Technologies that go in to system engineering of xEV systems; new technologies that can disrupt the evolution of xEV systems; - India Specific Vehicle Population - xEV Components to System Assembly - 2W EV Vehicle Systems Engineering & Integration - 3W EV Vehicle Systems Engineering & Integration - 4W EV 1 ton class Cargo systems - Off Road vehicle Systems (in plant cargo systems, Golf Carts etc) - 4W xEV hybrid systems integration - Buses and Large Vehicle Systems Engineering Solutions. *Laboratory Practice: Determination of Side Slip, Suspension Efficiency, and Brake Efficiency Using Car Test Lane; Adjusting the Toe Alignment on Wheels for the Given Vehicle Using a Wheel Alignment Machine; Vehicle Assessment and Tire Benchmarking for an electric 2-wheeler.*
Unit-3 - Modelling Electrical Sub Systems ***12 Hour***
Systems modelling and simulation - Modelling methodologies for EV energy management - Control strategies for energy management and drivability - Electrical System Design - High voltage architecture options within EVs and component selection - Power electronics: DC-DC converters (unidirectional and bidirectional) and machine drives - Electrical machine designs, performance prediction, ancillary requirements and manufacturability - Battery and ultra-capacitor technologies, vehicle integration, and performance characteristics (materials, performance, reliability, safety, recycling). *Laboratory Practice: Wiring Diagram Tracing, and Fault Diagnosis; Range Test of an electric 2-wheeler*
Unit-4 - Systems Integration and Analytical Tools ***12 Hour***
Vehicle development process overview - Requirements development - Components and architectures - Major components in power train - Controls integration - Component sizing and integration trade-offs -System design and development considerations - Vehicle integration (performance, drivability, NVH) - Power train integration - HV/LV electrical systems - Chassis - HVAC (HV compressor, HV heater, cabin comfort, efficiency considerations) - Verification and validation considerations and test requirements- Component test considerations - System test considerations - Fleet testing. *Laboratory Practice: Headlamp Alignment & AC refrigerant Refilling with Ancillary load estimation methods; Rack and Pinion Steering Assist System Benchmarking and Troubleshooting; Performance Evaluation of a Battery-operated electric 2-wheeler power train drive*
Unit-5 - Communication Standards ***12 Hour***
Communication standards - Communication architecture for DC fast charging - Communication protocols and verification procedures - Grid connectivity - Criteria for connecting EV to utility for AC level 1 and level 2 charging - Nature and scope of policies to stimulate widespread EV adoption - EVCI station - Policy formulation and implementation at various levels of government - Policies and incentives for EV adoption - Replacement of the gasoline tax funding source in an increasingly electrified environment. *Laboratory Practice: Wiring Diagram of E/E Interface, CAN communication interface for VCU and Chargers; EV charging – EVSE, Smart meter Grid connectivity – Criteria.*

Learning Resources	1. *Iqbal Husain, "Electric and Hybrid Vehicles, Design Fundamentals", CRC Press, third edition, 2021.* 2. *Goodarzi, Gordon A., Hayes, John G, "Electric powertrain: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles", Wiley, first edition, 2018.*	3. *James Larminie John Lowry, "Electric Vehicle Technology Explained", Wiley, second Edition, 2012.* 4. *Robert Bosch GmbH, "Bosch' Automotive Handbook", Bentley Publishers, eighth edition, 2011.* 5. *RiK De Doncker, "Advanced Electric Drives – Analysis, Modeling, Control", Springer publications, first edition, 2020.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Venkata Karthik, ZF India	*1. Dr. Deevesh Sharma, CSIR Durgapur.*	*1. Dr. C. Bharatiraja, SRMIST*
2. Dr. Shankar Venugopal, MTA, Mahindra and Mandira.	*2. Dr. Sethuraman Sankararaman - IIT Madras.*	*2. Dr. V. Pradeep, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EVE301T	Course Name	ADVANCED ENERGY SOURCES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide an overview of the global energy scenario with the basic importance of green and clean energy technology.*
CLR-2:	*familiarize with solar and wind energy sources, conversion technologies*
CLR-3:	*understand the potential of Biomass and biofuel energy sources*
CLR-4:	*outline the significance of hydrogen energy and fuel cell technology*
CLR-5:	*list the knowledge of various energy sources and hybrid technologies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the importance of green and clean energy technology in the current energy scenario*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	*2*
CO-2:	*illustrate solar and wind energy sources, conversion technologies and their applications*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	*2*
CO-3:	*realize the importance of biomass and biofuel conversion technologies.*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	*2*
CO-4:	*understand the technical aspects of Hydrogen energy and fuel cell technology.*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	*2*
CO-5:	*gain knowledge on various energy sources and their hybrid technologies*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	

Unit-1 – Overview of Energy Sources	***9 Hour***
Energy sources – Consumption – Classification – Conventional Energy sources – Environmental impacts – Sustainable development goals – Renewable energy sources – Energy status - Future energy scenario- quality and concentration of energy sources- worldwide progress in renewable energy- Environmental aspects of renewable energy Projects	
Unit-2 - Solar and Wind Energy	***9 Hour***
Solar radiation: Introduction - Solar physics –Empirical equations on horizontal surfaces -Global – diffused and beam radiation – Solar radiation on inclined surface – Solar radiation measurement – Instruments -Solar Cells, Photovoltaic power – Introduction, I-V Characteristics, Efficiency-Solar thermal systems. Wind Speed- Measurements Wind energy – Types – Components – Power speed characteristics-Choice of electrical generators-Power and Energy density – Grid integration –. Case study on wind and Solar charging stations for electric vehicles	
Unit-3 - Biomass and Biofuels	***9 Hour***
Biomass: Principles of Bio-Conversion – Anaerobic and Aerobic digestion – Types of Bio-gas digesters – Gas yield – Combustion characteristics of bio-gas – Applications, Biofuel based I.C. Engine operation, and economic aspects. Biofuels: Biomass characteristics and their availability – Biofuel production processes: Biomethane, Biomass to Ethanol Production, Biohydrogen, Alcoholic fermentation, Biodiesel, Microbial Fuel Cell – Biomass based steam power plant – Combined cycle powerplant – Cogeneration plant. - A Case Study on biogas based electric vehicle charging station.	
Unit-4 - Hydrogen and Fuel Cells	***9 Hour***
Hydrogen Production: Thermal Processes, Electrolytic Processes, Photolytic Processes -Hydrogen Distribution - Hydrogen Storage Fuel cell, Technologies and Types, Obstacles. Operation principles, Potential and I-V curve, Fuel and Oxidation Consumption, Fuel cell Characteristics – Efficiency, Durability, Specific power, Factors affecting. Lifetime cost of Fuel cell Vehicle - A Case Study on Fuel Cell based electric vehicle.	
Unit-5 - Hybrid Energy Systems	***9 Hour***

Wind-diesel system, wind - PV system, micro hydro-PV system, biomass - PV-diesel system, geothermal-tidal, Thermoelectric generator and OTEC systems.

Learning Resources	1. *James Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, fourth Edition, 2003.* 2. *Tom Denton, "Automotive Electrical and Electronic Systems", Pearson Publication, fifth Edition, 2016* 3. *RoutledgeS. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, first edition, 2015.* 4. *Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, third edition, 2021.*	5. *Robert W. Erickson, and Dragan Maksimovic "Fundamentals of Power Electronics", Springer, third edition,.2020* 6. *L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, first edition, 2012* 7. *Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design", Wiley India, third edition, 2007.* 8. *Wolfhard Lawrenz, "CAN System Engineering: From Theory to Practical Applications", Springer, second edition, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Vijay Raju, Deputy Director, National Productivity Council, Chennai	*1. Dr. M.Premalatha, Professor, NIT- Trichy*	*1. Dr.C.Naveen, SRMIST*
*2. **Dr.**S.R. Sivarasu, (RK-CECT), Coimbatore*	*2. Dr. K.Vijayakumar, Assistant Professor, IIITM Kanchipuram*	*2. Dr.R.Sridhar, SRMIST*

Course Code	21EVE302J	Course Name	VEHICLE ELECTRONICS SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concept of Electronic components for vehicle*
CLR-2:	*understand the concepts of sensors and actuators in vehicles*
CLR-3:	*learn the fundamentals of digital engine control system*
CLR-4:	*understand various controls used in vehicle dynamics*
CLR-5:	*understand various automotive grade processor and controller for EV*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enrich the students on the basics of electronics for automotive application*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*gain knowledge of the concepts of sensors and actuators*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*familiarize the principles of digital engine control systems*	*3*	-	-	-	-	-	-	*2*	-	-	-	-	*1*	-	-
CO-4:	*understand the processes on various controls on vehicles dynamics*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*acquire knowledge on future trends in automotive systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 – Overview of Automotive Electronics	***12 Hour***
Introduction to modern automotive systems - Evolution of automotive electronics - Need for electronics in automobiles - Application areas of electronic systems in modern automobiles: Electronics engines control - Electronic fuel control - Electronic ignition - Automotive transmissions - Electronic control unit (ECU) design cycle: V-Model development cycle - Components of ECU. *Laboratory Practice: automotive ECU Solution: On board Datalogging, advanced DTE algorithm interface, Vehicle FALL detection, SECURE Mode, Configurable software stacks*	
Unit-2 - Sensors and Actuators	***12 Hour***
Introduction to sensors and actuators - Types of sensors: sensor for speed - Throttle position - Exhaust oxygen level - Manifold absolute pressure - Crankshaft position - Coolant temperature sensor - Air bag sensor - Detonation sensor - Emission sensors - Vehicle speed sensor - Exhaust temperature - Air mass flow for engine application - Automotive ignition control actuators - Fuel injector actuator – Solenoids - Various types of electric motors - Piezoelectric force generators - Relays: Types, Thermal Relay, case study.	
Unit-3 - Vehicle Control System	***12 Hour***
Shock absorbers - Electronic dashboard indicating system - Onboard diagnosis system - Electromagnetic interference suppression - Electromagnetic compatibility - Security and warning system - Collision avoidance systems - Safety controls - Security alarms - Navigation system - BMS ASIC-bq76PL536A-Q1 - Battery Monitor IC- CC2662R-Q1 Wireless BMS MCU - ARBIN Battery Tester - BMS Development with Modeling software and Model - Based Design. *Laboratory Practice: Automotive VCU Integration in Bus, CAN buses interface, Smart BMS VCU/ECU Integration*	
Unit-4 - Vehicle Dynamics Electronic Controllers	***12 Hour***
Introduction to Anti-locking Braking System- principle - ABS with Electronic Brake-force Distribution control unit - control system design - Traction Control System - Automatic transmission control systems - Adaptive cruise control - Vehicle stabilization system - Electronic Suspension System and stability control - Control design for differential braking-based systems *Laboratory Practice: Simulation model of Adaptive cruise control Integration*	

Unit-5 - Automotive Grade Processors and Controllers	***12 Hour***
Automotive grade processors: Renesas for electrified drive trains - Architectural attributes of automotive grade processors - On-chip peripherals for ECU-overview - On-chip peripherals for electric power train control - On-chip peripherals for battery system - Implementation of EV motor controller with DSP. *Laboratory Practice: CAN and LIN ECU/VCU Integration, IoT Enabled Control*	

Learning Resources	1. *William.B.Ribbens , "Understanding Automotive Electronics" 8th edition Butterworth-Heinemann publications,2017.* 2. *De Silva & Clarence W," Sensors and actuators: Engineering System Instrumentation", CRC Press, 2015.* 3. *Tom Denton, Automobile Electrical and Electronics System, Elsevier, 4th Edition, 2012.*	4. *Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, London, 2010* 5. *Robert Bosch GmbH (Ed.) Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, 5th edition, John Wiley & Sons Inc., 2007.* 6. *Rajesh R "Vehicle Dynamics and Control", 2nd Edition Springer, 2012.* 7. *Reza N. Jazar, "Vehicle Dynamics: Theory and Application," T3rd Edition, Springer, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. B. Hariram Satheesh - Principal Scientist – ABB, India	*1. Dr.B.RSelvajothy, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	*1. Dr. C. Balaji, SRMIST*
2. Mr. Manikandan, Ola Electric, India	*2. Dr.Senthilkumar – NIT, Trichy*	*2. Dr. P. Sandeep Kumar, SRMIST*

Course Code	21EVE303T	Course Name	BATTERY TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand about Battery technologies*
CLR-2:	*gain the knowledge on different types of batteries*
CLR-3:	*understand battery management system*
CLR-4:	*study the different application of electric vehicles*
CLR-5:	*impact of batteries on sustainable development*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain insight into various components associated with battery technology*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*explore various chemicals used for different types of batteries*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-3:	*understand battery composition and BMS*	*3*	-	-	-	-	-	-	*1*	-	-	-	-	-	-	-
CO-4:	*acquire the knowledge on battery capacity used for EV*	*3*	-	-	-	-	-	-	*2*	-	-	-	-	*2*	-	-
CO-5:	*acquire knowledge about the contribution of batteries on sustainable development*	*3*	-	-	-	-	-	-	*2*	-	-	-	-	*1*	-	*2*

