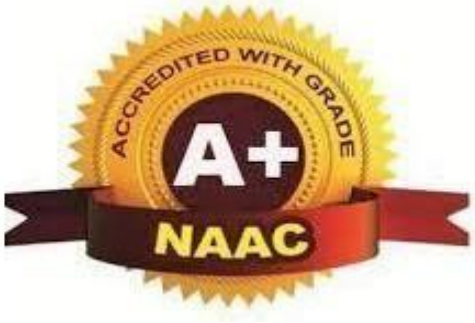
TULSIRAMJI GAIKWAD-PATIL
College of Engineering & Technology

Mohgaon, Wardha Road, Nagpur - 441 108

An Autonomous Institution



DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

M.Tech.in Electric Vehicle Technology

Teaching Scheme

From

Academic Year 2023-24

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

M1- To strive for rearing standard and stature of the students by practicing high standards of professional ethics, transparency and accountability.

M2- To provide facilities and services to meet the challenges of Industry and Society.

M3- To facilitate socially responsive research, innovation and Entrepreneurship.

M4- To ascertain holistic development of the students and staff members by inculcating knowledge and profession as work practices.

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

(An Autonomous Institution Affiliated to RTM Nagpur University, Nagpur)

Scheme of Examination and Syllabus

Scheme of Instructions for First Year M.Tech. Course in Electric Vehicle Technology

Semester–I (w. e. f.: AY2023-24)

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/week	Credits	Exam Scheme		
									CIE	ESE	TOTAL
1.	PCC	MEV1101	Power Electronic Converters for EV	4	-	-	4	4	40	60	100
2.	PCC	MEV1102	Electrical Drives for EV	3	-	-	3	3	40	60	100
3.	PCC	MEV1103	Electric Vehicle Structure Design	3	-	-	3	3	40	60	100
4.	PCC	MEV1104	Power Electronic Converters for EV Lab	-	-	2	2	1	25	25	50
5.	PCC	MEV1105	Computer Aided Design for EV Lab	-	-	2	2	1	25	25	50
6.	PEC	MEV11**06-09**	Professional Elective -I	3	-	-	3	3	40	60	100
7.	PEC	MEV11**10-13**	Professional Elective -II	3	-	-	3	3	40	60	100
8.	MCC	MAU1102	Disaster Management	2	-	-	2	Audit	-	-	-
			Total	**18**	**1**	**4**	**22**	**18**	**250**	**350**	**600**

L-Lecture T-Tutorial P-Practical CIE- Continuous Internal Evaluation

ESE-End Semester Examination (For Laboratory: End Semester Performance)

*-Program Elective/Audit Course/Open Elective (list is provided at the end of structure)

Tulsiramji Gaikwad-Patil College of Engineering &Technology, Nagpur

(An Autonomous Institution Affiliated to RTM Nagpur University, Nagpur)

Scheme of Examination and Syllabus

Scheme of Instructions for First Year M. Tech. Course in Electric Vehicle Technology

Semester–II (w. e. f.: AY2023-24)

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/week	Credits	Exam Scheme		
									CIE	ESE	TOTAL
1.	PCC	MEV1201	Battery Management Systems	3	-	-	3	3	40	60	100
2.	PCC	MEV1202	Advanced Control Systems for EV	3	-	-	3	3	40	60	100
3.	PCC	MEV1203	Battery Management Systems Lab	-	-	2	2	1	25	25	50
4.	PCC	MEV1204	Advanced Control System for EV Lab	-	-	2	2	1	25	25	50
5.	PCC	MEV1205	Vibration & Acoustic Lab	-	-	4	4	2	25	25	50
6.	FC	MEV1206	Research Methodology	2	-	-	2	2	25	25	50
7.	PEC	MEV12**07-10**	Professional Elective-III	3	-	-	3	3	40	60	100
8.	PEC	MEV12**11-14**	Professional Elective –IV	3	-	-	3	3	40	60	100
9.	MCC	MAU1202	IPR Patent Drafting	2	-	-	2	Audit	-	-	-
			Total	**16**	**-**	**8**	**24**	**18**	**260**	**340**	**600**

L-Lecture T-Tutorial P-Practical CIE- Continuous Internal Evaluation

ESE-End Semester Examination (For Laboratory: End Semester Performance)

*-Program Elective/Audit Course/Open Elective (list is provided at the end of structure

PROGRESSIVECREDITS=18+18=**36**

Tulsiramji Gaikwad-Patil College of Engineering &Technology, Nagpur

(An Autonomous Institution Affiliated to RTM Nagpur University, Nagpur)

Scheme of Examination and Syllabus

Scheme of Instructions for Second Year M.Tech. Course in Electric Vehicle Technology

Semester–III (w. e. f.: AY 2023-24)

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/week	Credits	Exam Scheme		
									CIE	ESE	TOTAL
1	PROJ	MEV2301	Dissertation Phase-I	-	-	20	20	10	100	100	200
2	PEC	MEV2302	MOOC course(8-12) $	-	-	-	-	3	-	-	-
3	OEC	M**$$**XX**01-06**	Open Elective-I	3	-	-	3	3	40	60	100
			Total	**3**	**-**	**20**	**23**	**16**	**100**	**100**	**200**

*$$-CS,SE,IP,MB

Note:

1. MEV2302will be decided by respective Guide in Consultation with Program Coordinator. Course is mandatory for student and his dissertation phase I will be considered incomplete without this Mandatory MOOC Course.

2. $ Programme coordinator will provide list of 03 MOOC courses of minimum 08 weeks duration (as per availability). Students are expected to complete any one out of three courses in order to get the required credits.

