TULSIRAMJI GAIKWAD-PATIL
College of Engineering & Technology

Mohgaon, Wardha Road, Nagpur - 441 108

An Autonomous Institute

DEPARTMENT OF ELECTRICAL ENGINEERING

M. Tech. Electric Vehicle Technology

Teaching Scheme

Considering

National Education Policy 2020

From

Academic Year 2024-25

Vision of Institute

To emerge as a learning Center of Excellence in the National Ethos in domains of Science, Technology and Management.

Mission of Institute

1. To strive for rearing standard and stature of the students by practicing high standards of professional ethics, transparency and accountability.
2. To provide facilities and services to meet the challenges of Industry and Society.
3. To facilitate socially responsive research, innovation and entrepreneurship.
4. To ascertain holistic development of the students and staff members by inculcating knowledge and profession as work practices.

Vision of the Department.

To emerge as a learning hub and center of excellence in the domain of Electrical Engineering.

Mission of the Department

1. To disseminate knowledge replete with quality education in the field of Electrical Engineering in meticulous and methodical manner.
2. To provide platform to address societal issues as well as challenges faced by industries.
3. To develop research culture and inculcate innovative and entrepreneurial skills.
4. To ensure overall development of students and staff by instilling knowledge and professional ethics as a part of lifelong learning.

Program Education Objectives (PEO)

1. Demonstrate and analyze the fundamental knowledge with respect to the various domains of Electrical Engineering.
2. Investigate and apply modern tools to develop innovativeness in different applications of Electrical Engineering domain.
3. Integrate new emerging trends and concepts in Electrical Engineering profession for sustainable development.
4. Develop professionals having managerial and administrative Qualities for Electrical Engineering related industries.
5. Promote lifelong learning, to prepare for the next challenges in the field of Electrical Engineering.

Program Outcomes (PO)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. He should be able to inculcate research quality among himself.

Tulsiramji Gaikwad-Patil College of Engineering & Technology, Nagpur

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SCHEME OF INSTRUCTION & SYLLABI

Department of Electrical Engineering

Scheme of Instructions: First Year M. Tech. in Electric Vehicle Technology (As Per NEP 2020)

Semester – I

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Credits	Exam Scheme				
									CT-1	CT-2	ICA	ESE	TOTAL
1.	PCC	MEV21101	Power Electronic Converters	4	-	-	4	4	20	20	-	60	100
2.	PCC	MEV21102	Vehicle Dynamics	4	-	-	4	4	20	20	-	60	100
3.	PCC	MEV21103	EV Motor Drives and Control	4	-	-	4	4	20	20	-	60	100
4.	PCC	MEV21104	EV Laboratory-I	-	-	4	4	2	-	-	25	25	50
5.	PEC	MEV21105-07	Programme Elective – I	4	-	-	4	4	20	20	-	60	100
6.	PEC	MEV21108-10	Programme Elective – II	4	-	-	4	4	20	20	-	60	100
			Total	**20**	**-**	**4**	**24**	**22**	**100**	**100**	**25**	**325**	**550**

L- Lecture SL-Self Learning P-Practical NHL- Notional Hrs/Wk (Total Notional Hrs)
CT1- Class Test 1 TA/CA- Teacher Assessment/Continuous Assessment
CT2- Class Test 2 ESE- End Semester Examination (For Laboratory End Semester performance)
ICA- Internal Class Assessment ISS- Independent Study & Seminar

Course Category	PCC (Programme Core Courses)	PEC (Programme Elective courses)	Research Methodology	ISS (Independent Study & Seminar)	Research Project/Dissertation	Semester Wise Credits
Credits	14	08	-	-	-	22
Cumulative Sum	14	08	-	-	-	22

PROGRESSIVE TOTAL CREDITS: 22

BoS Chairperson	Dean Academics PG	Vice Principal	Principal	Jul, 2024	1.00	Applicable for AY 2024-25 Onwards
				Date of Release	Version	

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SCHEME OF INSTRUCTION & SYLLABI

Department of Electrical Engineering

Scheme of Instructions: First Year M. Tech. in Electric Vehicle Technology (As Per NEP 2020)

Semester – II

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Credits	Exam Scheme				
									CT-1	CT-2	ICA	ESE	TOTAL
1.	PCC	MEV21201	Battery Management Systems	4	-	-	4	4	20	20	-	60	100
2.	PCC	MEV21202	Electric and Hybrid Vehicles	4	-	-	4	4	20	20	-	60	100
3.	PCC	MEV21203	EV Laboratory-I	-	-	4	4	2	-	-	25	25	50
4.	PEC	MEV21204-06	Programme Elective – III	4	-	-	4	4	20	20	-	60	100
5.	PEC	MEV21207-09	Programme Elective – IV	4	-	-	4	4	20	20	-	60	100
6.	RM	MME21204	Literature Review & Research Methodology	2	-	-	2	2	-	-	25	25	50
			Total	**18**	**-**	**04**	**22**	**20**	**80**	**80**	**50**	**290**	**500**