Unit-1 – Overview of Battery Technologies	***9 Hour***
Introduction - History and evolution of Battery Technology - Basics of electrochemistry and battery fundamentals - Overview of different types of batteries - Battery terminology and key performance metrics - Battery components and their functions - Battery Electrodes and Electrolytes - Cell Construction and Battery Design - Overview of battery modeling and simulation	
Unit-2 - Battery Chemistry and Types	***9 Hour***
Introduction - Lead-acid batteries: composition and applications, Nickel Cadmium and Nickel Metal Hydride batteries: Composition and principles - Lithium-ion batteries: chemistry and variants - Solid-state batteries: principles and advancements - Flow batteries: concept and types - Metal air electrochemical cells: Introduction and types, Comparing energy density and power density of batteries - Novel materials and next-generation batteries	
Unit-3 - Battery Management and Performance	***9 Hour***
Introduction - Principles and requirement of battery management systems (BMS) - Thermal management in batteries - State of Charge (SoC) and State of Health (SoH) estimation - Battery charging strategies and algorithms - Degradation and life cycle analysis - Safety issues and failure modes - Diagnostics and prognostics in battery systems.	
Unit-4 - Battery Application in Electric Vehicles	***9 Hour***
Introduction - Battery capacity - Energy balance for electric vehicles - Battery testing and certification standards - Dynamics testing: acceleration and braking - handling and impact testing - Occupant protection systems testing - Capacity discharge testing - Active and passive safety systems in EVs - Compliance with global safety standards	
Unit-5 - Role of Batteries in Sustainable Development	***9 Hour***

Introduction - Advancement in renewable energy storage - Role of batteries in smart grids and energy systems - Future trends in battery technology - Innovation in battery design and manufacturing - Challenges and opportunities in battery technology development - Environmental impact of batteries: Manufacturing and disposal - Recycling and reusing battery materials - Policy and regulations impacting battery technology

Learning Resources	1. *Advances in Battery Technologies for Electric Vehicles, by Bruno Scrosati & Jürgen Garche & Werner Tillmetz* 2. *Electric and Hybrid Vehicles. Power Sources, Models, Sustainability, Infrastructure and the Market, by Pistoia G.* 3. *Energy Systems for Electric and Hybrid Vehicles by K. T. Chau*	4. *Electric Vehicle Batteries: Moving from Research towards Innovation: Reports of the PPP European Green, by Emma Briec & Beate Müller* 5. *Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002* 6. *Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost, by Gianfranco Pistoia & Boryann Liaw*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Bhaskarsahu, Schneider Electric Ltd, bhaskar.sahu@schneider-electric.com	*1. Dr. K. S. Swarup, IITM, ksswarup@iitm.ac.isn*	*1. Dr. Phani Teja Bankupalli. SRMIST*
2. Dr. D.Maharajan, Senior Project Engineer, Hitachi Energy, Chennai	*2. Dr. P.Somasundaram, Professor, Department of EEE, Anna University, mpsomasundaram@annauniv.edu*	*2. Dr. R.Sridhar, SRMIST*

Course Code	21EVE304T	Course Name	TECHNO-ECONOMIC ANALYSIS OF ELECTRIC VEHICLE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the principles, components, and types of electric vehicles*
CLR-2:	*analyze the technological aspects of electric vehicles, including batteries, motors, power electronics, charging infrastructure, and energy storage*
CLR-3:	*evaluate the life cycle assessment, cost analysis, energy consumption and efficiency, carbon footprint, and environmental impact of electric vehicles*
CLR-4:	*identify the market trends, government policies, incentives, regulatory frameworks, and public perception of electric vehicles*
CLR-5:	*analyze case studies of electric vehicles and study the future trends of electric vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze basic configuration of electric vehicle*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*analyze the technological aspects of electric vehicles*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-
CO-3:	*acquire knowledge on economic analysis of EV*	*3*	-	-	-	-	-	-	*2*	-	-	*1*	-	*1*	-	-
CO-4:	*acquire knowledge on market trends and government policies*	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-	-
CO-5:	*familiarize different electric vehicles using case studies and the future trends of electric vehicles*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 – Overview of Electric Vehicles	***9 Hour***
History of electric vehicles: from early electric car prototypes to current models- Types of electric vehicles: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs)- Comparison with conventional vehicles: advantages and disadvantages of electric vehicles compared to traditional gasoline-powered cars- Key components of an electric vehicle: battery pack, electric motor, power electronics, on-board charger, regenerative braking system.	
Unit-2 - Technical Analysis of Electric Vehicles	***9 Hour***
Electric powertrain components: motor controller, inverter, gearbox, differential, axles- Battery technologies and charging systems: lithium-ion batteries, solid-state batteries, charging stations, charging time and range considerations- Power electronics and electric motors: brushless DC motors, induction motors, permanent magnet synchronous motors, power density and efficiency- Range, efficiency, and performance analysis: factors affecting electric vehicle range, energy efficiency metrics, acceleration, top speed, and handling performance.	
Unit-3 - Economic Analysis of Electric Vehicles	***9 Hour***
Total Cost of Ownership (TCO) analysis: upfront costs, fuel and maintenance savings, residual value, and financing options- Life-cycle assessment (LCA) of electric vehicles: environmental impact of electric vehicle manufacturing, use, and disposal-Policy incentives and regulatory environment: government subsidies, tax credits, and regulations promoting electric vehicle adoption- Business models for electric vehicle adoption: car sharing, ride-hailing, and subscription services- Carbon footprint analysis of electric vehicles.	
Unit-4 - Market Analysis of Electric Vehicles	***9 Hour***

Global electric vehicle market trends and forecasts: sales volume and growth, regional market shares, and competitive landscape- Market segmentation and customer behavior: consumer demographics, purchase motivations, and brand preferences- Electric vehicle adoption barriers and opportunities: infrastructure availability, battery range anxiety, consumer education, and technology advancement- Electric vehicle supply chain analysis: key players, value chain, and technology innovation.
Unit-5 - Case Studies and Future Outlook ***9 Hour***
Techno-economic analysis of electric vehicle case studies: cost-benefit analysis, impact on local economies, and user experience- Comparison of different electric vehicle models: market positioning, features, and performance- Future trends in electric vehicle technology and market adoption: autonomous driving, vehicle-to-grid (V2G) integration, and innovation in battery technology- Challenges and opportunities for electric vehicles: energy storage, power grid integration, and environmental sustainability.

Learning Resources	1. *Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamental", third edition, CRC Press, 2021.* 2. *James Larminie and John Lowry, "Electric Vehicle Technology: Exploring the Electric Vehicle Revolution", second edition, Wiley, 2012.* 3. *Gianfranco Pistoia, "Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market", first edition, Elsevier; 2010.*	4. *David Beeton, Gereon Meyer, "Electric Vehicle Business Models: Global Perspectives", first edition, Springer, 2019.* 5. *David L. Levy and Shanti Gamper-Rabindran, "Electric Vehicles in the Global Context: Experiences and Lessons from Seven Countries", first edition, MIT Press, 2018.* 6. *Yasuaki Sakamoto and Mark F. Miller, "Innovation in Electric Vehicle Technology", second edition, Springer, 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Murali, ZF India	*1. Dr. K. S. Swarup, IIT Madras*	*1. Dr. D. Sattianadan, SRMIST*
2. Dr. Shankar Venugopal, MTA, Mahindra and Mandira , India	*2. Dr. P. Somasundaram, Anna University, Chennai*	*2. Dr. C. Bharatiraja, SRMIST*

Course Code	21EVE305T	Course Name	AUTOMOTIVE MATERIALS AND MANUFACTURING PROCESSES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on the materials used for automotive components.*
CLR-2:	*learn about the lightweight materials for engineering applications*
CLR-3:	*familiarize the usage of composite material for automotive applications*
CLR-4:	*know about the advanced manufacturing process for automotive components*
CLR-5:	*understand the intricate relationship between material properties, component functionality, and manufacturing processes*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*familiar with advanced engineering materials*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*select the most appropriate lightweight material for automotive applications*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*illustrate the properties of composite material for automotive applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*evaluate advanced material properties for automotive components and select appropriate materials*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*evaluate the cause for failure of the components due to material or manufacturing process and recommend the appropriate remedy to avoid the failure*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Automotive Components and Materials — ***9 Hour***

Automotive components categories - Different materials used for automotive components - Functionality considerations of automotive parts - Factors influencing the selection of materials - Influence of material properties on functionality and forming - Strengthening mechanisms and their need - Ferrous and nonferrous metals - Analysis of the relative merits and demerits of metallic materials - Non-metallic materials - Thermoplastic and thermosets usage - Ceramic materials: Need for ceramics - Advantages and limitations of non-metallic materials.

Unit-2 - Lightweight Materials for Engineering Applications — ***9 Hour***

Introducing lightweight materials - Value vs. weight - Weight effect on fuel consumption - weight distribution in automotive - Crash safety laws - Trinity of lightweight design - Lightweight material implementations - Lightweight automotive materials: Magnesium alloys, Aluminum alloys, advanced high-strength steels, carbon fiber composites - Efficient material utilization - Steel body in white - Automotive materials: environmental and safety viewpoints - Improving crashworthiness - Multi-material enabling - Design strategies to get lightweight design - Hybrid design - CAE analysis and simulation for modeling of lightweight materials.

Unit-3 - Composites in Automotive Environment — ***9 Hour***

Need for composites - Properties of engineering composites and their limitations - Significance of Polymer - Metal and Ceramic matrix composite systems - Property correlation with reinforcement shape and distribution - Processing and application of different composites for automotive components.

Unit-4 - Advanced Manufacturing Process of Automotive Components — ***9 Hour***

Conventional casting and forging processes - Forming technology for lightweight materials - Powder metallurgy - Non-conventional machining technologies (Ultrasonic machining, Water jet cutting, Electrochemical processing, Laser cutting) - Joining technologies current and emerging: resistance spot welding, clinching, friction stir welding, Laser welding, Adhesive joining, structural adhesives, self-

piercing rivets, Thermal joining - Processing of Non-metallic materials for automotive components: Molding, Extrusion, Thermoforming, Foam moulding and tooling - Processing of ceramics: Slip casting technique.
Unit-5 - Selection of Materials and Manufacturing Techniques ***9 Hour***
Correlation of functionality of the component with material properties - Factors influencing material selection - Derivation of performance index based on the functionality of the component - Ashby technique for material selection - Shape factor - Selection of materials and processes based on the functionality and manufacturing feasibility - Case studies.

Learning Resources	1. *M. F. Ashby and H. Shercliff, D. Cubon, (2007) Materials Engineering Science, Processing and Design (fourth edition), Butterworth Publications.* 2. *C. Brian, G. Patrick and J. Colin. (2007) Automotive Engineering: Light Weight, Functional and Novel Materials, Taylor & Francis.* 3. *M. P. Groover. (2005) Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd edition, John Wiley & Sons.* 4. *W. D. Callister. (2005) Materials Science and Engineering an Introduction, 6th edition, John Wiley & Sons.*	5. *H. Yamagata. (2005) The Science and Technology of Materials in Automotive Engines, Yamaha Motor Co. Ltd., Japan Woodhead Publishing Limited.* 6. *G. Davies. (2003) Materials for Automobile Bodies, Butterworth-Heinemann Publications.* 7. *S. Kalpakjian and S. R. Schmid. (2003) Manufacturing Engineering and Technology, Pearson Education.* 8. *K. G. Budinski and M. K. Budinski. (2002) Engineering Materials Properties and Selection, 7th edition, Prentice-Hall of India.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Srinivasan Vijayaraghavan, Altair	*1. Dr.B.Raja, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	*1. Dr. Shubhabrata Datta, SRMIST*
2. Mr.Deepak Mohan Founder, Ozone Motors	*2. Dr.K.Ravikumar - IIT Delhi*	*2. Dr.G.Murali SRMIST*