L-Lecture T-Tutorial P-Practical

CIE- Continuous Internal Evaluation ESE-End Semester Examination (For Laboratory End Semester performance)PROGRESSIVECREDITS=36+16=**52**

Tulsiramji Gaikwad-Patil College of Engineering &Technology, Nagpur

(An Autonomous Institution Affiliated to RTM Nagpur University, Nagpur)

Scheme of Examination and Syllabus

Scheme of Instructions for Second Year M.Tech. Course in Electric Vehicle Technology

Semester–IV (w. e. f.: AY 2023-24)

Sr.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/week	Credits	Exam Scheme		
									CIE	ESE	TOTAL
1.	PROJ	MEV2401	Dissertation Phase-II	-	-	32	32	16	100	200	300
			Total	**-**	**-**	**32**	**32**	**16**	**100**	**200**	**300**

CIE- Continuous Internal Evaluation

ESE-End Semester Examination (For Laboratory End Semester Performance)

TOTAL CREDITS=52+16=**68**

Tulsiramji Gaikwad-Patil College of Engineering &Technology, Nagpur

(An Autonomous Institution Affiliated to RTM Nagpur University, Nagpur)

Scheme of Examination and Syllabus

Scheme of Instructions for Second Year M.Tech. Course in Electric Vehicle Technology

List of Professional Elective Courses

Semester-I			Semester-II	
Professional Elective-I	**Professional Elective-II**		**Professional Elective-III**	**Professional Elective-IV**
MEV1106: Switching Power Supplies	MEV1110: Control Techniques for EV Converters		MEV1207: EV Battery Charging Systems	MEV1211: Electric Vehicle Sensors Technology
MEV1107: Plug-In ElectricVehicles	MEV1111: Microprocessor Applicationin Automobile		MEV1208: Digitally basedConverters for EV	MEV1212:Electric Vehicle Maintenance
MEV1108:Vehicle Body Engineering	MEV1112: Energy Conversion Systems for EV		MEV1209: Automotive Chassis & Suspension	MEV1213:Smart Grid Interface of EV
MEV1109:Vehicle Aerodynamics	MEV1113: Automotive Safety		MEV1210: Internet of Things (IoT)	MEV1214: Economics of Electric Vehicles

List of Audit Courses and Open Electives

Semester–I	Semester–II	Semester-III
Audit Course-I	**Audit Course-II**	**Open Electives**
MAU1101: Research Paper Writing	MAU1201:Constitution of India	MCSXX01: Business Analytics
MAU1102:Disaster Management	MAU1202: IPR &Patent Drafting	MSEXX02: Cost Management of Engineering Projects
MAU1103:Sanskrit for Technical Knowledge	MAU1203:Stress Management by Yoga	MSEXX03:CompositeMaterials
MAU1104:Value Education	MAU1204:Personality Development through Life Enlightenment Skills	MIPXX04:Waste to Energy
		MEDXX05:IndustrialSafety
		MMBXX06: Operation Research

HOD
Department of Electronics & Comm.
Tulsiramji Gaikwad - Patil College
Engineering & Technology, Nagpur

Dean Academics
Tulsiramji Gaikwad-Patil
College Of Engineering
and Technology, Nagpur

Vice-Principal
TulsiRamji Gaikwad Patil
College Of Engineering &
Technology, Nagpur

Principal
Tulsiramji Gaikwad Patil College Of
Engineering and Technology, Nagpur

TULSIRAMJI GAIKWAD-PATIL College of Engineering & Technology

Mohgaon, Wardha Road, Nagpur - 441 108

An Autonomous Institute

ELECTRIC VEHICLE TECHNOLOGY (M. Tech)

Teaching Scheme & Syllabus

Second Semester

From

Academic Year 2023-24

Tulsiramji Gaikwad-Patil College of Engineering and Technology
Wardha Road, Nagpur-441108
NAAC Accredited (A+Grade)
An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1201: Battery Management System**

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

Course Objective:

1	To introduce learner to batteries, its parameters, modelling and charging requirements.
2	To develop battery management algorithms for batteries.
3	To study the basic of Electric vehicles and its major parts.

Course Outcomes

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

MEV1201.1	**Interpre**t the role of battery management system
MEV1201.2	**Identify** the requirements of Battery Management System
MEV1201.3	**Interpret** the concept associated with battery charging / discharging process
MEV1201.4	**Analyze** the various parameters of battery and battery pack
MEV1201.5	**Design** the model of battery pack

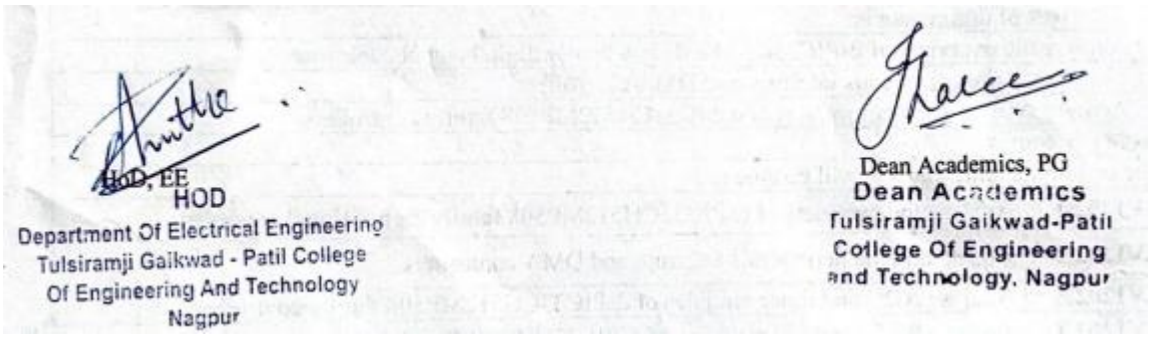
Course Contents

Unit I	**Introduction:** Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging.
Unit II	**Battery Management System Requirement:** Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation, Cell total energy and cell total power.
Unit III	**Battery State of Charge and State of Health Estimation, Cell Balancing:** Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium-ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing.
Unit IV	**Modelling and Simulation:** Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, simulating constant power and voltage, Simulating battery packs,
Unit V	**Design of battery BMS:** Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system.

Text Books

1	Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2	Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods.