L- Lecture SL-Self Learning P-Practical NHL- Notional Hrs/Wk (Total Notional Hrs)
CT1- Class Test 1 TA/CA- Teacher Assessment/Continuous Assessment
CT2- Class Test 2 ESE- End Semester Examination (For Laboratory End Semester performance)
ICA- Internal Class Assessment ISS- Independent Study & Seminar OJT/FP – On Job Training/Internships/Field Projects

Course Category	PCC (Programme Core Courses)	PEC (Programme Elective courses)	Research Methodology	ISS (Independent Study & Seminar)	Research Project/Dissertation	Semester Wise Credits
Semester -II	10	08	02	-	-	20
Cumulative Sum	**24**	**16**	**02**	-	-	**42**

PROGRESSIVE TOTAL CREDITS: 22+20=42

BoS Chairperson	Dean Academics PG	Principal	Principal	Jul, 2024	1.00	Applicable for AY 2024-25 Onwards
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Department of Electrical Engineering

Scheme of Instructions: Second Year M. Tech. in Electric Vehicle Technology (As Per NEP 2020)

Semester – III

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Credits	Exam Scheme				
									CT-1	CT-2	ICA	ESE	TOTAL
1.	PEC	MOOCs	MOOCs Course (12 weeks)	3	-	-	-	4	-	-	25	75	100
2.	RP/DI	MEV22302	Dissertation Phase-I	-	-	32	32	16	-	-	100	100	200
			Total	**3**	**0**	**32**	**32**	**20**	-	-	**125**	**175**	**300**

L- Lecture SL-Self Learning P-Practical NHL- Notional Hrs/Wk (Total Notional Hrs)
CT1- Class Test 1 TA/CA- Teacher Assessment/Continuous Assessment
CT2- Class Test 2 ESE- End Semester Examination (For Laboratory End Semester performance)
ICA- Internal Class Assessment RP/DI- Research Project/Dissertation

Course Category	PCC (Programme Core Courses)	PEC (Programme Elective courses)	Research Methodology	ISS (Independent Study & Seminar)	Research Project/Dissertation	Semester WiseCredits
Semester-III	-	04	-	-	16	20
Cumulative Sum	**24**	**20**	**02**	**Audit**	**16**	**62**

PROGRESSIVE TOTAL CREDITS: 42+20=62

				Jul, 2024	1.00	Applicable for AY 2024-25 Onwards
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Department of Electrical Engineering

Scheme of Instructions: Second Year M. Tech. in Electric Vehicle Technology (As Per NEP 2020)

Semester – IV

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Credits	Exam Scheme					
									CT-1	CT-2	CA	ICA	ESE	TOTAL
1	RP/DI	MEV22401	Dissertation Phase-II	-	-	40	20	20	-	-	-	100	200	300
			Total	**0**	**0**	**40**	**20**	**20**	-	-	-	**100**	**200**	**300**

L- Lecture SL-Self Learning P-Practical NHL- Notional Hrs/Wk (Total Notional Hrs)
CT1- Class Test 1 TA/CA- Teacher Assessment/Continuous Assessment
CT2- Class Test 2 ESE- End Semester Examination (For Laboratory End Semester performance)
ICA- Internal Class Assessment RP/DI- Research Project/Dissertation

Course Category	PCC (Programme Core Courses)	PEC (Programme Elective courses)	Research Methodology	ISS (Independent Study & Seminar)	Research Project/Dissertation	Semester Wise Credits
Semester-IV	-	-	-	-	20	20
Cumulative Sum	**24**	**20**	02	-	**36**	**82**

TOTAL CREDITS: 62+20=82

BoS Chairperson	Dean Academics PG	Vice Principal	Principal	Jul, 2024	1.00	Applicable for AY 2024-25 Onwards
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Program: M. Tech. Electric Vehicle Technology

List of Program Electives offered

By

Electrical Engineering Department

Program Elective- I	Program Elective-II	Program Elective- III	Program Elective- IV
Semester-I		Semester II	
MEV21105 - EVs in Smart Grid	**MEV21108** - Artificial Intelligence for EV	**MEV21204** - EV Battery Charging Systems	**MEV21207** – Plug In Electric Vehicles
MEV21106- Energy Storage Systems	**MEV21109** – IoT in EV Applications	**MEV21205**- Fuel Cell Technology	**MEV21208** - Advanced Power train Engineering
MEV21107 - EV Standards & Testing	**MEV21110** - Automotive Safety	**MEV21206** – Advanced Battery Technology for Electrical Vehicles	**MEV21209** - Advanced Battery Recycling Technologies

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21101: Power Electronic Converters

Teaching Scheme	
Lectures	4 Hrs/week
Tutorial	-
Practical	-
Total Credit: 4	

Examination Scheme	
ESE	60 Marks
CIE	40 Marks
Total	100 Marks
Duration of ESE :3Hrs	

Course Objective:

1	Understand the basic concepts and principles of power electronics, including semiconductor devices, switching regulators, and power conversion techniques.
2	Analyze and design different power converter topologies, such as buck, boost, buck-boost, and flyback converters, and understand their applications.
3	Explore various control methods used in power converters, including feedback control, pulse-width modulation (PWM), and digital control techniques.