Course Code	21EVE306T	Course Name	BATTERY MANAGEMENT SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*overview of battery management systems*
CLR-2:	*understand the concepts of requirements in BMS*
CLR-3:	*learn the control of battery managements*
CLR-4:	*understand various controls used in vehicle dynamics*
CLR-5:	*acquire knowledge on future trends in automotive vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the concept of electronic units*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*gain knowledge on the concepts of sensors and actuators*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*familiarize the principles of digital engine control systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*understand the processes on various controls on vehicles dynamics*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*acquire knowledge on future trends in automotive systems*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 – Overview of Battery Management Systems	***9 Hour***
Introduction to Battery Management System - Need of BMS Cells & Batteries - Electrochemical and lithium-ion cells - Rechargeable cell - Nominal voltage and capacity - C rate - Energy and power - Cells connected in series - Cells connected in parallel - Modes of Charging-Charging and Discharging Process - Overcharge and Undercharge - Classification of BMS by Topology and Function.	
Unit-2 - BMS Functionality and Requirements	***9 Hour***
Introduction to BMS functionality: CC-CV charger, monitor, balancer, protector - Requirements of BMS: Voltage Sensing, Temperature Sensing, Current Sensing, Isolation sensing, - High-voltage contactor control - Protection and interface - Communication Interface - Range estimation - State-of-charge estimation - State of Health estimation - Battery Life - Cycles of operation - Energy and power estimation.	
Unit-3 -Battery Management and Control	***9 Hour***
Control of battery management systems: basic thermal and high-voltage electrical control - Architectures for modular design, and different methods for cell equalization - Algorithms for estimating state-of charge and state-of-health - Model-based state estimation - Stack Management - Thermal Dynamics - Thermal Management - Cell balancing – Types - Active, Passive - SoC Algorithms - Battery cooling System - Circuits of balancing - Causes of cell imbalance - Aging of different types of batteries: challenges, modeling and solution methods.	
Unit-4 - Modelling and Simulation	***9 Hour***
Equivalent-circuit models (ECMs) - Physics-based models (PBMs) - Empirical modelling approach - Physics-based modelling approach - Vehicle range calculations – Simulation of constant power and voltage battery packs	
Unit-5 - Design of BMS	***9 Hour***
Design principles of battery BMS - Effect of distance - Load and force on battery life and BMS - Energy balancing with multi-battery system - BMS ASIC-bq76PL536A-Q1 Battery Monitor IC- CC2662R-Q1 Wireless BMS MCU - Communication Modules - CAN Open-Flex Ray - CANedge1 package. ARBIN Battery Tester - BMS Development with Modeling software and Model- Based Design.	

Learning Resources	1. *Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.* 2. *Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.* 3. *Ibrahim Dinçer, Halil S. Hamut and Nader Javani, Thermal Management of Electric Vehicle Battery Systems, John Wiley& Sons Ltd., 2016.*	4. *Balakumar Balasingam, Robust Battery Management System Design With MATLAB, Artech, 2023.* 5. *Gregory Plett, Battery Management Systems, Volume II: Equivalent-Circuit Methods, Artech, 2015.* 6. *Jingshan Liand et al, Advances in Battery manufacturing, service, and Management Systems, Wiley-IEEE Press 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. C.S Naveen, Decibels Lab Private Limited, Bangalore	*1. Dr. K. Selvajyothi, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	*1. Mr.B.Vinothkumar, SRMIST*
2. Mr. Nikhilesh Mishra - Grinntech Motors & Services (P) Ltd	*2. Dr. Sreedhar Madichetty, Mahindra University*	*2. Mr.V.Manojkumar, SRMIST*

Course Code	21EVE307T	Course Name	ADVANCED POWER ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the advanced power switching devices like SiC and GaN*
CLR-2:	*comprehend the design and modelling of DC-DC converters*
CLR-3:	*understand the concepts of resonant converters*
CLR-4:	*design power electronic front end converters to improve power factor*
CLR-5:	*explore advancements in high power inverters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge on the concepts of SiC and GaN devices and its application*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*develop power converter models under steady-state and small-signal conditions*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze and design resonant converters*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*articulate the concept of front-end converter design for power factor enhancement*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*develop high power inverters to improve power quality*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Modern Power Electronic Devices	***9 Hour***
Construction and Operation of SiC and GaN based Power Electronic switches – Steady state and Transient VI characteristics of high frequency switches – Design of Driver circuits – Design of heat sink, Challenges in SiC and GaN MOSFETs.	
Unit-2 – DC to DC Converters Design and Modelling	***9 Hour***
Converter transfer functions for buck, boost and buck-boost topologies - Basic AC modeling approach - State space averaging - Circuit averaging and averaged switch modeling - High voltage gain converters - Multi-Port Converters.	
Unit-3 – Design of Resonant Converters	***9 Hour***
Resonant Converter – Principles and Types of resonant converter: Series, Parallel and Series-Parallel, Resonant switch converters: ZCS, ZVS, Resonant DC Link Converter – Resonant inverter: Design, modes of operation and characteristics.	
Unit-4 - Front-End Converters	***9 Hour***
Traditional methods to improve power factor: Semi- converter, extinction angle control, symmetrical angle control – Active front-end converters - Single phase: Boost, voltage doubler and PWM rectifiers –voltage and current controlled three-phase PWM rectifiers	
Unit-5 - High Power Inverters	***9 Hour***
Review of two-level inverters - SPWM and SVPWM techniques for inverter operation - Diode clamped multilevel inverter: Neutral point voltage balance, Active Neutral Point Clamped Inverter - Modular multilevel inverters - Reduced switch count multilevel inverters.	

Learning Resources	1. *Ned Mohan, Tore M. Undeland, and William P. Robbins, "Power Electronics: Converters, Applications, and Design" Wiley, 2015.* 2. *B. Jayant Baliga, "Power Semiconductor Devices and Circuits" World Scientific, 2016.* 3. *Weuzeli Cipriano, Edison Roberto, "Advanced Power Electronics Converters", IEEE Press, Wiley, 2015.* 4. *Muhammad H. Rashid, "Power Electronics: Converters, Applications, and Design" Cengage Learning, 2018.*	5. *Marian K. Kazimierczuk, "Resonant Power Converters" Wiley, 2011.* 6. *Henry Shu-hung Chung; Huai Wang; Frede Blaabjerg; Michael Pecht, "Reliability of Power Electronic Converter Systems" IET Digital Library, 2015.* 7. *Joseph Vithayathil, "Power Electronics: Principles and Applications" CRC Press, 2019.* 8. *J. Michael Jacob, "Power Electronics: Principles and Applications" Tata McGraw-Hill Education, 2008.* 9. *Nihal Kularatna, "Power Electronics Design Handbook: Low-Power Components and Applications" Newnes, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Bhaskarsahu, Schneider Electric Ltd,India	*1. Dr. Bradley Lehman, Northeastern University, USA*	*1. Dr. C. Bharatiraja, SRMIST*
2. Dr. B. Hariram Satheesh - Principal Scientist – ABB, India	*2. Dr.Sanjeevikumar Padmanaban Professor, University of South-Eastern Norway*	*2. Dr. Ravi Eswar K M, SRMIST*

Course Code	21EVE308J	Course Name	ELECTRIC VEHICLE POWERTRAIN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of electric vehicles power train*
CLR-2:	*analyze the electric vehicles dynamics and transmission characteristics*
CLR-3:	*understand the modelling of electric vehicles power train*
CLR-4:	*analyze the modeling and simulation of electric vehicles power train batteries*
CLR-5:	*understand the modelling of thermal management system electric vehicles power train subsystems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine the modelling and characterization of electric vehicles power train*	*3*	*2*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-2:	*familiarize electric vehicles dynamics*	*3*	*-*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-3:	*design and development of electric vehicles power train subsystems*	*3*	*2*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-4:	*acquire knowledge on modeling, design, and deployment of batteries in electric vehicles*	*3*	*2*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-5:	*perform a software simulation of an electric vehicles power train with real-time thermal constraints*	*3*	*2*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*

Unit-1 – Overview of Electric Vehicles Power Train	***12 Hour***
Fundamental concept and components of EV Power Train - EV Power Train Classifications - Transmission and driveline systems - Vehicle layout with reference to power plant location and drive systems - Classification of vehicle based on body types - Powertrain Components Selection - Nomenclature and understanding calculation for EV components - Tradeoff analysis and component sizing - Control parameter optimization. Laboratory Practice: Simulation on EV Power Train to validate the traction performance.	
Unit-2 - Electric Vehicles Power Train Dynamics	***12 Hour***
Basics of Vehicle Dynamics - Fundamental approaches to vehicle dynamics modeling - SAE Vehicle axis system, Forces, and Moments Affecting Vehicle - Earth Fixed coordinate system and Dynamic axle loads - Equations of motion - Transmission characteristics. Acceleration Performance Power train components: power and traction limited acceleration - transverse weight shift - front wheel drive vs rear wheel drive vs. all-wheel drive vehicles. Laboratory Practice: EV all-terrain vehicle, EV four wheel vehicle dynamics model.	
Unit-3 - Modelling of Power Train	***12 Hour***
Electric plant subsystem – Four-wheel powertrain system model - Electric vehicle motor and battery sizing calculation - Optimizing vehicle electrical design through system level simulation - Quasi-static approach based powertrain modeling - Dynamic approach based powertrain modeling, Advanced transmission sizing and optimization - Driving cycles modelling and analysis of electric and hybrid electric vehicles propulsion and braking - Vehicle braking modelling and analysis - High-fidelity model of an electric motor for control system design and verification - EV powertrain design with model-based development. Laboratory Practice: Modeling and simulation of propulsion and braking system.	
Unit-4 - Modeling of Batteries and Simulation	***12 Hour***

Equivalent circuits to represent the dynamic behavior of a battery cell - Battery data acquisition and analysis - Battery modeling- Impact of cell temperature on battery aging -Modeling battery management systems - Battery thermal management system design - Model-based parameter identification of healthy and aged Li-ion batteries-Thermal effect and cooling system development - Li-ion cell modeling and battery management system modeling - Hardware-in-the-loop battery and BMS testing for electric vehicle (HEV) power train. *Laboratory Practice: Modeling of EV battery packs & its SoC and SoE Estimation.*
Unit-5 - Thermal Management System ***12 Hour***
EV Thermal management systems - Battery Thermal Management System Design - Battery cooling and heating -Motor cooling systems - Power electronics cooling - HVAC system - Power conditioning and Filtering, Power, Voltage Conversion- Cooling system - Battery electric vehicle with liquid-cooled motor – Model based Design of EV motor control development time using simulation models to design and verify control algorithms. Laboratory Practice: Electric Vehicle Thermal Model and Thermal Management System.

Learning Resources	1. *Amir Khajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid Vehicles-Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, first edition, 2014.* 2. *Chris Mi, Abul Masrur & David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.* 3. *Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley& Sons Ltd, first edition, 2016.*	4. *Ali Emadi, "Handbook of Automotive Power Electronics and Drives", Taylor & Francis Group, first edition, USA, 2005.* 5. *Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation", IGI Global, 2013.* 6. *M. Ehsani, Y. Gao, S. Longo, K. Ebrahim," Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", third edition.* 7. *Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design, second edition", CRC Press, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*15%*	*30%*	-
Level2	*Understand*	*20 %*	-	-	*15%*	*30 %*	-
Level3	*Apply*	*20 %*	-	-	*20%*	*20 %*	-
Level4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	*10%*	-	-	*15%*	-	-
Level 6	*Create*	*10%*	-	-	*15%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Haricharan.radhakrishnan, Volvo trucks India	*1. Dr. Raghu Selvaraj, CSIR-Central Mechanical Engineering Research Institute (CMERI), India*	*1. Dr. C. Bharatiraja, SRMIST*
2. Mr. Shivambhati, Abhinava Rizel Pvt, India	*2. Dr. Sheldon Williamson, Ontario Tech University, Canada*	*2. Dr. K. Vijayakumar, SRMIST*

Course Code	21EVE309J	Course Name	ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of energy storage systems*
CLR-2:	*analyze the different types and applications of energy storage systems*
CLR-3:	*understand the battery characteristics and parameters*
CLR-4:	*apply the concept of battery modelling and battery management system*
CLR-5:	*understand battery testing, battery disposal and recycling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on various parts of the energy storage systems and their functions*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*describe discharging and charging process of a lithium-ion battery*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the characteristics and parameters of batteries*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*design the lithium-ion battery packs and battery management system*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*perform battery testing and recycling of secondary batteries*	*3*	-	-	-	-	-	*2*	*2*	-	-	-	-	-	-	*2*

Unit-1 – Introduction to Energy Storage ***12 Hour***

History of energy storage - Energy storage processes - Technologies and applications - Flow batteries - Lithium-ion batteries - Introduction to lithium-ion battery: Components, functions, advantages and disadvantages of lithium-ion batteries - Growth and development of Li-Ion batteries - Charging procedures and charging speed - Depth of discharge limitations and cycle lives.
Laboratory Practice: Simulation of Lithium-ion batteries