	Artech House, 2015.
3	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002
4	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
5	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008
Reference Books	
1	Vedam Subrahmanyam, " Electric drives concepts and applications" McGraw-Hill, 1996.
2	James Larminie, John Lowry, "Electric Vehicle Technology", Wiley, 2003.
Useful Links	
1	https://www.coursera.org/learn/battery-management-systems
2	https://nptel.ac.in/courses/108106170



Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441108

NAAC Accredited (A+Grade)

An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1202: Advance Control Systems for EV**

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

Course Objectives

The Objectives of this course is:

1.	Analyse the overview of dsPIC33CH512MP508 family digital signal controller
2.	Understand the peripherals interrupt and DMA controllers
3.	Analyse ADC and timer modules of dsPIC33CH512MP508 family controllers.

Course Outcomes

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

MEV1202.1	Analyse the overview of dsPIC33CH512MP508 family digital signal controller
MEV1202.2	Understand the peripherals interrupt and DMA controllers.
MEV1202.3	Analyse ADC and timer modules of dsPIC33CH512MP508 family controllers.
MEV1202.4	Analyse PWM and I/O modules of dsPIC33CH512MP508 family controllers.
MEV1202.5	Analyse I2C, SPI and CAN protocols used in the DSP.

Course Contents

Unit I	**Introduction to the dsPIC33C family digital signal controller** Block diagram of dsPIC33/PIC24 Enhanced CPU, On chip memory and Peripherals, Applications and Features of dsPIC Family, Data memory, Modulo Addressing
Unit II	**Interrupt Controller** Introduction, Interrupt Vector Table (IVT), interrupt control and status registers, non-maskable traps interrupt processing timing, interrupt setup procedures
Unit III	**Analog to Digital Converter** Introduction, Registers, Register Map, Conversion Sequence, ADC Operation, Application Examples, Operation During Power-Saving Modes, Effects of Reset **Configurable Logic Cell (CLC):** Overview and Features **Timer 1 Module** Introduction, Control Registers, Modes of Operation, Interrupts, Operation in Power-Saving Modes
Unit IV	**High resolution PWM with Fine Edge Placement** Registers, Register Maps, Common Functions Register Map, PWM Generator Register Map, Architecture Overview Operation, PWM Clocking, PWM Generator (PG) Features, Common Features, Lock and Write Restrictions, Application Examples.
Unit V	**Queued Serial Peripheral Interface:** Overview, Block Diagram, Signal Description, Memory map Registers, Operating Modes

	Inter-Integrated Circuit (I2C): Features, modes of Operation, Block Diagram, Memory Map and Registers, Functional Description. CAN Flexible Data-Rate (FD) Protocol Module: Introduction, CAN FD Message Frames, Registers, Modes of Operation, Configuration

Text Books	
T.1	dsPIC33Cxxx Reference manual.
T.2	dsPIC33CH512MP508-Family-Data-Sheet-DS70005371D
Reference Books	
R.1	Ioan Doré Landau, Gianluca Zito ,Digital Control Systems: Design, Identification and Implementation (Communications and Control Engineering)

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

Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441108

NAAC Accredited (A+Grade)

An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1203: Battery Management System lab**

Teaching Scheme			**Examination Scheme**	
Lectures			**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	2 Hr / Week		**Total**	50 Marks
Theory Credits : 2			**Duration of Exam :**	

Course Objectives

The Objectives of this course is:

1.	To introduce learner to batteries, its parameters, modelling and charging requirements.
2.	To develop battery management algorithms for batteries.
3.	To study the basic of Electric vehicles and its major parts.

Course Outcomes

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

MEV1203.1	**Interpret** the role of battery management system
MEV1203.2	**Identify** the requirements of Battery Management System
MEV1203.3	**Interpret** the concept associated with battery charging / discharging process
MEV1203.4	**Analyze** the various parameters of battery and battery pack
MEV1203.5	**Design** the model of battery pack

List of Experiments

1.	To model a lead-acid battery cell using the Simscape™.
2.	Observe the charging and discharging process, and plot graph of charging/load current, SOC, temperature, DOC, and terminal voltage.
3.	To analyse the effect of temperature on the performance of a Lithium-Ion battery model.
4.	To simulate and plot the result of temperature, SOC, current, and terminal voltage for the HV Battery Charge/Discharge using realistic DC-link current profile, which originates from a dynamic driving cycle.
5.	To study Lithium Battery Cell - One RC-Branch Equivalent Circuit and it's simulation.
6.	To simulate Ni-MH Battery Model with the DC machine and show the charging and discharging process using DC machine.
7.	To simulate Lithium-Ion (LiFePO4) Battery and analyse the effect of DOD and discharge rate on battery ageing considering 1000 h simulation time.
8.	Modelling and Simulation of BMS for passive cell balancing in EV using MATLAB/SIMULINK
9.	Battery controller based on SoC for charging and discharging of battery in EV using MATLAB/SIMULINK
10.	SoC control of Lithium-Ion battery in MATLAB/Simulink

Text Books

T.1	Prof. Sunil Pawar, "Electric Vehicle Technology" Notion Press Publication, 2nd edition, 2020.

HOD
Department Of Electrical Engineering
Tulsiramji Gaikwad - Patil College
Of Engineering And Technology
Nagpur

Dean Academics, PG
Dean Academics
Tulsiramji Gaikwad-Patil
College Of Engineering
and Technology, Nagpur

Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441108

NAAC Accredited (A+Grade)

An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1204: Advance Control Systems for EV lab**

Teaching Scheme			**Examination Scheme**	
Lectures			**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	2 Hr / Week		**Total**	50 Marks
Theory Credits : 2			**Duration of Exam :**	

Course Objectives

The Objectives of this course is:

1.	To study the effect of field weakening in DC motor control
2.	To understand the open loop and closed loop control of DC motor
3.	To study PWM generation and control of 3-phase induction motor. To understand the significance of dead time in PWM generation.

Course Outcomes

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

MEV1204.1	**Demonstrate** the effect of field weakening in DC motor control.
MEV1204.2	**Design** open loop and closed loop control of DC motor.
MEV1204.3	**Analyze** the control of 3 phase induction motor.
MEV1204.4	**Demonstrate** the significance of dead time in PWM generation.
MEV1204.5	**Develop** controllers for BLDC and PMSM drives.