Course Outcomes

At the end of the unit, students will be able to:

MEV21101.1	**Analyze** the characteristics of Power electronics devices and to determine the suitable device for a particular application.
MEV21101.2	**Analyze** the effects of source inductance and load variations on converter performance.
MEV21101.3	**Describe** the fundamental principles and operational differences between linear and switching voltage regulators.
MEV21101.4	**Implement** various PWM techniques, including sine-triangular and space vector PWM, to design and simulate DC-AC converters.
MEV21101.5	**Classify** and describe the operation of AC voltage controllers, including on-off and phase control techniques.

Course Contents

Unit I	**Semiconductor Devices** Review of Semiconductor devices like Power BJT, SCR, MOSFET, IGBT, GTO, MCT; Static and dynamic characteristics of these devices; Single quadrant, Two quadrant and bid-directional switches.
Unit II	**AC-DC Converters** Single phase and three phase half wave and full wave, 1-phase and 3-phase half controlled and fully controlled converters, Analysis with R & RL load, Performance parameters for converters,Operation in continuous and dis-continuous mode, Reactive power considerations, Operation in conversion and inversion mode, Effect of source inductance, Power factor improvement techniques, Dual Converters.
Unit III	**Switching Voltage Regulators** Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations - Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; C'uk converter, Sepic Converter.
Unit IV	**DC-AC converters/Inverters** Classification; Review of line commutated inverters, Concept of Unipolar and Bipolar PWM, 120° and 180° conduction mode of inverter, Sine-triangular PWM, Effect or carrier frequency on the harmonics, Space Vector Pulse Width Modulation, Other PWM techniques, Current

Unit V	**Three phase AC voltage controllers and Cycloconverters** **AC voltage controllers**: Review of On-off and phase control; Single phase full wave controllers and their analysis with resistive loads; Three phase full wave controllers, Analysis with R-load, Three phase bi-directional delta-connected controllers **Cycloconverters**: single-phase to single-phase cycloconverter, 3-phase to 1-phase cyclo-converter, 3-phase to 3-phase cycloconverter circuits; circulating current operation; non-circulating current operation; mean output voltage and harmonics in supply current waveform
Text Books	
1	Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
2	Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2003.
3	P.C.Sen, "Modern Power Electronics ", S. Chand and Co. Ltd., New Delhi, 2012.
4	G.K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Ltd. Publishers, 1986 (Reprint 2008).
Reference Books	
1	P.T. Krein, "Elements of Power Electronics", Oxford University Press, 1998.
2	Joseph Vithayathil , "Principles of Power Electronics", Mc-Graw Hill
Useful Links	
1	http://nptel.iitm.ac.in/coursecontents_elec.php
2	https://archive.nptel.ac.in/courses/117/103/117103148/

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21102: Vehicle Dynamics

Teaching Scheme			**Examination Scheme**	
Lectures	4 Hr / Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		Total	100 Marks
Theory Credits: 4			**Duration of Exam:** 3 Hours	

Course Objectives

The Objectives of this course is:

1. Understand the dynamics of vehicle ride under different riding condition.
2. Address the underlying concepts and methods behind Vehicle Dynamics.
3. Analyse the behaviour of the vehicles under acceleration, ride and braking.

Course Outcomes

At the end of the unit, students will be able to:

MEV21102.1	**Analyse** the dynamics of vehicle under different riding condition.
MEV21102.2	**Analyse** acceleration and braking performance in electric vehicle to understand the vehicle dynamics under these conditions.
MEV21102.3	**Articulate** road loads and tyre dynamics in electric vehicles.
MEV21102.4	**Interpret** riding comfort & vibrations, cornering and roll over in electric vehicles to understand the vehicular dynamics.
MEV21102.5	**Infer** on the suspension kinematics and controllable suspension elements used in electric vehicles.

Course Contents

Unit I	**Basics of Vehicle Dynamics:** History, vehicle classifications, fundamental approaches to vehicle dynamics modelling; SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, Brake proportioning, braking efficiency.
Unit II	**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. **Braking Performance:** Braking force analysis; brake design and analysis; federal regulation on braking performance; antilock braking system; wheel lock-up; tire/road friction; safety and maintenance issues in braking.
Unit III	**Road Loads:** Wind drags and car body design, rolling resistance; breakdowns of total road loads; gas mileage analysis and driving styles; Aerodynamics. **Tire and Tire Dynamics:** Tire specifications and constructions; tire motion analysis; tire force analysis; tire contact stress analysis; tire vibration analysis; tire models.
Unit IV	**Ride & Cornering/steering:** Riding comfort; perception of vibration; vibration sources; vibration transmission to the passengers; lower speed cornering; high speed corner; cornering bicycle model; Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover.
Unit V	**Chassis and Suspension Systems:** Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center

	Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension Elements: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions.