Unit-2 – Selection of LI-ion Battery ***12 Hour***

Types of lithium-ion battery: Lithium Cobalt Oxide (LCO), Lithium Iron Phosphate Battery (LFP), Lithium Manganese Oxide (LMO), Lithium Nickel Cobalt Aluminum Oxide (LNCA), Lithium Nickel Manganese Cobalt Oxide (LNMC), Lithium Polymer battery, Lithium Polymer battery technology - Difference between the lithium ion and lithium polymer - Applications of Li-ion battery: Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements, Automotive applications- Drive cycles, SLI (starting, lighting and ignition) batteries - Start-stop (Micro) Hybrids, Power assist hybrids.
Laboratory Practice: Simulation of Lithium Polymer Battery

Unit-3 - Battery Characteristics ***12 Hour***

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics - Efficiency of batteries - Heat generation - Battery design - Performance criteria for Electric vehicles batteries - Power and energy requirements of batteries- Battery operating and performance parameters - Charge-discharge characteristics of batteries - Measurement of current, voltage and temperature.
Laboratory Practice: Performance analysis of batteries

Unit-4 - Battery Modelling and Management Systems ***12 Hour***

General approach to modelling batteries - Selection of battery for EVs and HEVs - Traction battery pack design - Requirement of battery monitoring - Battery state of charge estimation methods - Battery cell equalization problem - Thermal control - Energy and Power estimation - Battery management system: Definition, Parts: Power Module, Battery, DC-DC Converter, load - Communication channel - Battery pack safety - Battery standards and tests - Cell balancing: Causes of imbalance, Active Balancing, Passive balancing *Laboratory Practice: Simulation of BMS*
Unit-5 - Testing and Recycling of Batteries ***12 Hour***
Battery testing - Limitations for transport and storage of cells and batteries – Recycling - Disposal and second use of batteries - Battery Leakage: gas generation in batteries, leakage path, leakage rates - Ruptures: Mechanical stress and pressure tolerance of cells, safety vents - Explosions: Causes of battery explosions, explosive process - Thermal Runway: High discharge rates, short circuits, charging and discharging - Environment and Human Health impact assessments of batteries - General recycling issues - Methods of recycling of EV batteries. *Laboratory Practice: Testing of batteries*

Learning Resources	1. *Wu, Yuping, "Lithium-ion Batteries Fundamentals and Applications", CRC Press, Taylor and Francis, first edition, 2015.* 2. *San Ping Jiang, "Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles", Wiley, first edition, 2015.* 3. *James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley and Sons Ltd, second edition, 2012.*	4. *Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley and Sons Ltd., first edition, 2016.* 5. *Ralph J. Brodd, Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa, "Lithium-Ion Batteries Science and Technologies", Springer, 2009.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manikandan, OLA Electric	*1. Dr. Selvajyothi, IIITDM*	*1. Dr. K.Vijyakumar, SRMIST*
2. Dr. K. Karthikeyan, ABB India Ltd.	*2. Dr. Ragavan K., IIT Gandhinagar*	*2. Mr. D. Selvabharathi, SRMIST*

Course Code	21EVE401T	Course Name	FUEL CELL ELECTRIC VEHICLES AND HYDROGEN TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understanding fundamental hydrogen production and utilization*
CLR-2:	*exploring diverse fuel cell types for application insights*
CLR-3:	*analyzing fuel cell roles, safety, and vehicle comparisons*
CLR-4:	*investigating varied FCEV designs and component intricacies*
CLR-5:	*comprehending powertrain elements' function and regulation for FCEVs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the fundamental principles hydrogen production and utilization*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*2*
CO-2:	*ability to differentiate and assess various fuel cell types, understanding their specific applications*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	-
CO-3:	*analyze the role of fuel cells in automobiles, examining safety considerations and conducting comparative evaluations*	*3*	*1*	-	-	-	-	-	*2*	-	-	-	-	*2*	-	-
CO-4:	*investigate diverse FCEV designs, exploring their intricate components and operational complexities*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*comprehend the function and control mechanisms of powertrain components regulating FCEVs*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Hydrogen Energy	***9 Hour***
Introduction to hydrogen economy - Hydrogen production: green hydrogen, blue hydrogen and grey hydrogen, storage and transportation systems - Electrolysis of water - Thermos chemical cycles - Transmission and infrastructure requirements - Safety and environmental impacts - Applications of hydrogen gas: Industrial and energy applications - Use of hydrogen in mobility	
Unit-2 - Fuel Cell Technology	***9 Hour***
Introduction to Fuel cell Technology - Working principle and operational characteristics of fuel cell - Types of fuel cells - Advantages and limitations of fuel cell - Application of fuel cell – Case Study - Overview of fuel cell modeling and simulation - Electrical equivalent model of fuel cell - Fuel cell power conditioning systems – Introduction and applications	
Unit-3 - Fuel Cells in Automotive Applications	***9 Hour***
Introduction to fuel cell electric vehicle (FCEV) - FCEVs across the world - Comparison of battery electric vehicle and FCEV - Research and Development of high - Performance fuel Cell for EV - Fuel cell propulsion system - Safety and standards of FCEV - Case study: Analyze real-world data and user experiences to compare the performance - Environmental impact, and market acceptance of BEV and FCEV.	
Unit-4 - Architecture and Components of Fuel Cell Electrical Vehicle	***9 Hour***

Architecture of FCEV - Pure FCEV and Hybrid FCEV topologies - Fuel cell and Battery (FC + B) - Fuel Cell + Ultra capacitor (FC + UC) - Fuel Cell + Battery + Ultra capacitor (FC + B + UC) - Case study: Simulate FC powered motor control.
Unit-5 - Control and Management of FCEV ***9 Hour***
Analysis of pure FCEV and Hybrid FCEV topologies - Basic control strategies for FCEVs - Controller for voltage regulation - Controller for power regulation - Simplified handling models for power, energy management - Controllers for energy management - Rule-based control strategies - Optimization-based control strategies - Case study: Optimization strategies employed for the powertrain components

Learning Resources	1. *Hydrogen Fuel: Production, Transport, and Storage edited by Ram B. Gupta CRC press -2009* 2. *Electric and Hybric-Electric Vehicles: Fuel Cell Hybrid EVs - Ronald Jurgen - SAE, 2011.* 3. *J Larminie, A L Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley, 2013* 4. *X Li, Principles of Fuel Cells, Taylor and Francis, 2005* 5. *Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009*	6. *Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.* 7. *Automotive Fuel Technology-Electric, Hybrid and Fuel-Cell Vehicles: Jack Erjavec& Jeff Arias - Thomson Delmar Learning, 2007*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Makrand Lad, Volvo Group	*1. Dr. Raghu Selvaraj, CSIR-Central Mechanical Engineering Research Institute (CMERI), India*	*1. Dr. Phani Teja Bankupalli, SRMIST*
2. Mr.Siddharth,Keysight Technologies India Pvt. Ltd.	*2. Dr. Deevesh Sharma, CSIR Durgapur, India*	*2. Dr.C.Bharatiraja, SRMIST*

Course Code	21EVE402T	Course Name	ELECTRIC VEHICLES THERMAL DESIGN AND MANAGEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize about the heat transfer phenomenon in electric vehicles*
CLR-2:	*understand the heat generation in the motor*
CLR-3:	*develop insight and the need of thermal management in traction batteries*
CLR-4:	*familiarize and execute controllers for various power electronics devices*
CLR-5:	*insight on the reliability analysis on various thermal components that are prone to failure.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the heat transfer equations to understand the physics of heat generation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*perform thermal analysis on motors*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*perform thermal and electro chemical analysis on Batteries*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*implement effective heat dissipation strategies for power conditioner*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*perform reliability analysis on various thermal components*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Heat Transfer Fundamentals	***9 Hour***
Need for heat transfer study in electric vehicles - Fundamental criteria for heat transfer - Modes of heat transfer - conduction and convection rate equations - Thermal properties - Heat diffusion equation - boundary and initial condition - Plane wall - temperature distribution, thermal resistance	
Unit-2 -Thermal Management of Motors	***9 Hour***
Cause of heat generation in motors - Sources of heat transfer at various points - losses within the stator slot-windings - stator laminations, rotor laminations, and rotor magnets or conductors - Effect of motor type and operating condition (torque, speed) on heat distribution - Operational temperature limitations of electrical insulation - Impact of material interfaces on temperature distribution and heat transfer.	
Unit-3 - Thermal Management for Batteries	***9 Hour***
Temperature sensitivity of batteries heat generation in various batteries - Factors affecting heat generation - Electrochemical factors - Internal heat generation - Rate of Discharge - Joules heat - Battery ageing effect - SoC-operating current - Enthalpy and Entropy change - Thermal runaway - Battery thermal management systems - With and without vapour compression cycle (classification) and layout	
Unit-4 - Thermal Management for Electric Circuits	***9 Hour***
Thermal management in power electronics and controllers - Manage and dissipate heat - Limit failure - increase reliability – Increase power density - Reduce Cost - Thermal conductivity analysis of various materials used in PCB - Heat sink configuration and design - Heat Pipe geometry - Design and calculation - Liquid cooled plates - Materials for gap free interfacing - Micro-fluidics - Advanced Cooling: Nano-fluids - Materials and its effects	

Unit-5 - Reliability Analysis of Thermal Components	***9 Hour***
Reliability analysis of various components - Mean time between failure of various components - Bayes law - Notion of a probability model and the likelihood - Monte Carlo techniques - Latin hypercube sampling - Variance reduction technique.	

Learning Resources	1. *Advances in Battery Technologies for Electric Vehicles, 1st Edition, Editors: Bruno ScrosatiJurgenGarche Werner Tillmetz, Hardcover ISBN: 9781782423775, e-Book ISBN: 9781782423980, Imprint: Woodhead Publishing, Published Date: 21st May 2015.* 2. *Linden's Handbook of Batteries, Fifth Edition 5th Edition, by Kirby W. Beard (Author), ISBN-13: 978-1260115925, ISBN-10: 1260115925.* 3. *Hydrogen and Fuel Cells Emerging Technologies and Applications, Book • 2nd Edition • 2012 Authors: Bent Sørensen, Hardcover ISBN: 9780123877093, eBook ISBN: 9780123965035.*	4. *Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals" Published by: CRC Press, Boca Raton, Florida, USA, 2003.* 5. *Thomas B. Johansson," Renewable Energy: Sources for Fuels and Electricity" Islan Press 2009*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Shivam Bhatia, Abhinava Rizel Pvt.lt, India	*1. Dr.B.Raja, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	*1. Dr. Shubhabrata Datta, SRMIST*
2. Mr.Sandeep, Matlab	*2. Dr.K.Ravikumar - IIT Delhi*	*2. Dr.S.Manikandan, SRMIST*

Course Code	21EVE403T	Course Name	VEHICLE TROUBLESHOOTING AND MAINTENANCE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the Fundamentals parts of automotive computers
CLR-2:	comprehend the self-troubleshooting equipment with trouble codes
CLR-3:	enrich the knowledge of troubleshooting tools
CLR-4:	understanding the faults and testing methods
CLR-5:	study the onboard troubleshooting equipment

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	understand the basics of automotive computers and network systems	3	-	-	-	2	-	-	-	-	-	-	-	1	-	-
CO-2:	cognize the self-troubleshooting equipment and limitations	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO-3:	development of troubleshooting tools with equipment's	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	examine the faults and testing the vehicles in six-step approach	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO-5:	familiarize the onboard troubleshooting equipment and limitations	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-

Unit-1 - Computer Engine Control	**9 Hour**
Automotive computer system - Principles of operation - Computer data - Computer interfaces - Control of output devices - Computer memories - Fault codes - Adaptive operating strategy of the ECM - Networking of computers - Vehicle network systems - Prototype network systems	
Unit-2 - Self-Troubleshooting and Fault Codes	**9 Hour**
Access to Diagnostic trouble codes (DTC) - Developments in self-diagnosis - Diagnostic equipment and limitations of DTCs - Diagnostic equipment and limitations of DTCs.	
Unit-3 - Troubleshooting Tools and Equipment	**9 Hour**
Breakout boxes - Diagnostic tools connected to ECM - Digital multimeter - Portable flat screen oscilloscopes - Diagnostic tool and oscilloscope combined - Pressure gauges - Calibrating test instruments - Location charts and wiring diagrams - Sources of diagnostic data - Exhaust gas emissions and emission system testing.	
Unit-4 - Troubleshooting Techniques	**9 Hour**
Circuit testing - Vehicle-specific details - Six-step approach - Skills required for effective diagnosis - An approach to fault finding - Emissions testing - Ignition system tests - Diesel injection - Sensor tests on other systems - Intermittent faults.	
Unit-5 - On-Board Troubleshooting	**9 Hour**
On-board troubleshooting – a first perspective - gasoline on-board diagnostic monitors - On-board diagnostics – a second perspective - OBD for Engine systems - chassis systems - electrical systems - transmission systems	