List of Experiments

1.	Model the DC motor and study the effect of field weakening on the speed.
2.	Design suitable current PI gains so that current control bandwidth is 150 Hz and the damping coefficient is 0.7 for DC motor.
3.	Demonstrate four-quadrant operation of DC Motor control.
4.	Illustrate the stability of the DC motor using bode plot for open loop and closed loop cases.
5.	Design and simulate Variable Voltage Variable Frequency Control for 3 phase induction motor.
6.	Generate sinusoidal PWM for single phase inverter.
7.	Generate PWM signals for H bridge inverter incorporating dead time.
8.	Simulate space vector PWM technique
9.	Discuss BLDC motor drives.
10.	Study of PMSM drives

Text Books

T.1	K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019

HOD, EE
HOD
Department Of Electrical Engineering
Tulsiramji Gaikwad - Patil College
Of Engineering And Technology
Nagpur

Dean Academics, PG
Dean Academics
Tulsiramji Gaikwad-Patil
College Of Engineering
and Technology, Nagpur

Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441108

NAAC Accredited (A+Grade)

An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1205: Vibration and Acoustic lab**

Teaching Scheme			**Examination Scheme**	
Lectures	-		**ESE**	25 Marks
Tutorial	-		**CIE**	25 Marks
Practical	2 Hr / Week		**Total**	50 Marks
Theory Credits : 2			**Duration of Exam :**	

Course Objectives

The Objectives of this course is:

1.	To study the effect of field weakening in DC motor control
2.	To understand the open loop and closed loop control of DC motor
3.	To study PWM generation and control of 3-phase induction motor. To understand the significance of dead time in PWM generation.

Course Outcomes

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

MEV1205.1	**Demonstrate** the significance of experimentation and explore the possibility of carrying out engineering investigations.
MEV1205.2	**Acquire** hands on experience on the various test-rigs, experimental set up.
MEV1205.3	**Measure** the various technical parameters by instrument and by mathematical relationship
MEV1205.4	**Validate** actual performance of the system experimentally
MEV1205.5	**Analyse** experimental test data for further improvement of the system

List of Experiments

1.	Demonstration of various noise and vibration measuring instruments.
2.	Modal analysis of automotive components.
3.	Measurement of Sound pressure level of automotive noise sources.
4.	Measurement of sound absorption coefficient of sound absorbing materials.
5.	Noise measurement of an electric motor.
6.	Vibration measurement of an electric motor.
7.	Measurement of sound transmission loss of sound absorbing materials.
8.	Measurement of vehicle pass by noise
9.	Measurement of Sound power level of automotive noise sources.
10.	Performance test on Tractor / Genset diesel engine.

Text Books

T.1	Ganesan. V, Internal Combustion Engines, Mc Graw Hill Education 2017
T.2	Norton, Michael; Karczub, Denis, Fundamentals of Noise and Vibration Analysis for Engineers.
T.3	McConnell, Kenneth G., Vibration Testing - Theory and Practice, John Wiley & Sons 2008.

HOD, EE HOD
Department Of Electrical Engineering
Tulsiramji Gaikwad - Patil College
Of Engineering And Technology
Nagpur

Dean Academics, PG
Dean Academics
Tulsiramji Gaikwad-Patil
College Of Engineering
and Technology, Nagpur

	Tulsiramji Gaikwad-Patil College of Engineering and Technology Wardha Road, Nagpur-441108 **NAAC Accredited (A+Grade)** **An Autonomous Institute affiliated to RTMNU Nagpur**	

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

Semester-II **MEV1206: Research Methodology**

Teaching Scheme			**Examination Scheme**	
Lectures	2 Hr / Week		**ESE**	30 Marks
Tutorial	-		**CIE**	20 Marks
Practical	-		**Total**	50 Marks
Theory Credits : 2			**Duration of Exam: 2** Hrs	

Course Objectives

The Objectives of this course is:

1.	To develop the research aptitude among the researchers
2.	To develop the most appropriate methodology for his/her research
3.	To make them familiar with different research methods and techniques

Course Outcomes

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

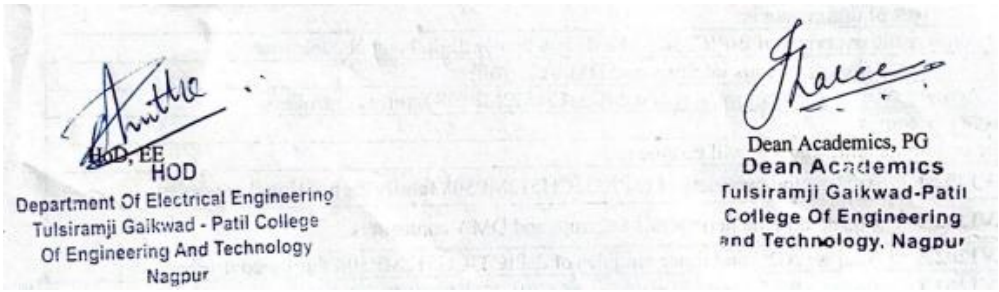
MEV1206.1	**Describe** the meaning and importance of research
MEV1206.2	**Outline** the concept of research design and survey methodology
MEV1206.3	**Explain** Collection of data, processing of data and descriptive measures of data
MEV1206.4	**Inferential** analysis of data with hypothesis testing and multivariate techniques
MEV1206.5	**Illustrate** the Structure and components of research report

Course Contents

Unit I	**RESEARCH FORMULATION AND DESIGN** Definition and objective of research, types of research, steps in research process, research Design, concept and types of research design, defining and formulating the research problems, importance of literature review- primary and secondary sources, reviews, monographs, patent, research database, web sources, identifying gap areas from the literature and research data base, surveying synthesis, Interpretation.
Unit II	**SAMPLING & DATA INTERPRETATION** Mathematical tools for analysis, statistical analysis of data, regression analysis, correlation, concept of best fit and exact fit, exact fit, theory, examples from linear regression with one and more unknowns.
Unit III	**PATENT RIGHTS AND IPR** Patents and its basics, process of filing patent at national and international level, Introduction and significance of intellectual property rights, commercialization, royalty, copyright, trade related aspects of IPR, Administration of patent system in India, licensing and transfer of technology, case studies
Unit IV	**RESEARCH AND PUBLICATION ETHICS:** Research and Integrity, Scientific mis conduct: Falsification, Fabrication and Plagiarism (FFP), Conflict of research, Predatory publishers and Journals, Open access publication, citation and acknowledgement, reproducibility and accountability, software tools for similarity check
Unit V	**REPORT WRITING** Structure and components of research report, types of report, layout of research report, mechanism of writing a research report, referencing in academic writing, Abstracting, Bibliography