Text Books	
T.1	Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication.
T.2	Vehicle Dynamics, Theory and Application, Reza N. Jazar, Springer, 2009, ISBN 978-0-387-74243-4, e- ISBN 978-0-387-74244-1.
Reference Books	
R.1	Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012.
R.2	Rajesh Rajamani, Vehicle Dynamics & control, Springer.
R.3	R.V. Dukkipati, Vehicle dynamics, Narsova Publications.

Useful Links	
1	https://nptel.ac.in/courses/108103008

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21103: EV Motor Drives and Control

Teaching Scheme			**Examination Scheme**	
Lectures	4 Hr / Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits : 4			**Duration of Exam: 3** Hrs	

Course Objectives

The Objectives of this course is:

1.	Understand requirement of EV motors.
2.	Understand speed control of Induction motor.
3.	Understand different sensors and sensorless operation of motor.

Course Outcomes

At the end of the unit, students will be able to :

MEV21103.1	**Describe** the characteristics of the motors use in EV.
MEV21103.2	**Analyze** dynamics of DC motor and different controllers used in their control.
MEV21103.3	**Describe** the speed control and PWM techniques used in the control of Induction motor.
MEV21103.4	**Analyze** the operation and control of permanent magnet ac motors.
MEV21103.5	**Analyze** sensor-less control of 3-phase ac motors.

Course Contents

Unit I	**EV Motors Characteristics:** Requirement of EV motors, Comparison of EV motors. **DC Motor:** Basics of DC Motor Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadran operation. **DC Motor Dynamics & Control:** Current Loop Control, Speed Control Loop.
Unit II	**Dynamical System Control:** Gain & Phase Margins, PD Controller, PI Controller, Selecting PI Gain for Speed Controller, PI Controller Design, PI Controller with Reference model Comparison of conventional PI Controller with PI controller with Reference Model, 2 DOI Controller with Internal Model Control, Load Torque Observer, Feedback Linearization Simplified Modeling of Practical Current Loop.
Unit III	**Induction Motor:** Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakag inductance, circle diagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor. **Induction Motor Speed Control:** Rotor Field oriente control, Stator Field Oriented Control, Field Weakening Control, Variable Voltage Variabl Frequency Control.
Unit IV	**Permanent magnet ac motors:** PMSM and BLDC, PMSM dynamic modelling, PMSM torque equations, PMSM contro methods, machine sizing, current, voltage and speed limits, extending constant power spee range, current control methods.
Unit V	**Position & Current Sensors:** Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling **Sensor less control of ac motors:** Voltage Model Estimator, Current Model Estimator Closed-loop MRAS observer, PMSM sensor less control.

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21107: EV Standards & Testing

Teaching Scheme		Examination Scheme	
Lectures	4 Hrs/week	ESE	60 Marks
Tutorial	-	CIE	40 Marks
Practical	-	Total	100 Marks
Total Credit: 4		Duration of Exam:3 Hrs .	

Course Objectives

The Objectives of this course are:

1.	To introduce different standards related to electric vehicles.
2	To understand type testing of electric vehicle.
3	Know government policies related to EVs.

Course Outcomes

At the end of the unit, students will be able to:

MEV21107.1	**Illustrate** different standards related construction and safety in electric vehicles.
MEV21107.2	**Describe** central motor vehicles rules (CMVR) type of standards for electric and hybrid electric vehicles.
MEV21107.3	**Describe** CMVR types of standards for retro fitment of existing IC engine driven vehicles.
MEV21107.4	**Illustrate** safety standards of traction batteries.
MEV21107.5	**Describe** government policies like national electronic mobility plan related to EVs.

Course Contents

Unit I	**Basic of types of EV and Testing:** Electric power train vehicles-construction and functional safety requirements measurement of electrical energy consumption, Method of measuring the range, Measurement of net power and the maximum 30-minute power, CMVR type approval for electric power train vehicles, ISO 26262.
Unit II	**Schemes and Regulations:** Introduction to Vehicle safety standards, Rules and Regulations, Environmental impurities and safety requirements, Battery Operated Vehicles -Safety Requirements of Traction Batteries, Automotive safety components certification by various organizations (ARAI, SIAM, SAE, ASME, FMVSS).
Unit III	**EV Testing – I:** Instruments and Types of test tracks, Static testing of vehicles-CMVR physical verification, Tyre Tread Depth Test. Electric Vehicle Conductive AC Charging System, Electric Vehicle Conductive DC Charging System
Unit IV	**EV Testing – II:** Electric vehicle – Safety Norms, Energy consumption and Power test, Dynamics testing of vehicles, Vehicle component testing. CMVR Type Approval for Hybrid Electric Vehicles, CMVR Type Approval for Hybrid Electric Vehicles of M and N Category with GVW > 3500 kg
Unit V	**Testing of Stations & Government Policies:** Tests for HEV and charging stations.