Learning Resources	1. *Allan W. M. Bonnick, Automotive Computer Controlled Systems Diagnostic tools and techniques, Butterworth-Heinemann, 2011.* 2. *Tom Denton, Advanced Automotive Fault Diagnosis, Second Edition,2006.* 3. *Automotive Technology Principles, Diagnosis, and Service By James D. Halderman · 5th Edition 2016..*	4. *Modern Automotive Technology for Maintenance and Light Repair By James E. Duffy · 2019* 5. *Brakes, Brake Control and Driver Assistance Systems Function, Regulation and Components, Springer Fachmedien Wiesbaden,2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Shekhar Malani - Devise Electronics Pvt. Ltd	*1. Dr.B.Raja, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	*1. Dr. Shubhabrata Datta, SRMIST*
2. Mr. C S Naveen, Decibels Lab Private Limited, Bangalore	*2. Dr. Raghu Selvaraj, CSIR-Central Mechanical Engineering Research Institute (CMERI), India*	*2. Dr.C.Bharatiraja, SRMIST*

Course Code	21EVE404T	Course Name	EV PRODUCT DEVELOPMENT PROCESSES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the basics of product design in EV
CLR-2:	understand the market and consumer needs
CLR-3:	enrich the knowledge of planning EV product
CLR-4:	understand the testing of product with standards
CLR-5:	study the EV Certification process and marketing strategies

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	understand the importance of product design and development	3	1	-	-	-	1	-	1	-	-	-	-	-	-	-
CO-2:	comprehend the needs and challenges	3	-	-	-	-	-	-	2	-	-	-	-	1	-	-
CO-3:	development of Key performance indicators with market research	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	illustrate the EV testing procedure and standards	3	2	-	-	-	-	-	3	-	-	-	-	2	-	-
CO-5:	familiarize the concept of manufacturing product with commercialization	3	-	-	-	-	-	-	-	-	-	1	-	2	-	-

Unit-1 - Product Design and Development — **9 Hour**

Importance of Engineering and Industrial design -design process - Relevance of product lifecycle issues in design - Societal considerations in Engineering and Industrial Design - Generic product development process - Various phases of product development - Planning for products - Product Development for Safety - Product Safety and User Safety Concepts - Examples of Safe Developments - Design Standardization and Cost Reduction.

Unit-2 - Market Needs — **9 Hour**

Market Trends and Forecasts for Electric Vehicles - Consumer Adoption Patterns and Factors Influencing EV Purchases - Regulatory Landscape: Incentives, Policies, and Standards-Case Studies of Successful EV Market Penetration - Market Challenges and Opportunities for EV Product Developers Voice of Customer (VoC) - Customer populations - Hierarchy of human needs - Need gathering methods - Establishing engineering characteristics - Competitive benchmarking - Quality Function Deployment (QFD) - House of Quality (HoQ)

Unit-3 - Planning EV Products — **9 Hour**

Product Development - Lifecycle for Electric Vehicles - Identifying Target Markets and Customer Segments - Setting Product Development Objectives and Key Performance Indicators (KPIs) - Conducting Feasibility Studies and Market Research - Creating an EV Product Concept, Design and development

Unit-4 - Testing of Products and Standards — **9 Hour**

Prototyping Techniques for Electric Vehicles - Virtual Prototyping and Simulation Tools - Physical Prototyping and Testing Processes - Performance Testing: Range, Efficiency, Safety, and Reliability - Iterative Design and Feedback Loops in Prototyping - Standardization Methodology - Benefits of Product Standardization; International, National, Association and Company Level Standards; ISO 12405, ISO 18243, ISO 15118, ISO 26262, IEC 61851 for EMI and EMC, SAE J2990, ARAI, Tesla Standards and IP ratings.
Unit-5 - Manufacturing and Commercialization ***9 Hour***
Design for Manufacturing (DFM) in EV Product Development - Supply chain management for electric vehicle components - Regulatory compliance and certification processes -Marketing and branding strategies for EVs - launching and scaling EV products in the Market

Learning Resources	1. *Karl T.Ulrich, Steven D.Eppinger, Anita Goyal, "Product Design and Development", McGraw –Hill Education (India) Pvt. Ltd, 6th Edition, 2016..* 2. *Kenneth Crow, "Concurrent Engineering/Integrated Product Development". DRM Associates, 6/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book.*	3. *Kevin N Otto, Kristin L Wood, "Product Design – Techniques in Reverse Engineering and New Product Development", Pearson Education, Inc, 2016* 4. *Paul trott "Innovation Management and New Product Development" 5th Edition Sep 2011*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Siddhaarth Madabushi - Tri Electric Private Limited	*1. . Dr. Arun Kumar Verma, IIT Jammu, India*	*1. Dr. Shubhabrata Datta, SRMIST*
2. Mr. C S Naveen, Decibels Lab Private Limited, Bangalore	*2. Dr. Deevesh Sharma, CSIR Durgapur, India*	*2. Dr.C.Bharatiraja, SRMIST*

Course Code	21EVE405T	Course Name	TRENDS IN VEHICLE STYLING AND ERGONOMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the techniques involved in automotive body design to comprehend the styling process*
CLR-2:	*explore aerodynamic principles and crashworthiness factors to integrate safety and performance in vehicle design*
CLR-3:	*understand the automotive materials, their properties and selection criteria*
CLR-4:	*understand various aspects influencing field of view design*
CLR-5:	*understand the pivotal role of ergonomics engineers, their methods, and challenges in enhancing vehicle design for user comfort and safety*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the stages and methodologies in automotive body design, from concept sketching to 3D model*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze aerodynamic principles, wind tunnel testing, and crashworthiness factors influencing vehicle design and safety*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-3:	*address materials selection, lean manufacturing impact, and manufacturing technologies to align design with production efficiency*	*3*	-	-	-	*1*	-	-	-	-	-	-	*1*	-	-	-
CO-4:	*analyze the intricacies of field of view design within vehicles, considering visibility challenges and design implications*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*explore the role and responsibilities of ergonomics engineers, analyzing their contributions, evaluation methods, and challenges in vehicle development*	*3*	-	-	-	-	-	-	*1*	-	-	-	*1*	-	-	-

Unit-1 - Styling Process	***9 Hour***
The studios, working environment and structure -Product planning – Brainstorming -Review of competition - Concept sketching and package related sketching - Full sized tape drawing - Clay modelling - 2D systems -3D systems	
Unit-2 - Aerodynamics and Crashworthiness	***9 Hour***
Aerodynamic forces – Drag - Drag reduction - Stability and cross-winds – Noise - Underhood ventilation - Cabin ventilation - Wind tunnel testing - Computational fluid dynamics - Crashworthiness and its influence on vehicle design: Accident and injury analysis - Vehicle impacts: general dynamics, crush characteristics - Structural collapse and its influence upon safety.	
Unit-3 - Modern Materials and Manufacturing Challenge	***9 Hour***
Structure and manufacturing technology of automotive materials - Mechanical and physical properties of automotive materials - Materials selection for automotive components - Component materials case studies -manufacturing challenge: Lean product development and lean production - Design to manufacture as a single process and IPPD - Manufacturing analysis, tools and methods - Materials processing and technology.	

Unit-4 - Field of View from Automotive Vehicles	***9 Hour***
Introduction to field of view - Linking vehicle interior to exterior - Types of Fields of View - Forward-field-of-view evaluations - Command sitting position - short and tall driver problems - Sun visor design issues - Wiper and defroster requirements - Mirror design issues - Mirror locations - Convex and aspherical mirrors - Other visibility issues.	
Unit-5 - Role of Ergonomics Engineers in The Automotive Design Process	***9 Hour***
Systems engineering model describing the vehicle development process - Vehicle evaluation - Goal of ergonomics engineers - Evaluation measures - Tools, Methods, and Techniques - Ergonomics engineer's responsibilities - Steps in ergonomics support process during vehicle development - Steps in the early design process - Trade-offs in the design process - Problems and challenges	

Learning Resources	1. *An Introduction to Modern Vehicle Design - Julian Happian-Smith, First published Reed Educational and Professional Publishing Ltd 2002* 2. *ERGONOMICS in the Automotive Design Process - Vivek D. Bhise, CRC Press Taylor & Francis Group – 2012*	3. *Automotive Ergonomics: Driver-Vehicle Interaction- by Nikolaos Gkikas , CRC Press 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Deepak Mohan Founder, Ozone Motors	*1. Dr. Deevesh Sharma, CSIR Durgapur, India*	*1. Dr. Shubhabrata Datta, SRMIST*
2. Mr.Siddhaarth Madabushi - Tri Electric Private Limited	*2. Dr. Sethuraman Sankararaman - IIT Madras, India*	*2. Dr.C.Bharathiraja, SRMIST*

Course Code	21EVE406T	Course Name	EV REGULATIONS AND POLICY FRAMEWORK	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand about EV policies*
CLR-2:	*understand the multifaceted government roles*
CLR-3:	*understand various standards of EV*
CLR-4:	*gain knowledge on the policies aimed at safeguarding the environment*
CLR-5:	*know about the EV regulation policy*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge on the evolution, necessity and benefit of EV policy*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-2:	*understand the importance of government initiatives toward EV usage*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-3:	*understand the standards and protocols for the safe operation of EV*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-4:	*evaluate the impact of environmental standards on climatic change*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	*1*
CO-5:	*articulate the challenges involved in implementing the regulatory policies*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-

Unit-1 - EV Policy and Regulation	***9 Hour***
Need for regulation - Historical development of EV policies - Stakeholders in EV regulation (government, industry, consumers), Comparative analysis of EV policies in different countries - The role of international agreements and organizations - Economic rationale for EV policy and regulation - Environmental implications of EVs and regulatory responses	
Unit-2 - Government Policies and Incentives	***9 Hour***
Subsidies and incentives for EV manufacturing - Taxation policies related to EVs (purchase, import, export) - Consumer incentives for EV adoption (rebates, tax credits) - Policies promoting EV infrastructure development - Role of public transport policies in EV adoption - Fleet procurement and government leadership - Zoning, and urban planning for EVs - Energy policies impacting EV deployment	
Unit-3 - Frameworks and Standards	***9 Hour***
Safety standards for EVs and charging stations - Intellectual property issues in EV technology - Consumer protection laws for EV buyers - Privacy and data security in EV systems - Liability and insurance issues for EVs - Homologation and certification processes - Standardization of EV charging systems - International trade laws affecting EVs.	
Unit-4 - Environmental Regulations	***9 Hour***
Emission standards - Life cycle assessment and renewable energy integration - Battery disposal and recycling policies - Noise regulations - Urban air quality - Carbon pricing and its impact in the aspect of climate change policies	
Unit-5 - EV Regulation Policy Challenges	***9 Hour***
Emerging technologies and regulatory implications - Policy considerations for autonomous EVs - The role of artificial intelligence in EV regulation - Challenges in cross-border policy harmonization - public perception and societal impact of EV policies - The role of non-governmental organizations in shaping EV policies.	

Learning Resources	1. *Electric powertrain: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles by Gordon A. & John G* 2. *Modern electric, hybrid electric, and fuel cell vehicles, by Ebrahimi & Kambiz M. & Ehsani & Mehrdad & Gao & Yimin & Longo & Stefano* 3. *Fundamentals and Application of Lithium-ion Batteries in Electric Drive Vehicles, by Jiuchun Jiang & Caiping Zhang*	4. *Electric Vehicle Machines and Drives: Design, Analysis and Application by K. T. Chau* 5. *Electric powertrain: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles, by Gordon A. & John G*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Shekhar Malani - Devise Electronics Pvt. Ltd.	*1. Dr. Deevesh Sharma, CSIR Durgapur, India*	*1. Dr. Leenus Jesu Martin M, SRMIST*
2. Mr.Karthik, Abhinava Rizel Pvt, India	*2. Dr. Deepak , IIT Madras, India*	*2. Mr. Jerome Stanley M - SRMIST, SRMIST*

Course Code	21EVE407T	Course Name	e-MOBILITY ECOSYSTEM AND DEPLOYMENT PRACTICES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understanding groundwork by exploring the history, key components and ecological significance of e-mobility*
CLR-2:	*understanding EV technologies, charging infrastructures, and their integration into energy systems to grasp their complexities*
CLR-3:	*understanding the challenges and considerations in developing sustainable charging infrastructure and grid integration for electric vehicles*
CLR-4:	*examining the impact of policies and regulations on shaping e-mobility adoption and safety standards*
CLR-5:	*exploring the environmental, economic, and societal implications while envisioning future innovations for sustainable e-mobility*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehending the evolution, components, and environmental impact of electric mobility*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	*2*
CO-2:	*understand diverse EV technologies, charging infrastructure, and their grid integration*	*3*	-	-	-	-	-	-	*2*	-	-	-	-	*1*	-	-
CO-3:	*analyzed charging station deployment, grid integration challenges, and financial models for sustainable infrastructure*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	*1*	-	-
CO-4:	*assessed the impact of environmental policies, safety regulations, and their effects on e-mobility adoption*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-5:	*evaluated life cycle impacts, circular economy practices, socio-economic implications, and future innovations in e-mobility*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-	-	*1*