Text Books	
T.1	C R Kothari, Research Methodology: methods and techniques, New Age International Publication Ltd
T.2	Neuman, W. Lawrence. 2000. Social research methods: qualitative and quantitative approaches. Boston: Allyn and Bacon
Reference Books	
R.1	Michael Alley, The Craft of Scientific Writing (3rd Edition), Springer, New York, 1996
R.2	Philip Reubens (General editor), Science and Technical Writing – A Manual of Style (2nd Edition), Routledge, New York, 2001
R.3	N.S. Gopalakrishnan & T.G. Agitha, Principles of Intellectual Property (2009), Eastern Book Company, Lucknow

Useful Links	
1	https://dcu.libguides.com/c.php?g=654993&p=4603983
2	https://library.famu.edu/c.php?g=276373&p=1841937



Tulsiramji Gaikwad-Patil College of Engineering and Technology
Wardha Road, Nagpur-441 108
NAAC Accredited (A+ Grade)
(An Autonomous Institute Affiliated to RTM Nagpur University, Nagpur)

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

Semester-II **MEV1207: EV Battery Charging System**

Teaching Scheme			**Examination Scheme**	
Lectures	2 Hr / Week		**ESE**	60 Marks
Tutorial	-		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits : 2			Duration of Exam: 3 Hrs	

Course Objective

1	To understand working of different types of electric vehicles.
2	To explain the battery parameters.
3	To illustrate battery charging and modeling.
4	To introduce novel and alternate energy sources.

Course Outcomes:

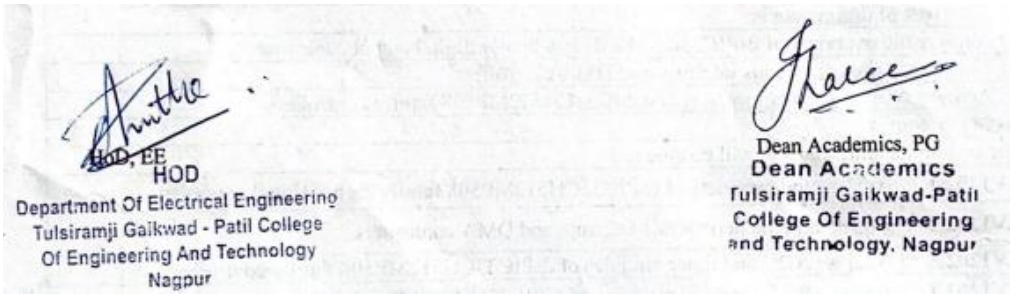
At the end of the unit, students will be able to :

MEV1207.1	**Describe** battery basics and its different types used in electric vehicles.
MEV1207.2	**Analyze** the capacity of different types of batteries used in electric vehicles
MEV1207.3	**Analyze** the impacts of rate of charge effect and environmental effects in different battery charging methods
MEV1207.4	**Compare** the fast charging and discharging behavior of different types of batteries
MEV1207.5	**Analyze** battery performance management systems used with respect to battery operation and safety.

Course Contents

Unit I	**EV BATTERIES**: Electric Vehicle Operation, Battery Basics, Introduction to Electric Vehicle Batteries, Fuel Cell Technology, Choice of a Battery Type for Electric Vehicles. 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 II	**EV BATTERY EFFICIENCY AND ITS MODELLING :** Effects of VRLA Battery Formation on Electric Vehicle Performance, Regenerative Braking, Electric Vehicle Body and Frame, Fluids, Lubricants, and Coolants, Effects of Current Density on Battery Formation, Effects of Excessive Heat on Battery Cycle Life, Battery Storage, The Lithium-ion Battery, Traction Battery Pack Design . Battery Modeling, the purpose of battery modeling, Battery equivalent circuit, Modeling battery capacity, Simulation a battery at a set power, Calculating the Peukert Coefficient, Approximate battery sizing.
Unit III	**ELECTRIC VEHICLE BATTERY CHARGING** :Charging NiMH Batteries, Rate of Charge Effect on Charge Acceptance Efficiency of Traction, Battery Packs, Environmental Influences on Charging, Charging Methods for NiMH Batteries, Charging Technology, Battery Pack Corrective Actions.
Unit IV	**ELECTRIC VEHICLE BATTERY FAST CHARGING** :On-board & off-board charging, The Fast Charging Process, Configuration, Using Equalizing/Leveling Chargers, Inductive Charging. **ELECTRIC VEHICLE BATTERY DISCHARGING :** Definition of NiMH Battery

	Capacity, Discharge Capacity Behavior, Discharge Characteristics of Li-ion Battery, Discharge of an Electric Vehicle Battery Pack, Cold-Weather Impact on Electric Vehicle Battery Discharge.
Unit V	**ELECTRIC VEHICLE BATTERY PERFORMANCE** : The Battery Performance Management System, BPMS Thermal Management System, The BPMS Charging Control, High-Voltage Cabling and Disconnects, Safety in Battery Design, Battery Pack Safety— Electrolyte Spillage and Electric Shock, Charging Technology, Electrical Insulation Breakdown Detection, Electrical Vehicle Component Tests, Building Standards, Ventilation.
Text Books	
1	Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002.
2	Battery Technology For Electric Vehicles Public Science And Private Innovation by Albert N. LINK, Taylor and Francis,2015.
3	Advanced Battery Management Technologies For Electric Vehicles by Rui Xiong , Weixiang Shen, Wiley, March 2019.
Reference Books	
1	M. Barak (Ed.), T. Dickinson, U. Falk, J.L. Sudworth, H.R. Thirsk, F.L. Tye, “Electrochemical Power Sources: Primary & Secondary Batteries”, IEE Energy Series 1, A. Wheaton &Co, Exeter, 1980.
2	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.