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21107: EV Standards & Testing

Teaching Scheme		Examination Scheme	
Lectures	4 Hrs/week	ESE	60 Marks
Tutorial	-	CIE	40 Marks
Practical	-	Total	100 Marks
Total Credit: 4		Duration of Exam:3 Hrs .	

Course Objectives

The Objectives of this course are:

1.	To introduce different standards related to electric vehicles.
2	To understand type testing of electric vehicle.
3	Know government policies related to EVs.

Course Outcomes

At the end of the unit, students will be able to:

MEV21107.1	**Illustrate** different standards related construction and safety in electric vehicles.
MEV21107.2	**Describe** central motor vehicles rules (CMVR) type of standards for electric and hybrid electric vehicles.
MEV21107.3	**Describe** CMVR types of standards for retro fitment of existing IC engine driven vehicles.
MEV21107.4	**Illustrate** safety standards of traction batteries.
MEV21107.5	**Describe** government policies like national electronic mobility plan related to EVs.

Course Contents

Unit I	**Basic of types of EV and Testing:** Electric power train vehicles-construction and functional safety requirements measurement of electrical energy consumption, Method of measuring the range, Measurement of net power and the maximum 30-minute power, CMVR type approval for electric power train vehicles, ISO 26262.
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Unit V	**Testing of Stations & Government Policies:** Tests for HEV and charging stations.

Text Books	
T.1	Energy Storage Technologies and Applications, Ahmed Faheem Zobaa, InTech Publishers, 2013.
T.2	Lithium Batteries and Other Electrochemical Storage Systems, Christian Glaize, Sylvie Geniès, ISTE & John Wiley, 2013.
T.3	Davide Andrea, Battery Management Systems for Large Lithium-Ion Battery Packs, Artech, 2010.
Reference Books	
R.1	Jiang, J. and Zhang, C., Fundamentals and Applications of Lithium-ion Batteries in Electric Drive Vehicles, 2015, Wiley Publications.
R.2	Angel Kirchev, Battery Management and Battery Diagnostics, Ch.20 of Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Elsevier, 2015.
R.3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

Useful Links	
1	https://www.coursera.org/learn/battery-management-systems
2	https://nptel.ac.in/courses/108106170

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21106: Energy Storage Systems

Teaching Scheme			**Examination Scheme**	
Lectures	4 Hr / Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits : 4			**Duration of Exam :** 3 Hours	

Course Objectives

The Objectives of this course is:

1.	To understand the basics of batteries.
2.	To infer about the battery charging.
3.	To illustrate battery charging and modelling.

Course Outcomes

At the end of the unit, students will be able to:

MEV21106.1	**Discuss** the basic understanding of batteries.
MEV21106.2	**Analyse** the battery parameters and their variations during charge and discharge cycles.
MEV21106.3	**List** different types of batteries and **analyse** their performance parameters.
MEV21106.4	**Examine** the battery charging requirements and develop the complete battery model.
MEV21106.5	**Identify** novel and alternate energy sources which could be used in EVs.

Course Contents

Unit I	**Basics of Batteries:** Battery basics, battery parameters, types of battery. Introduction - Electrical Energy Storage (EES)-Definition-Role, Energy storage components, Applications and Technical benefits of energy storage systems, Financial Benefits of energy storage systems, Techno economic characteristics of energy storage systems.
Unit II	**Battery Parameters:** Electrochemical Batteries, Cell and battery voltages, Charge (or Amp hour) capacity, Energy stored, Specific energy, Energy density, Specific power, Amp hour (or charge) efficiency, Energy efficiency. Self-discharge rates, Battery geometry, Battery temperature, Battery life and number of deep cycles.
Unit III	**Types of Batteries:** Lead Acid Batteries, Nickel-based Batteries: Introduction, Nickel cadmium, Nickel metal hydride batteries, Sodium-based Batteries, Lithium Batteries, Metal Air Batteries.
Unit IV	**Battery Charging and Modelling:** Battery Charging, Battery chargers, Charge equalization, Use of Batteries in Hybrid Vehicles, Complex hybrids, Battery Modelling, the purpose of battery modelling, Battery equivalent circuit, Modelling battery capacity, Calculating the Peukert Coefficient, Approximate battery sizing.
Unit V	**Energy Storage Systems:** Classification – Pumped Hydro storage, batteries energy storage, flow batteries energy storage, flywheel energy storage, super capacitor energy storage, Super conducting magnetic energy storage, Fuel cell Hydrogen energy storage, thermal energy storage, compressed air energy storage, assessment and comparison of energy storage technologies.