Unit-1 - E-Mobility Ecosystem	***9 Hour***
Overview of Electric Mobility - Evolution of electric vehicles, Importance of sustainable transportation -Key Components of E-Mobility: Electric vehicles (EVs), Charging infrastructure, and Battery technologies - Environmental Impact: Reduction of carbon footprint, Life cycle analysis of electric vehicles - Case Studies: Successful e-mobility projects, Lessons learned from failures.	
Unit-2 - Electric Vehicle Technologies	***9 Hour***
Types of Electric Vehicles- Latest Battery Technologies - Types of electric motors: Efficiency and performance considerations - Charging Infrastructure: Types of charging stations, Charging standards and protocols- Vehicle-to-Grid (V2G) Technology: Utilizing EVs for grid support, Bidirectional energy flow- Case Studies: Challenges and solutions	
Unit-3 - Infrastructure Development	***9 Hour***
Charging Station Deployment: Urban and rural considerations, Fast-charging networks - Grid Integration: Impact on the electricity grid, Smart grid technologies – Interoperability, Standardization in charging infrastructure - Financial Models for Charging Infrastructure: Public and private investment, Revenue models for charging stations- Case Studies: Lessons learned from deployment challenges.	
Unit-4 – Policies and Regulations	***9 Hour***

Environmental Policies: Emission standards for vehicles, Incentives for green transportation - Vehicle Standards and Safety Regulations: Crash testing and safety standards, Certification processes for electric vehicles - Case Studies: Impact of regulatory frameworks on e-mobility adoption.
Unit-5 - Sustainable Practices and Future Developments ***9 Hour***
Life Cycle Analysis of Electric Vehicles - Environmental impact assessment, Recycling and disposal considerations, Circular Economy in E-Mobility: Reuse of EV components (Battery), Sustainable manufacturing practices- Social and Economic Impact - Future Innovations, Autonomous electric vehicles, Predictions for the future of e-mobility

Learning Resources	1. *EV Engineering Fundamentals : A beginner's guide to e-mobility book - Notion Press - 2022* 2. *Handbook of Electric Vehicle Charging Infrastructure Implementation - NITI Aayog, Ministry of Power (MoP) Sanjeev Kumar Kassi, WRI India, Chaitanya Kanuri.* 3. *E-Mobility A New Era in Automotive Technology - M. Kathiresh, G. R. Kanagachidambaresan, Sheldon S. Williamson - 2022.*	4. *Charging India: developing e-mobility ecosystem - Diwan, Parag - Pentagon Press LLP – Latest edition 2021*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Shankar Venugopal, MTA, Mahindra and Mandira , India	***1.*** *Dr.B.Raja, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	***1.*** *Dr.P.Suresh, SRMIST*
2. *Mr.Shekhar Malani - Devise Electronics Pvt. Ltd*	***2.*** *Dr. Deevesh Sharma, CSIR Durgapur, India*	***2.*** *Dr.C.Bharatiraja, SRMIST*

Course Code	21EVE408P	Course Name	ELECTRIC VEHICLES TESTING AND CERTIFICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							1	0	4	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Gain that knowledge of EV subsystem and EVSE charging Testing and Extend competence*
CLR-2:	*Experiment with Dyno Electric Vehicle Motor and Electric Vehicle Supply Equipment (EVSE) by interfacing EV motor and controller and chargers respectively*
CLR-3:	*Design and build test cases for EV drive train and charging EVSE.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Elucidate the working of the EV subsystem and EVSE charging Testing system*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*Demonstrate the use of Dyno Electric Vehicle Motor and Electric Vehicle Supply Equipment*	*3*	*3*	*3*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*Design and develop test case scenarios for Battery Performance testing lifecycle testing, EV drive train, and EVSE test cases*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*2*	*3*	*3*	*1*

Introduction to Electric Vehicles Testing and Certification — ***15 Hour***

Review on International and AARI EV Testing and Certification.

Battery Testing: Introduction to EV battery Performance testing of EV batteries, Battery lifecycle testing, Safety testing for batteries (thermal, electrical, mechanical), and Battery management system (BMS) testing.

Electric Motor and Powertrain Testing: Electric motor performance and drive line efficiency testing, Powertrain system testing load performance testing, Thermal management testing for motors, Durability and reliability tests for motors, Noise, vibration, and harshness (NVH) testing, Regenerative braking system testing, and Integration testing with other EV systems.

Vehicle Dynamics and Safety Testing: EV Power train dynamics testing: acceleration, braking, handling, Crashworthiness, and impact testing, Occupant protection systems testing, and Active and passive safety systems in EVs.

Testing of vehicle-to-vehicle (V2V) communication: EVSE charging stations Testing, Autonomous, and driver-assistance systems testing, Weather and environmental testing, and Compliance with global safety standards.

Compliance, Certification, and Quality Assurances: Testing Documentation for certification, Homologation process for EVs and testing, Interoperability testing for EVs and EVSE charging stations, Emissions, and efficiency compliance testing, Post-certification monitoring, and audits.

Laboratory Practice — ***60 Hour***

- *Experiments on Battery Testing: Load and Performance testing of EV batteries, Battery lifecycle testing, Safety testing for batteries (thermal, electrical, mechanical), and Battery management system (BMS) testing.*
- *Experiments EV motor dyno test: Mechanical section load motor, torque sensor, and other mechanical components; Drive control section; Electrical parameter measurement section, Field data acquisition: tested motor torque and speed as well as the parameters such as temperature and pressure of the motor and its control during the test process, controls the load system to perform relevant work condition tasks and provides a human-machine control interface - test control software system*

- *Electric Vehicle Supply Equipment Testing: Verify the efficiency, output ripples, charging performance, electrical safety performance, EMI EMC, and communication protocols as per the national and international standards covering all charging methodologies viz. CCS, CHAdeMO, GB/T, and Bharat chargers.*

Project Design:

The students should work as a team of not more than 3 to develop an Arduino real time Project which involve:

- *Designing, developing, coding, demonstrating, and implementation of motor/controller/chargers/ other EV subsystems*
- *Demonstrating competence in applying EV subsystem design and certification*
- *Exhibiting mastery in technical writing, and presentation skills and in preparing formatted Testing and Certification reports*
- *Managing and working as a team in completing the preparation of Testing and Certification reports within the given time frame adhering to standards.*

Learning Resources	1. *Research Institute of the Automotive Industry with the Ministry of Heavy Industries, Govt. of India, Automotive Industry Standard Procedure For Accreditation Of Testing Agencies For Notification Under Rule 126 OF CMVR, Printed By The Automotive Research Association of India (ARAI) P.B. NO. 832, PUNE 411 004, July 2022* 2. *Document on Test Method, Testing Equipment And Related Procedures For Testing Type Approval And Conformity Of Production (Cop) Of Vehicles For Emission As Per Cmv Rules 115, 116 AND 126, MINISTRY OF ROAD TRANSPORT AND HIGHWAYS, GOVERNMENT OF INDI.*	3. *Electric Vehicle Supply Equipment (EVSE) Test Instrumentation: Guidance Documentation, Created January 6, 2023, Updated August 14, 2023* 4. *Keysight, EVSE testing documents. 2023*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of unit test (20%)		CLA-2 Project Based Learning (60%)		Report and Viva Voce (20% Weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	-	5%	-	30%	-	-
Level 2	Understand	30%	-	-	5%	-	30%	-	-
Level 3	Apply	20%	-	-	15%	-	20%	-	-
Level 4	Analyze	20%	-	-	15%	-	20%	-	-
Level 5	Evaluate	-	-	-	30%	-	-	-	-
Level 6	Create	-	-	-	30%	-	-	-	-
	Total	100 %		100 %		100%			

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. B V Shamsundara, Director, ARAI, India	1. Dr. Raghu Selvaraj, Scientist · CSIR-Central Mechanical Engineering Research Institute (CMERI) Durgapur, India	1. Dr. C.Bharatiraja, SRMIST
2. Mr. Chandrasekhar Konda - Head Electrical and Electronics Pvt.Ltd, India	2. Dr. Deepak, IITM, India	2. Dr. M. Jerome Stanley, SRMIST

Course Code	21EVE409T	Course Name	AUTOMOTIVE INTERFACES, FAULT DIAGNOSTICS AND SECURITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	gain a comprehensive understanding of communication protocols for automotive system
CLR-2:	diagnose the fault using model-based and data-driven approaches
CLR-3:	grasp the fundamentals of automotive cybersecurity in compliance with industry standards.
CLR-4:	understand secure interfaces with the unique challenges posed by automotive communication protocols
CLR-5:	assess the security implications and challenges associated with autonomous vehicles and connected car technologies.

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	exhibit a thorough understanding of communication protocols, and electronic components for automotive systems	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	apply model-based and data-driven fault diagnosis methods to identify, analyze, and troubleshoot issues in automotive systems	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	design and implementation of cybersecurity measures for automotive systems	3	-	-	-	-	1	-	2	-	-	-	-	-	-	-
CO-4:	design and implementation of secure interfaces for automotive communication protocols, addressing vulnerabilities and deploying intrusion detection and prevention mechanisms	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	evaluate and address security challenges specific to autonomous and connected vehicles, considering the unique risks.	3	-	-	-	2	1	-	2	-	-	-	-	-	-	-

Unit-1 - Fundamentals of Automotive Systems and Interfaces	9 Hour
Introduction to Automotive Systems: Overview of vehicle architecture - Basics of automotive electronics - In-Vehicle Communication Networks: Introduction to automotive communication protocols (e.g., CAN, LIN) - Networking topologies in automotive systems - Sensor and Actuator Interfaces: Types of automotive sensors and actuators - Signal conditioning and processing - Human-Machine Interface (HMI) in Vehicles: Dashboard design and user interaction - Integration of infotainment systems	
Unit-2 - Fault Diagnosis Techniques in Automotive Systems	**9 Hour**
Introduction to Fault Diagnosis: Importance of fault diagnosis in automotive systems - Challenges and considerations - On-Board Diagnostics (OBD): standards and regulations, Diagnostic trouble codes (DTCs) and diagnostics tools - Model-Based Fault Diagnosis: Mathematical models for fault detection - System identification techniques - Data-Driven Fault Diagnosis: Machine learning applications in fault diagnosis - Case studies on real-world fault scenarios	
Unit-3 - Automotive Security	**9 Hour**
Introduction to Automotive Cybersecurity: Threat landscape in connected vehicles - Overview of cybersecurity standards (ISO/SAE 21434) - Security in In-Vehicle Networks: Authentication and encryption in automotive communication - Secure software updates (OTA) - Vehicle Access and Key Management: Secure access control systems - Key fob and electronic key security.	

Unit-4 – Secure Automotive Interfaces	***9 Hour***
Security Considerations in Automotive Interfaces: Vulnerabilities in CAN and LIN networks - Protection against physical attacks - Intrusion Detection and Prevention: Methods for detecting malicious activities - Preventive measures against cyber-attacks - Case Studies on Automotive Security Incidents: Analysis of real-world security breaches - Lessons learned and best practices	
Unit-5 - Emerging Technologies and Future Trends	***9 Hour***
Machine Learning and AI in Automotive Systems: Applications of AI in fault diagnosis and security - Ethical considerations in AI for automotive - Autonomous Vehicles and Cyber-Physical Systems - Integration of security measures in autonomous vehicles - Communication challenges in connected and automated vehicles - Ethical Considerations and Societal Impacts: Privacy concerns in automotive systems - Regulatory and ethical frameworks.	