Tulsiramji Gaikwad-Patil College of Engineering and Technology
Wardha Road, Nagpur-441 108
NAAC Accredited (A+ Grade)
(An Autonomous Institute Affiliated to RTM Nagpur University, Nagpur)

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

Semester-II **MEV1210: Internet of Things (IoT)**

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

Course Objectives

The Objectives of this course is:

1.	To provide a good understanding of Internet of Things (IoT) and it's envisioned deployment domains.
2.	To provide an understanding of smart sensors/actuators with their internet connectivity for experimentation and designing systems.
3.	To impart knowledge in the design and development of IoT systems with enablement ensuring security and assimilated privacy

Course Outcomes

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

MEV1210.1	**Identify** the Components that forms part of IoT Architecture.
MEV1210.2	**Evaluate** the appropriate protocol for communication between IoT.
MEV1210.3	**Setup** the connections between Cloud to Fog and MIST networking.
MEV1210.4	**Analyze** the database for IoT.
MEV1210.5	**Describe** the Radar sensor and detectors for vehicle safety.

Course Contents

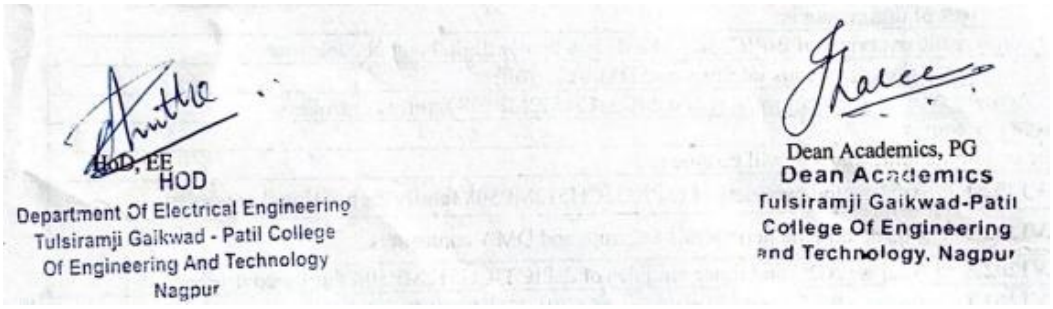
Unit I	**Internet of Things:** Introduction, Wireless sensor networks need for IoT, Edge resource pooling and caching, client side control, and configuration, Basics of Networking, Smart objects as building blocks for IoT, Embedded systems platforms for IoT, IO drivers.
Unit II	**Operating system for IoT:** requirement of OS, examples: mbed, Contiki, RIOT **IoT Communication Protocols:** IPV6, 6LowPAN, CoAP, MQTT, Machine-to-Machine Communications.
Unit III	**Software Defined Networks (SDN):** From Cloud to Fog and MIST networking for IoT Communications, Principles of Edge/P2P networking, Cloud and Fog Ecosystem for IoT Review of architecture, Security and privacy in Fog
Unit IV	**Database for IoT:** OLAP and OLTP, NoSQL databases, Row and column Oriented databases, Introduction to Columnar DBMS CStore, Run: Length and Bit vector Encoding, Integrating Compression, and Query Execution in Columnar databases.
Unit V	**Radar sensor Detectors for vehicle safety:** Introduction to Radar sensor detectors,Types (Long range, medium, short range and ultra-short, mechanically scanning LIDAR), Working, benefits,

Text Books

T.1	A Bahaga, V. Madisetti, "Internet of Things- Hands on approach", VPT publisher, 2014.

T.2	McEwen, H. Cassimally, “Designing the Internet of Things”, Wiley, 2013.
T.3	Joe Biron & Jonathan Follett, Foundational Elements of an IoT Solution – The Edge, The Cloud and Application Development, Oreilly,1st Edition, 2016.
Reference Books	
R.1	The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, Lucas Darnell, 2016.
R.2	The Internet of Things – Opportunities and Challenges http://www.ti.com/ww/en/internet_of_things/pdf/14-09-17-IoTforCap.pdf
R.3	Wireless Connectivity for the Internet of Things – One size does not fit all http://www.ti.com/lit/wp/swry010/swry010.pdf.

	Useful Links
1	https://developer.mbed.org/handbook/AnalogIn
2	http://www.libelium.com/50_sensor_applications/
3	http://www.m2mlabs.com/framework



Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441 108

NAAC Accredited (A+ Grade)

An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1211: Electric Vehicle Sensors Technology**

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

Course Objectives

The Objectives of this course are:

1.	To study and analyze various sensor technologies for vehicles.
2.	To understand the types of sensor applications in electric vehicles.
3.	To study the fundamentals about communication in Electric vehicle.

Course Outcomes

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

MEV1211.1	Understand different technologies used with respect to Sensor.
MEV1211.2	Describe different sensors used in vehicles.
MEV1211.3	Identify different actuators used in vehicles.
MEV1211.4	Use diagnostic tools such as digital multimeter, oscilloscope in detecting the faults using ECM.
MEV1211.5	Illustrate communication protocols and infotainment systems used in vehicles.

Course Contents

Unit I	**Basics of Sensors** Difference between sensor, transmitter, and transducer - Primary measuring elements - selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, Response time, Dead band. Signal transmission - Types of signal: Pneumatic signal; Hydraulic signal; Electronic Signal. Principle of operation, construction details, characteristics and applications of the potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, Photo-resistive sensor.
Unit II	**Types of Sensors** Optical sensors, variable resistance type sensors, temperature sensors, Pressure sensors, variable capacitance sensors, Flow sensors, Hall Effect, hot wire, thermistor, piezoelectric, piezoresistive, based sensors. lambda sensor, detonation sensor,
Unit III	**Actuators:** Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems: Solid-state switches, Solenoids, Injectors, stepper motors, relays, ABS actuators, electrohydraulic actuators, Exhaust gas recirculation actuators
Unit IV	**Automotive Safety Systems Sensors:** Preventive design, designing for minimum injury in an accident, seat belts, seat belt pre-tensioner with load limiter, airbags, electronic vehicle stability (traction control system, Hill Hold) and occupants protection system, pedestrian protection, isocar seat fix, child-lock.