	Impact through Proper Planning
Text Books	
T.1	James Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley-IEEE Press, March 2012.
T.2	Qiuwei Wu, "Grid Integration Of Electric Vehicles In Open Electricity Markets", John Wiley & Sons, Ltd, 2013.
T.3	Ali Keyhani and Muhammad Marwali, "Smart Power Grids 2011", Springer, 2011.
Reference Books	
R.1	Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, "Plug In Electric Vehicles in Smart Grids Integration Techniques", Springer Science + Business Media Singapore Pte Ltd., 2015.
R.2	Canbing Li, Yijia Cao, Yonghong Kuang and Bin Zhou, "Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid", Springer-Verlag Berlin Heidelberg, 2016.

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21105: EVs in Smart Grid

Teaching Scheme			Examination Scheme	
Lectures	4 Hr / Week		ESE	60 Marks
Tutorial	-		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 4			Duration of Exam: 3 Hrs	

Course Objective

1	To understand the cyber security of Plug in Electric Vehicle technologies in Smart Grid.
2	To understand the PEV Load and Its Impact on Static Voltage Stability.
3	To understand the PEV Load and Its Impact on Static Voltage Stability.

Course Outcomes:

At the end of the unit, students will be able to :

MEV21105.1	**Understand** power system operations, issues with existing system and capabilities of Smart Grid (SG).
MEV21105.2	**Analyze** the scope of distributed generation and Demand side management in SG.
MEV21105.3	**Describe** the PEV Load and Its Impact on Static Voltage Stability.
MEV21105.4	**Illustrate** the cyber security of Plug in Electric Vehicle technologies in Smart Grid.
MEV21105.5	**Describe** the PEV Load and Its Impact on Static Voltage Stability.

Course Contents

Unit I	**Introduction of Smart Grid**: Basic understanding of power systems. Evolution of power electronics in power system applications. Smart grid definition. Smart grid vs. conventional grid. Smart Grid technologies in Generation, Transmission and Distribution. Present development & International policies in Smart Grid. Smart Grid – Overview and stakeholders.
Unit II	**Smart Grid features:** Distributed generation, storage, Demand Dispatch (DD), Demand Response (DR), Advanced Metering Infrastructure (AMI), Wide Area Monitoring Protection and Control (WAMPAC), Wide Area Control System (WACS). Sensors - CT, PT; Devices – Intelligent Electronic Devices (IED), Phasor Measurement Unit (PMU), Phasor Data Concentrator (PDC), relays, DR Switch; Communication - Standards, Technology and protocols.
Unit III	**Wireless Power Transfer (WPT) for Electric Vehicles (EVs):** PEV Technologies, PEV Systems, impacts, Smart Charging Infrastructure, Integration of PEVs to Electric Grid Promotional Programs on PEVs. Wireless Energy Transfer Methods, Inductive Coupling Versus Magnetic Resonance Coupling, Modelling the WPT System, WPT for EV Charging, Stationary WPT for EV Charging, Dynamic WPT for EV Charging.
Unit IV	**Cyber Security of Plug-in Electric Vehicles in Smart Grids: Application of Intrusion:** Detection Methods, Smart Grids with PEVs, Communication Infrastructure, Communication Standards, Cyber Security Challenges, Data Attacks and Intrusions in PEV Communications, Intrusion Detection Methods, Application to the Detection of Malicious PEV Penetration Level.
Unit V	**PEV Load and Its Impact on Static Voltage Stability:** Modeling of PEV Charging Load, Introduction to Power System Load Characteristics, Modeling of the PEV Charging Load, Effects of Charger Resistances on Load Model Parameters, Newton Raphson Power Flow with PEV Load, Impact of PEV Charging Load on System Static Voltage Stability, Voltage Stability Theory, Static Voltage Stability Analysis, Mitigating PEV Charging Impacts through Voltage Control, Mitigating PEV Charging

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21104: EV Laboratory-I

Teaching Scheme			**Examination Scheme**	
Lectures			**ESE**	50 Marks
Tutorial	-		**CIE**	50 Marks
Practical	4 Hr / Week		**Total**	100 Marks
Theory Credits: 2			**Duration of Exam :**	

Course Objectives

The Objectives of this course is:

1.	Understand the design and operation of buck converter.
2.	Understand the design and operation of flyback and forward converter.
3.	Understand the operation of non-isolated bidirectional onboard charger and inverter.

Course Outcomes

At the end of the unit, students will be able to:

MEV21104.1	**Analyze** the effect ESR of filter capacitor on the performance of the buck converter.
MEV21104.2	**Compare** the performance of synchronous buck converter with buck converter.
MEV21104.3	**Design** rectifier operated on universal mains with the feature of PFC.
MEV21104.4	**Design** flyback and forward converter.
MEV21104.5	**Analyze** non-isolated bidirectional onboard charger and inverter.