Learning Resources	1. *Robert Bosch , "Automotive Handbook. Robert Bosch".* 2. *Silvio Simani , Cesare Fantuzzi , Ronald Jon Patton, "Model-based Fault Diagnosis in Dynamic Systems Using Identification Techniques", Springer, 2003* 3. *Rodrigo Garcia-Valle, João A. Peças Lopes, ".Electric Vehicle Integration into Modern Power Networks", Springer 2013*	4. *Dr. Ahmad MK Nasser, "Automotive Cybersecurity Engineering Handbook", Packt publisher, 2023* 5. *Josep Aulinas, Hanky Sjafrie, "AI for Cars", CRC press, 1st edition, 2022*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Santhiya, Tataelxi , Bangalore, India	***1.*** *Dr.Sheldon Williamson Professor , Ontario Tech University, Canada*	***1.*** *Dr.K.Vijayakumar, SRMIST*
2. *Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China*	***2.*** *Dr Hariharan Muthusamy. Associate Professor; National Institute of Technology, Uttarakhand.,*	***2.*** *Dr.K.Sivanathan, SRMIST*

Course Code	21EVE410T	Course Name	INDUSTRIAL AUTOMATION AND IoT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the architecture and principles of industrial IoT (IIoT)*
CLR-2:	*acquire knowledge on the components and communication of IIoT*
CLR-3:	*describe the data types and visualization*
CLR-4:	*gain knowledge on process and retrieving of data*
CLR-5:	*understand the process of industrial automation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge in IIoT principals and architecture*	*3*	-	-	-	*2*	-	-	*2*	-	-	-	-	-	-	-
CO-2:	*elaborate knowledge on components and communication for IIoT*	*3*	-	-	-	*2*	-	-	*2*	-	-	-	-	-	-	-
CO-3:	*explore knowledge on data types and visualization*	*3*	-	-	-	*2*	-	-	*2*	-	-	-	-	-	-	-
CO-4:	*describe the process of retrieving of data and data analytics for IIoT*	*3*	-	-	-	*2*	-	-	*2*	-	-	-	-	-	-	-
CO-5:	*familiarize the process of industrial automation*	*3*	-	-	-	*2*	-	-	*2*	-	-	-	-	-	-	-

Unit-1 - IIoT Architecture and Principles	***9 Hour***
Architecture of IIoT, IoT node, – IoT enabling technologies – Levels of deployment – Challenges of IIoT- Domain specific IoTs – SDN and NFV for IoT – ISO/OSI model – MAC address and IP address - Overview of TCP/IP and UDP - DNS – Classes of IP addresses – Static and dynamic addressing - IPV4 – IPV6 and 6LoPAN.	
Unit-2 – Sensors for IIoT and Communication Technologies	***9 Hour***
Introduction to Sensors (Description and Working principle) Types of sensors, working principle of basic Sensors - Ultrasonic Sensor, IR sensor, MQ2, Temperature and Humidity Sensors (DHT-11) - Digital switch - Electro Mechanical switches - Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID - Industry standards communication technology (LoRAWAN, OPC UA, MQTT) - connecting into existing Modbus and Profibus technology – wireless network communication.	
Unit-3 - Visualization and Data Types of IIoT	***9 Hour***
Front-end EDGE devices - Enterprise data for IIoT - Emerging descriptive data standards for IIoT - cloud data base - could computing - Fog - Edcomputing - Connecting an Arduino/Raspberry pi to the Web: Introduction, setting up the Arduino/Raspberry pi development environment - Options for Inconnectivity with Arduino - Configuring Arduino/Raspberry pi board for the IoT.	
Unit-4 – Retrieving Data and Process Data Analytics	***9 Hour***
Extraction from Web: Grabbing the content from a web page, Sending data on the web, Troubleshooting basic Arduino issues - Types of IoT interaction, Machine to Machine interaction (M2M). Process analytics – Dimensions for Characterizing process- Process implementation technology - Tools and Use Cases- open source and commercial tools for Process analytics-Big data Analytics for process data – Analyzing Big process data problem –Crowd sourcing and Social BPM -Process data management in the cloud. Case study: Health monitoring, IoT smart city, Smart irrigation, Robot surveillance	
Unit-5 - Automation	***9 Hour***

Automation overview - Requirement of automation systems - Architecture of Industrial Automation system - Introduction of PLC and supervisory control and data acquisition (SCADA) - Industrial bus systems: modbus & Profibus - Role of computers in measurement and control - Programmable logic controllers(PLC) - Analog digital input and output modules - Distributed Control System (DCS) - integration with PLC & Computers - Basic construction and configuration of robot, Pick and place robot, Welding robot - Internet of things for plant automation and overview of Industry 4.0

Learning Resources	*1. Mahmood, Zaigham, The Internet of Things in the Industrial Sector, 1st Ed, Springer, 2019.* *2. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, Industrial Internet of Things: Cyber manufacturing System, 1st Ed, SpringerPublication, 2017.* *3. Ismail Butun, Industrial IoT Challenges, Design Principles, Applications, and Security, springer, 1st Ed, 2020.* *4. ArshdeepBahga and Vijay Madisetti, "Internet of Things A Hands-on Approach", Universities Press, 2015*	*5. Alasdair Gilchrist," Industry 4.0:The Industrial Internet of Things", Apress, 2016.* *6. Vikalp Joshi Manoj Adhikari Raju Manoj Rajesh Singh Anita Gehlot, Industrial Automation by, 1st Ed, BPB Publications, 2019* *7. Frank Lamb, Industrial Automation: Hands-On, 1st Edition, McGraw-Hill Education, 2013* *8. Mike Wilson, Implementation of Robot Systems, 1st Ed, Elsevier, 2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Gibin Chacko George, Advanced Micro Devices	*1. Dr. A. R. Jac Fredo, Ph.D – IIT-Bhubaneswar*	*1. Dr. R. Femi, SRMIST*
2. Mr. Vineeth Kartha, Mathworks	*2. Dr. A.Amalin Prince, BITS-Pilani, Goa*	*2. Dr. R. Narayanamoorthi, SRMIST*

Course Code	21EVE411T	Course Name	MACHINE VISION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the need and significance of machine vision*
CLR-2:	*explore the basics of image processing*
CLR-3:	*explore the Computational Stereo and 3D structure*
CLR-4:	*explore the components of the machine vision system*
CLR-5:	*understand application using machine vision*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*elaborate the human vision and machine vision with basics of physics theory*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-2:	*perform image, video processing operations*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-3:	*perform stereo vision for 3d reconstruction*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*elaborate different Vision system devices and lighting techniques*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-5:	*develop applications based on machine vision system using advanced techniques*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*2*	-	*1*

Unit-1 – Overview of Machine Vision	***9 Hour***
Human vision – Machine vision and Computer vision – Benefits of machine vision – Block diagram and function of machine vision system- implementation of industrial machine vision system – Physics of Light – Interactions of light – Refraction at a spherical surface – Thin Lens Equation	
Unit-2 - Image Processing Fundamentals	***9 Hour***
Digital Image - Monochrome and Colour Images - Image Brightness and Contrast - 2D - 3D, and 4D Images - Digital Image Representation - Digital Image File Formats - Fundamental Image Operations – Points - Edges, and Vertices - Point Operations - Thresholding - Brightness - Geometric Transformations - Spatial Transformation - Affine Transformation - Image Interpolation - Nearest-Neighbor Interpolation - Bilinear Interpolation - Bi-cubic Interpolation - Fundamental Steps in Digital Image Processing - Morphological Image Processing: Dilation, Erosion, Opening, Closing - Hit-or-Miss transformation - Object Recognition	
Unit-3 - Computational Stereo and Motion	***9 Hour***
Computational Stereopsis – Geometry, parameters –correlation-based methods, feature-based methods – Epipolar Geometry, eight-point algorithm – Reconstruction by triangulation, scale factor and up to a projective transformation – Visual Motion – Motion field of rigid objects – Optical Flow - Estimation of motion field – 3D structure and motion from sparse and dense motion fields – Motion based segmentation.	
Unit-4 – Machine Vision and System Components	***9 Hour***
Machine Vision System - Machine Vision Camera: CCD and CMOS Image Sensors, TDI Sensor, Camera Type - Area Scan Cameras - Line Scan Cameras - Smart Cameras - Camera Lens- Resolution - Contrast and Sharpness - Lenses and their parameters: Types of Lenses, Lens Mounts - Lens Selection Examples-Field of View Much larger than Camera sensor size or Smaller or close to camera sensor size - Machine vision lighting:Light Sources in Machine Vision, Illumination Techniques-Backlighting, Front Lighting, Diffused Lighting, Oblique Lighting, Dark Field Lighting, Infrared and Ultraviolet Light – Filters - Machine Vision Software - Machine Vision Automation - Integration of Machine Vision Components	

Unit-5 - Motion Analysis and Emerging Trends in Machine Vision	***9 Hour***
Differential motion Analysis - Optical Flow - Analysis based on correspondence of interest points - Detection of specific motion Patterns - Video Tracking - History of Industrial Revolution(s) - Machine Vision and Industry 4.0 - Emerging Vision Trends in Manufacturing - 3D Imaging - Emerging Vision Trends in Manufacturing - Applications in Machine and Computer Vision: Face detection, face recognition, eigen faces.	

Learning Resources	1. *Alexander Hornberg, "Handbook of Machine Vision", First Edition, Wiley-VCH; 1st edition,21 July 2006* 2. *Rafael C. Gonza Lez, Richard E. Woods "Digital Image Processing", Foth edition, pearson, ISBN-10 : 9353062985, 2018* 3. *Sheila Anand and L.Priya , —A Guide for Machine Vision in Quality Control‖, Taylor & Francis Inc, Imprint CRC Press Inc, Dec 2019*	4. *Yi Ma, Jana Kosecka, Stefano Soatto, Shankar Sastry, "An Invitation to 3-D Vision From Images to Models", First Edition, 2004.* 5. *Davies E.K., "Machine Vision: Theory, Algorithms, Practicalities", 3rd Edition, Elsevier, 2005..* 6. *Milan Sonka, "Image Processing Analysis and Machine Vision", Vikas Publishing House,2007*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Santhiya, Tataelxi , Bangalore, India*	***1.*** *Dr.Sheldon Williamson Professor , Ontario Tech University, Canada*	***1.*** *Mr.V.Manojikumar, SRMIST*
2. *Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China*	***2.*** *Dr Hariharan Muthusamy. Associate Professor; National Institute of Technology, Uttarakhand.*	***2.*** *Dr. R. Senthilnathan SRMIST*

Course Code	21EVE412T	Course Name	MACHINE DESIGN AND MECHANICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the basics of steady and variable stresses applied to machines
CLR-2:	apply engineering principles to design shaft and their associated elements
CLR-3:	acquire knowledge of temporary and permanent joints
CLR-4:	understanding the designing of gears and friction drives
CLR-5:	gain knowledge on the bearing and springs

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	select and design materials to withstand different stresses	3	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	design the solid and hollow shaft, belts, brakes and clutches	3	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-3:	understand temporary and permanent joints	3	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-4:	design and examine the gears and friction drives	3	3	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-5:	select and design different types of bearing and spring that support rotating machinery	3	3	-	-	-	-	-	-	-	-	-	-	1	-	-

Unit-1 - Stresses in Machine Members	**9 Hour**
Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers, fits and tolerances – Direct, Bending and torsional stress equations – Impact and shock loading – calculation of principle stresses for various load combinations, eccentric loading – curved beams – crane hook and 'C' frame- Factor of safety - theories of failure – Design based on strength and stiffness – stress concentration – Design for variable loading.	
Unit-2 - Shafts and Couplings	**9 Hour**
Design of solid and hollow shafts based on strength, rigidity and critical speed – Keys, keyways and splines - Rigid and flexible couplings.	
Unit-3 - Temporary and Permanent Joints	**9 Hour**
Threaded fasteners - Bolted joints including eccentric loading - Knuckle joints - Cotter joints – Welded joints - Riveted joints for structures - Theory of bonded joints.	
Unit-4 – Design of Gears and Friction Drives	**9 Hour**
Gear drives - Types of gear - Terminology of gear - Standard systems of gear tooth - Force analysis of spur - Helical - Bevel, and worm gears - Beam and wear strength of spur – Helical - bevel and worm gears - Lewis and Buckingham's equation - Effective load on spur gear tooth - Virtual number of teeth of helical and bevel gears - Effective load on gear teeth - Selection of materials - Design of belt - Rope, and chain drives: Types of belts, Flat- and Round-Belt Drives, V-belts, Wire Rope – Chains - Brakes and clutches: Types of Brakes and Clutches, Clutch/Brake selection and specification - Clutch and Brake materials - Disc Clutches - Disk Brakes - Drum Brakes.	
Unit-5 - Design of Bearing and Springs	**9 Hour**

Bearings - Comparison of Sliding and Rolling contact bearings - Types of sliding contact bearings - Bearing materials - Lubricating oils - Types of rolling contact bearings - Load carrying capacity - Equivalent bearing load - Load-life relationship - Selection of bearing life - Design of helical and leaf springs: Spring rate, Spring configuration, Spring materials - Design of helical compression springs - Helical extension springs - Helical torsion springs, and Belleville springs - Stresses in leaf springs – Nipping - Equalized stresses.