	Miscellaneous: SHVS system, lane departure warning, adaptive cruise control, automatic emergency braking system, 360º degree camera.
Unit V	**Sensors and Communication:** LiDAR, RADAR, Camera - specifications and utilization, CAN OBD, communication V2V, VI, V2X, Internet of Cars. ADAS Applications: Simultaneous localization and motion, path planning, ambience awareness, driver drowsiness and intent detection, machine learning algorithms for automotive applications.
Text Books	
1	Jiri Marek, Hans Peter Trah, "Sensors Applications, Sensors for Automotive Technology" by Wiley, 1st Edition. 2003
2	Ronald K Jurgen, "Navigation and Intelligent Transportation Systems – Progress in Technology", Automotive Electronics Series, SAE, USA, 1998.
3	William B Ribbens, "Understanding Automotive Electronics", 7th edition, Butter worth Heinemann Woburn -2012

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

HOD, EE
HOD
Department Of Electrical Engineering
Tulsiramji Gaikwad - Patil College
Of Engineering And Technology
Nagpur

Dean Academics, PG
Dean Academics
Tulsiramji Gaikwad-Patil
College Of Engineering
and Technology, Nagpur

Tulsiramji Gaikwad-Patil College of Engineering and Technology
Wardha Road, Nagpur-441 108
NAAC Accredited (A+ Grade)
An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1212: Electrical Vehicle Maintenance**

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

Course Objectives

The Objectives of this course is:

1.	To understand the objective of maintenance in Electric vehicles
2.	To identify the schedule for maintenance for Electric vehicles
3.	To know the Do's and Don'ts & precautions to avoid faults in Electric vehicles

Course Outcomes

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

MEV1212.1	**Recognize** need of maintenance in Electric Vehicle.
MEV1212.2	**Describe** types of maintenance and safety for automobile components.
MEV1212.3	**Utilize** the concepts used regarding the Safety of vehicles.
MEV1212.4	**Explain** need of rules & statutory regulations pertaining to safety.
MEV1212.5	**Apply** the precautions in electrical equipment installation in vehicle

Course Contents

Unit I	Introduction to EV safety Equipment's and tools. Introduction & need of maintenance, Types of maintenance systems, Breakdown maintenance, Preventive maintenance, Predictive maintenance, Total productive maintenance
Unit II	**Vehicle Maintenance**: Electric vehicle maintenance as compared to combustion engine; Electrical Motor Maintenance, braking systems maintenance, Electric Drive Maintenance, Battery Maintenance, Maintenance of various sensors fitted on the vehicle
Unit III	**Maintenance Schedule**: Standard inspection points, schedule and requirements for Battery pack, Brakes, Chargers, connectors and cables used in EV
Unit IV	**Vehicle Safety** Definition of Safety: Hazard, accident, major accident hazard, responsibility, authority, accountability, Monitoring. Need of Safety, Rules & Statutory regulations for safety of persons
Unit V	**Equipment in electrical installation:** Dos & don'ts for Electric Vehicle, Precautions to be taken to avoid fire due to electrical faults, types and operation of fire extinguishers. Safety related to EV and high voltage handling.

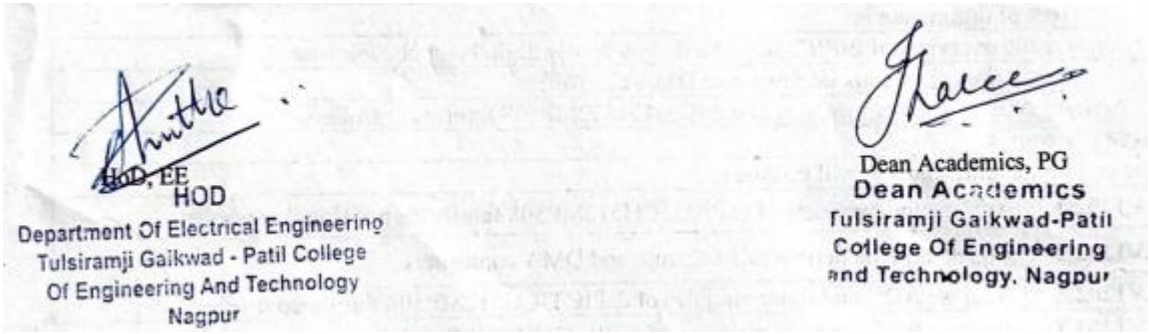
Text Books

T.1	Rao, B V S Asia Club House, First Reprint, 2011, Operation and Maintenance of Electrical Equipment Vol-I,
T.2	Rosenberg. Mc GRAW-HILL, 1st Edition, May 2003, Maintenance and Repairs
T.3	Sharotri, S.K. Glencoe/ Mcgraw- Hill; 2nd Edition , June 1969; Preventive Maintenance of Electrical Apparatus

Reference Books

R.1	Vehicle Maintenance and garage practice, jigar a. doshi, dhruv u. panchal, jayesh p. maniar, phi learning

R.2	Deshpande. M. V. PHI Learning Pvt. Ltd., 2010, Design and Testing of Electrical Machines.
Useful Links	
1	https://youtu.be/3E1SXG7VkQk?si=QjnusH4oAqg8mbit
2	https://youtu.be/A3fHQsIkYeU?si=NwEQJTGhPXSgSu7k



Tulsiramji Gaikwad-Patil College of Engineering and Technology
Wardha Road, Nagpur-441 108
NAAC Accredited (A+ Grade)
An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1213: Smart Grid Interface of EV**

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

Course Objectives

The Objectives of this course is:

1.	To study the possible methods of integration of Electric Vehicle in smart grid networks.
2.	To study the effects of smart grid on the Electric Vehicle.
3.	To give students an insight to the ever-evolving world of Smart Grid & Electric Vehicles.