List of Experiments

1.	Design and simulate a voltage mode buck converter and study the effect of ESR of filter capacitor used on the performance of the converter.
2.	Design and simulate a current mode buck converter for car battery.
3.	Design and simulate synchronous buck converter and compare its efficiency with buck converter.
4.	Design and simulate a buck-boost converter operated from a car battery.
5.	Design a 100 W rectifier operated on universal mains and demonstrate the starting inrush current.
6.	Design and simulate the passive PFC for a rectifier circuit.
7.	Design and simulate flyback converter without parasitic elements.
8.	Design and simulate a two-switch forward converter using two MOSFETs and a couple of diodes to recycle the magnetizing energy.
9.	Design and simulate non-isolated bidirectional onboard charger.
10.	Design and simulate DC- AC converter using IGBT.

Text Books

T.1	Christophe Basso, "Switch Mode Power Supplies: SPICE Simulations and Practical Designs", McGraw-Hill,2008.

	National Electric Mobility Mission Plan 2020 (NEMMP2020), Faster Adoption and Manufacture of (Hybrid and Electric Vehicles) – FAME, Niti Aayog Report on Transforming Mobility
Text Books	
T.1	Clemens Guhmann, Simulation and Testing for Vehicle Technology, Springer International Publishing AG.
T.2	Ronald K Jurgen, "Navigation and Intelligent Transportation Systems – Progress in Technology", Automotive Electronics Series, SAE, USA, 1998.
T.3	William B Ribbens, "Understanding Automotive Electronics", 7th edition, Butter worth Heinemann Woburn -2012

Reference Books	
R.1	Dennis Foy, Automotive Telematics, Red Hat, 2002.
R.2	Yilin Zhao, Vehicle Location and Navigation Systems, Artech House, 1997.
R.3	Jay Farrell and Matthew Barth, The Global Positioning System and Inertial Navigation, McGraw- Hill, 1999.

Useful Links	
1	https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf
2	https://niti.gov.in/content/national-mission-transformative-mobility-and-battery-storage

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21108: Artificial Intelligence for EV

Teaching Scheme	
Lectures	4 Hrs/week
Tutorial	-
Practical	-
Total Credit: 4	

Examination Scheme	
ESE	60 Marks
CIE	40 Marks
Total	100 Marks
Duration of Exam:3 Hrs .	

Course Objectives

The Objectives of this course are:

1.	Integrating AI technologies with the design, development, and operation of electric vehicles.
2	Introduction to AI in the Context of EVs. Data Analysis and Management
3	Vehicle-to-Everything (V2X) Communication

Course Outcomes

At the end of the unit, students will be able to:

MEV21108.1	**Apply** Knowledge Representation and Inference Strategies.
MEV21108.2	**Integrate** Advanced Logic Systems
MEV21108.3	**Understand and Apply** Fuzzy Logic Concepts
MEV21108.4	**Understand** Neural Network Fundamentals
MEV21108.5	**Implement** Genetic Algorithms and Evolutionary Programming

Course Contents

Unit I	**Artificial Intelligence Basesd EV System**: Natural language system – perception system for vision speech and touch - expert or knowledge based system – knowledge acquisition – knowledge of representation – inference strategy – expert controller. Suggested Reading: Artificial Intelligence basics
Unit II	**Artificial Intelligence:** Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic. Suggested Reading: Paradigms of Artificial Intelligence Programming Applications: Renewable Energy
Unit III	**Fuzzy Logic:** Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods Suggested Reading: fuzzy logic with engineering application Applications: Renewable Energy
Unit IV	**Artificial Neural Network:** Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks. Applications: Domestic and Commercial applications
Unit V	**Evolutionary Techniques:** Introduction and concepts of genetic algorithms and evolutionary programming Hybrid Systems: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems. Suggested Reading: Modern evolutionary techniques Applications: Renewable Energy Conversion

Text Books

T.1	Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications, PHI New Delhi, 2017
T.2	Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc. 1996

Reference Books	
R.1	Goldberg D.E. "Genetic Algorithms in Search Optimization & Machine Learning", Wesley Co., New York. 2000
R.2	Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India. 2008

Useful Links	
1	https://www.kobo.com/us/en/ebooks/artificial-intelligence
2	https://nptel.ac.in/courses/106105077/

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21109: IoT in EV Applications

Teaching Scheme		Examination Scheme	
Lectures	4 Hrs/week	ESE	60 Marks
Tutorial	-	CIE	40 Marks
Practical	-	Total	100 Marks
Total Credit: 4		Duration of Exam:3 Hrs.	