Learning Resources	1. *Machine Design, An Integrated Approach, by, Robert L. Norton, Fourth Edition.* 2. *Shigley's Mechanical Engineering Design, by Richard Budynas (Author), Keith Nisbett (Author), Tenth Edition.* 3. *Introduction to Machine Design by V. B. Bhandari, Fourth edition.* 4. *Alfred Hall, Halowenko, A and Laughlin, H., "Machine Design", Tata McGraw-Hill BookCo. (Schaum's Outline), 2010.*	5. *Ansel Ugural, "Mechanical Design – An Integral Approach", 1st Edition, Tata McGraw-Hill Book Co, 2003.* 6. *Fundamentals of Machine Component Design [Apr 24, 2018] Juvinall, Robert C. and Marshek, Kurt M. (6th Edition).*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.S.Karthik Mahindra and Mahnida, MRV, Chennai	***1.** Dr.B.Raja, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	***1.** Dr. Shubhabrata Datta, SRMIST*
2. Mr.Kathirvel, Valeo, Chennai	***2.** Dr. PSS Srinivasan, KIOT, Salem, Tamil Nadu, India*	***2.** Dr. J. Daniel Glad Stephen, SRMIST*

Course Code	21EVE413T	Course Name	HYPERLOOP TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the introduction of Hyperloop*
CLR-2:	*cognize the fundamental components of the hyperloop*
CLR-3:	*enrich the knowledge of hyperloop infrastructure and implementation*
CLR-4:	*understand the hyperloop safety and standardization*
CLR-5:	*study the Hyperloop technology and make strategies for developments*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basics of the transportation of Hyperloop*	*3*	-	-	-	-	*1*	*1*	-	-	-	-	-	-	-	*1*
CO-2:	*comprehend the hyperloop materials and components with energy medium*	*3*	*2*	-	-	-	-	-	*1*	-	-	-	-	-	-	-
CO-3:	*development of hyperloop infrastructure with regulations policies*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-	-	-
CO-4:	*access security standards with cyber threats*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-5:	*familiarize the future of hyperloop challenges and developments*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 -Hyperloop Technology ***9 Hour***

Overview of transportation challenges Current issues: congestion, emissions, speed limitations- Historical context and development of high-speed transportation-Evolution of transportation: trains to planes-Concept and vision of the Hyperloop-Basic principles of the Hyperloop concept -Key features and benefits of Hyperloop technology -Speed capabilities, energy efficiency, reduced travel time, environmental advantages.

Unit-2 – Design of Hyperloop Pod ***9 Hour***

Hyperloop pod construction and design: aerodynamics, materials, safety features Maglev technology and levitation principles -Magnetic levitation and its role in Hyperloop-Tube design and construction materials, engineering, and environmental considerations-Vacuum technology and its role in Hyperloop-Importance of low-pressure environment-Energy sources and consumption in the Hyperloop system -Analysis of energy options: solar, electric.

Unit-3 - Hyperloop Infrastructure ***9 Hour***

Planning and designing Hyperloop routes Factors: geography, population density, economic viability-Regulatory considerations and challenges Existing regulations, need for new regulations -Environmental impact assessment Implications and mitigation strategies -Cost analysis and funding models-Breakdown of costs, funding options: public-private partnerships-Case studies of ongoing or proposed Hyperloop projects Lessons learned from successful and unsuccessful implementations

Unit-4 – Safety And Security in Hyperloop Transportation ***9 Hour***

Risk assessment and management in Hyperloop-Identification of potential risks, mitigation strategies -Emergency protocols and evacuation procedures Protocols for various emergency scenarios, evacuation strategies -Cybersecurity measures for Hyperloop systems -Potential cyber threats, security measures -Regulatory standards for safety in high-speed transportation -International safety standards, compliance requirements

Unit-5 - Future Developments and Challenges in Hyperloop	***9 Hour***
Electric Vehicles and Hyperloop Integration - Safety mechanisms for high-speed and high-vacuum transportation - Real-time communication protocols for autonomous EVs and Hyperloop pods - Overcoming scalability challenges in urban and intercity environments - AI and machine learning for predictive maintenance - Autonomous vehicle-to-Hyperloop interface design IoT-enabled monitoring systems for smart transportation Cybersecurity threats and mitigation strategies in integrated networks	

Learning Resources	1. *HYPERLOOP: The future of high-speed" by Hyperloop Partnership, Stephen A. Cohn, et al. 2021* 2. *"The Future of Transportation: From Autonomous Cars to Hyperloops "by Ryan Perri 2023* 3. *From the Temple of Zeus to the Hyperloop: Greg L. Hand 2018*	4. *https://www.avishkarhyperloop.com/* 5. *https://hyperloopconnected.org/2020/04/making-hyperloop-the-safest-mode-of-transportation/*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Deepak Mohan Founder, Ozone Motors	*1. Dr. Satya Chakravarthy, IITMadras*	*1. Mr.B.Vinothkumar, SRMIST*
2. Mr.Venkata Karthik, ZF India	*2. Dr.Pappa, MIT, Anna University*	*2. Mr.V.Manojkumar, SRMIST*

Course Code	21EVE414T	Course Name	POWER SYSTEMS AND MICROGRID	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic knowledge of power systems*
CLR-2:	*know about the various components in microgrid*
CLR-3:	*understand the renewable energy integration*
CLR-4:	*comprehend the various components in the smart grid for EV integration*
CLR-5:	*understand the advanced developments in EVs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the basic knowledge of power systems*	*3*	*2*	-	-	-	-	*1*	-	-	-	-	-	-	-	-
CO-2:	*illustrate the overview of the power system and its components*	*3*	-	-	-	-	-	-	*1*	-	-	-	-	-	-	-
CO-3:	*acquire the knowledge about integration of renewable energy sources*	*3*	*1*	-	-	-	-	*1*	-	-	-	-	-	-	-	*2*
CO-4:	*articulate various components for smart grid and EV*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*interpret the developments of EVs in the future aspect*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	*1*	-	*1*

Unit-1 – Introduction to Power Systems	***9 Hour***
Structure of power system, Element of DC & AC distribution system – Radial and ring main distributor - Effect of system voltage on efficiency - Conventional power generation hydro power generation - Thermal power generation - nuclear power generation - Single line diagram - Impedance and reactance diagram of a system - Per unit calculations - Per unit representation of a power system - Types of faults - Electrostatic and electromagnetic effects	
Unit-2 - Microgrids	***9 Hour***
Concept and definition of microgrid - Review of sources of microgrids - Typical structure and configuration of a microgrid - AC and DC microgrids - Power electronics interfaces in DC and AC microgrids - Communication infrastructure - Modes of operation and control of microgrid: grid connected and islanded mode - Active and reactive power control - Protection issues - Anti-islanding schemes: passive, active and communication-based techniques	
Unit-3 - Integration of Renewable Energy Sources	***9 Hour***
Solar Power Systems: Photovoltaic Technology - Wind energy systems and technologies - Integration of solar and wind energy into microgrids - Energy storage solutions for microgrids - Hybrid renewable energy systems - Grid interconnection and islanding operation - Demand response and load management - renewable energy policies and regulations	
Unit-4 – Smart Grids	***9 Hour***
Architecture of smart grid system - Concept and evolution of smart grids - Smart meters and advanced metering infrastructure - Wide area monitoring systems - Motion and dynamic equations of the electric vehicles: various forces acting on the vehicle in static and dynamic conditions - Basic concept of electric traction - Introduction to energy storage requirements in electric vehicles	
Unit-5 - Advanced Development for EVs	***9 Hour***

Integration of electric vehicles into smart grids - Vehicle-to-Grid and Grid-to-Vehicle technologies - Introduction to energy management strategies used in hybrid and electric vehicles - Various charging techniques and schematic of charging stations - Electric vehicle supply equipment - Smart vehicles in smart grid -Need of charging station selection (CSS) server - Smart meter - Smart charger: Purpose and benefits.

Learning Resources	1. *Sustainable Power Systems: Modelling, Simulation and Analysis, by Nava Raj Karki & Rajesh Karki & Ajit Kumar Verma & Jaeseok Choi (eds.)* 2. *Control and Dynamics in Power Systems and Microgrids, by Lingling Fan* 3. *Microgrids Design and Implementation, by Antonio Carlos Zambroni de Souza & Miguel Castilla*	4. *Urban DC Microgrid. Intelligent Control and Power Flow Optimization, by Manuela Sechilariu & Fabrice Locment* 5. *Control and dynamics in power systems and microgrids, by FAN & LINGLING* 6. *Large Scale Grid Integration of Renewable Energy Sources, by Antonio Moreno-Munoz*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level1	*Remember*	*20%*	-	*15%*	-	*20%*	-
Level2	*Understand*	*20%*	-	*15%*	-	*20%*	-
Level3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Srinivasan Vijayaraghavan, Altair	*1. Dr.B.Raja, Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram*	*1. Dr. C. Nithya, SRMIST*
2. Sandeep, Matlab	*2. Dr.Thanga Raj Chelliah - IIT Roorkee*	*2. Dr.C.Bharatiraja, SRMIST*

Course Code	21EVE415T	Course Name	ELECTRIC VEHICLE SAFETY AND PRACTICES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the various safety measures followed in EV*
CLR-2:	*understand the necessity of protecting high voltage components in electric vehicles*
CLR-3:	*understands the roles of prominent international and regional standardization organizations involved in shaping electric vehicle standards.*
CLR-4:	*understand the process of certification and the role of Indian Standard Organizations in ensuring quality and safety.*
CLR-5:	*understand market trends, consumer behavior, and emerging technologies.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the various battery safety protection methods*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-2:	*optimize safety features within high-voltage electric drivetrains, enhancing safety during normal operation and emergency scenarios.*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-3:	*examine the evolution of electric vehicles and the factors that led to the need for standardized practices.*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-4:	*gain a comprehensive understanding of the Indian regulatory landscape for electric vehicles*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-
CO-5:	*demonstrate a comprehensive understanding of the evolving technologies in electrically driven vehicles, including advancements in batteries, electric drivetrains, and smart systems.*	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-	-

Unit-1 – Electric Vehicle Safety	***9 Hour***
Different aspects of electric safety - Electric system safety: Protection against electric shocks - Voltage levels on board electric vehicles - Protection against direct and indirect contact - Functional system safety: System activation warning, Power on procedure, Driving backwards - Prevention of fierce reverse braking, Emergency disconnect device - Electrical regenerative braking - Battery charging safety: Electrical aspects, Mechanical aspects, Chemical aspects, Explosion hazards - Vehicle Maintenance, Operation and Training	
Unit-2 - High Voltage Electric Vehicle Safety	***9 Hour***
Electric vehicle components - Operational functions - Various high voltage components present in electric and Hybrid vehicle's - Water and dust protection requirements for High voltage cables - High voltage safety systems - High Voltage Interlock systems - Failure control techniques - Electrical Isolation requirements in Electric Vehicle Design - Isolation Fault detection systems - High Voltage Multimeters and Insulation Testers - Standard operating procedure of safely disconnecting high voltage systems in electric and Hybrid Vehicles	
Unit-3 - Genesis of Electric Vehicle Standardization	***9 Hour***

Need of standardization - Standardization of charging plugs - Standardization of voltage - Standardization of speed - Tires and tire efficiency - Standardization of battery jars and trays - Standardization of motors - Safety standards - International Safety Regulations for Electric Vehicle
Unit-4 – Indian Electric Vehicle Standards and Specifications ***9 Hour***
Electric vehicle safety and security standards - ARAI standards and Government Mandates - BIS Standards for electric vehicle Charging: Indian Standards for AC and DC Charging - Indian Standards for battery swapping - Central Electricity Authority (CEA) Standards: Measures relating to Safety and Electric Supply - Technical standards for connectivity of distributed generation resources.
Unit-5 – Standards for Hybrid Vehicles ***9 Hour***
Standardization of the hybrid vehicle - IEC standardization on hybrid vehicles - ISO standardization on hybrid vehicles - European standardization on hybrid vehicles - SAE standards on hybrid vehicles - Hybrid vehicle performance standards: recommendations - Technology for the future: The Fuel Cell vehicle, Fuel cell standardization at IEC, ISO, SAE and Europe.

Learning Resources	1. *Enge, Per, Nick Enge, and Stephen Zoepf. 2021. Electric Vehicle Engineering. 1st ed. New York: McGraw Hill, ISBN: 9781260464078.* 2. *Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, "Electric and Hybrid Vehicles: Technologies, Modelling and Control" - A Mechatronic Approach, ISBN: 978-1-118-34151-3, April 2014, 432 Pages.*	3. *Craig Smith, "Car Hacker's Handbook A Guide for the Penetration Tester", ISBN-13: 978-1-59327-703-1, March 2016, 304 pp* 4. *Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", CRC press, 2017, 736 pages.* 5. *William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Elsevier Publishing.2003*

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Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Santhiya, Tataelxi, Bangalore, India	*1. Dr. Sheldon Williamson Professor, Ontario Tech University, Canada*	*1. Dr. D. Selvabharathi, SRMIST*
2. Paul, HanKaiSi Intelligent Technology Co., Ltd., Guizhou, China	*2. Dr Hariharan Muthusamy. Associate Professor; National Institute of Technology, Uttarakhand.*	*2. Dr. K. Selvakumar, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

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