Course Outcomes

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

MEV1213.1	**Elaborate** elements of Smart Grid along with terminologies associated with it.
MEV1213.2	**Explain** the communication protocols used in Smart Grid.
MEV1213.3	**Analyze** Impact of EV on smart grid in terms of grid stability.
MEV1213.4	**Evaluate** the role of renewable energy interface in demand response coordination in EV.
MEV1213.5	**Assess** the smart charging algorithms to forecast EV charging demand.

Course Contents

Unit I	**Introduction to Smart Grid:** Smart Grid Architecture, Standards for Smart Grid System, Elements and Technologies of Smart Grid System Distributed Generation Resources.
Unit II	**Communication Protocols in Smart Grid:** Open Charge Point Protocol (OCPP), ISO 15118, Open ADR (Open Automated Demand Response), Modbus, IEC 61850, IEEE 2030.5, Smart Grid Communication Standards (e.g., Zigbee, Wi-Fi, Cellular).
Unit III	**V2G Technology:** Working of V2G Technology**,** Charging Phase, Discharging Phase, Bidirectional Communication, Benefits of V2G Technology, Grid Stability, Peak Load Management, Renewable Energy Integration, Revenue Generation, Environmental Benefits.
Unit IV	**Renewable Energy Integration:** Renewable Energy Forecasting, Dynamic Pricing and Incentives, Real-Time Grid Monitoring, Demand Response Coordination and Interface for coordinating EV charging with renewable energy generation in smart grid, optimizing charging times to coincide with periods of high renewable energy availability.
Unit V	**Data Analytics and Optimization –** Smart Charging Algorithms, algorithms to minimize energy costs for EV owners while maximizing the use of renewable energy and maintaining grid stability, algorithms to forecast EV charging demand, optimize charging schedules.

Text Books	
T.1	S. Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, 1st Edition.
T.2	Lars T. Berger, Krzysztof Iniewski, “Smart Grid Applications, Communications and Security (WSE)”, Wiley–IEEE Press, 2nd Edition.
T.3	Salman, S.K., 2017. Introduction to the Smart Grid: Concepts, Technologies and Evolution (Vol. 94). IET
Reference Books	
R.1	Lu, J. and Hossain, J., 2015. Vehicle-to-grid: linking electric vehicles to the smart grid. Institution of Engineering and Technology.
R.2	Rajakaruna, S., Shahnia, F. and Ghosh, A. eds., 2014. Plug In Electric Vehicles in Smart Grids: Integration Techniques. Springer.
R.3	Rajakaruna, S., Shahnia, F. and Ghosh, A. eds., 2014. Plug in electric vehicles in smart grids: charging strategies. Springer.

Useful Links	
1	https://nptel.ac.in/courses/108107113
2	https://nptel.ac.in/courses/108106170

Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441 108

NAAC Accredited (A+ Grade)

An Autonomous Institute affiliated to RTMNU Nagpur

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

Semester-II **MEV1214: Economics of Electric Vehicles**

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

Course Objectives

The Objectives of this course is:

1.	To get the knowledge and skills to navigate the complexities of the electric vehicle market.
2.	To get the knowledge and skills to navigate the complexities of electric vehicle charging infrastructure, assess investment opportunities, and contribute to the development of effective strategies
3.	To gain a comprehensive understanding of the economic benefits and challenges associated with the widespread adoption of electric vehicles (EVs).

Course Outcomes

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

MEV1214.1	**Evaluate** the initial purchase cost and total cost of ownership (TCO) of EVs
MEV1214.2	**Analyze** global and regional market trends in EV adoption,
MEV1214.3	**Analyze** of cost trends and projections for EV batteries
MEV1214.4	**Evaluate** government policies and incentives aimed at supporting the development of charging infrastructure
MEV1214.5	**Evalu**ate potential societal benefits resulting from widespread EV adoption

Course Contents

Unit I	**Cost Analysis of Electric Vehicles:** Initial purchase cost vs. Total Cost of Ownership (TCO) analysis Factors affecting the cost of EVs: Battery costs, economies of scale, government incentives, charging infrastructure Comparison with Internal Combustion Engine (ICE) vehicles: Fuel costs, maintenance costs, depreciation.
Unit II	**Market Dynamics and Demand for Electric Vehicles:** Global and regional market trends in EV adoption. Consumer preferences and attitudes towards EVs. Policy and regulatory frameworks influencing EV markets. Forecasting future market growth and penetration rates.
Unit III	**Electric Vehicle Battery Economics** Battery technology overview: Lithium-ion, Solid-state, etc. Cost trends and projections for EV batteries Factors influencing battery cost reduction: Research and development, economies of scale, recycling Implications of battery costs on EV affordability and adoption

Unit IV	**Charging Infrastructure Economics** Overview of charging infrastructure types: Home charging, public charging stations, fast charging. Investment costs and business models for charging infrastructure Impact of charging infrastructure on EV adoption rates. Government policies and incentives to support charging infrastructure development.
Unit V	**Economic Impacts of Electric Vehicles** Economic benefits and challenges of widespread EV adoption Effects on traditional automotive industry: Supply chain disruption, job displacement, new business opportunities Economic implications for energy sector: Electricity demand, grid integration, renewable energy deployment Potential societal benefits: Air quality improvement, healthcare cost reduction, energy independence

Text Books	
T.1	Anthony Ademola Adeyanju, "Electric Vehicle Economics: Statistical and Economic Analysis**",** **LAP** LAMBERT Academic Publishing (April 15, 2020)
T.2	Cecilia Briceno-Garmendia, Wenxin Qiao and Vivien Foster, "The Economics of Electric Vehicles for Passenger Transportation", World Bank Publications. May 23, 2023
T.3	A.K. Babu, "Electric & Hybrid Vehicles' Khanna Publishing House
Reference Books	
R.1	Prakash Nirupama– "The Future of Electric Vehicles in India", Publisher: Zorba Books