Course Objectives

The Objectives of this course are:

1.	The objectives are designed to provide a comprehensive understanding of how IoT can enhance the functionality, efficiency, and management of electric vehicles.
2	Define and explain the role of IoT in electric vehicles and its impact on performance, efficiency, and user experience.
3	Identify and describe the specific IoT technologies and sensors used in electric vehicles, such as battery management systems, telematics, and charging infrastructure.

Course Outcomes

At the end of the unit, students will be able to:

MEV21109.1	**Illustrate** how IoT promises can be applied in a specific industry or application.
MEV21109.2	**Explain** the basic function and typical applications of industrial sensors in IoT systems.
MEV21109.3	**Describe** the function and significance of each component within the wireless sensor structure.
MEV21109.4	**Explain** the purpose and functionality of the ACOEM Eagle in IoT applications.
MEV21109.5	**Analyze** how sensor values are internally represented and how data is persisted and externalized.

Course Contents

Unit I	**Introduction:** Internet of Things Promises–Definition– Scope–Sensors for IoT Applications–Structure of IoT– IoT Map Device
Unit II	**IoT Sensors:** Industrial sensors – Description & Characteristics–First Generation – Description &Characteristics– Advanced Generation – Description & Characteristics–Integrated IoT Sensors – Description & Characteristics–Polytronics Systems – Description &Characteristics–Sensors' Swarm – Description & Characteristics–Printed Electronics –Description & Characteristics–IoT Generati Roadmap
Unit III	**Technological Analysis:** Wireless Sensor Structure–Energy Storage Module–Power Management Module–RF Module–Sensing Module
Unit IV	**IoT Development Examples :** ACOEM Eagle – EnOcean Push Button – NEST Sensor – Ninja Blocks -Focus onWearable Electronics
Unit V	**IoT Projects :** Creating the sensor project - Preparing Raspberry Pi/ ARM Cortex - Clayster libraries HardwareInteracting with the hardware - Interfacing the hardware- Internal representation ofsensor values - Persisting data - External representation of sensor values – Exportingsensor data - Creating the actuat project- Hardware - Interfacing the hardware -Creating a controller - Representing sensor values - Parsing sensor data – Calculatingcontrol states - Creating a camera - Hardware -Accessing the serial port RaspberryPi/ ARM Cortex - Interfacing the hardware - Creating persistent default settings Addingconfigurable properties - Persisting the settings - Working with the current settings -Initializi the camera

Text Books	
T.1	Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014
T.2	Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015

Reference Books	
R.1	Editors OvidiuVermesan Peter Friess,'Internet of Things – From Research and Innovation to Market.
R.2	N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

Useful Links	
1	https://archive.nptel.ac.in/courses/108/108/108108123/
2	https://onlinecourses.nptel.ac.in/noc22_cs53/preview

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Program: M. Tech. Electric Vehicle Technology (EVT)

Semester-I MEV21110 : Automotive Safety

Teaching Scheme	
Lectures	4 Hrs/week
Tutorial	-
Practical	-
Total Credit: 4	

Examination Scheme	
ESE	60 Marks
CIE	40 Marks
Total	100 Marks
Duration of Exam: 3 Hrs.	

Course Objectives

The Objectives of this course are:

1.	Study and practice of design cars, construction, equipment's.
2	Regulation to minimize the occurrence and consequences of traffic collisions.
3	Design the safety system for vehicles

Course Outcomes

At the end of the unit, students will be able to:

MEV21110.1	**Comprehend** application of passive and active safety for vehicle.
MEV21110.2	**Describe** importance of ergonomics in automotive safety and human response to impact.
MEV21110.3	**Design** the vehicle safety system.
MEV21110.4	**Describe** various regulations of vehicle safety and safety testing methods.
MEV21110.5	**Design** the locking and safety system for vehicles.

Course Contents

Unit I	Introduction Design of the body for safety, energy equation, engine location, and deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.
Unit II	Safety Concepts Active safety: driving safety, conditional safety, perceptibility safety, operating safety; passive safety: exterior safety, interior safety, deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact
Unit III	Safety Equipment's Seat belt, regulations, automatic seat belt tightened system, collapsible steering column, tilt able steering wheel, air bags, electronic system for activating air bags, bumper design for safety.
Unit IV	Collision Warning and Avoidance Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system Interactions.
Unit V	Comfort and Convenience System Steering and mirror adjustment, central locking system, Garage door opening system, type pressure control system, rain sensor system, environment information system

Text Books

T.1	Bosch - "Automotive Handbook" - 5th edition - SAE publication - 2000.
T.2	J.Powloski - "Vehicle Body Engineering". - Business books limited, London - 1969.

Reference Books

R.1	Ronald.K.Jurgen - "Automotive Electronics Handbook" - Second edition- McGraw-Hill Inc., - 1999
R.2	J. Y. Wong, Theory of Ground Vehicles, A wiley Inter science Publications

	Useful Links
1	https://onlinecourses.nptel.ac.in/noc23_de01/preview
2	https://archive.nptel.ac.in/courses/107/106/107106088/

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