**Semester- II**

| Power Electronic Converters | | | |
|---|---|---|---|
| Course Code | MEVT201 | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

- Understand the essentials of power conversion
- Design practical non isolated converters
- Design practical offline converters
- Design practical isolated converters
- Bidirectional converter topologies for Electric Vehicles

**Module-1**

**Power Semiconductor Devices**

Ideal and Typical Power Switching Waveforms, Ideal and Typical Power Device Characteristics, Unipolar Power Devices, bipolar Power Devices, MOS-Bipolar Power Devices.

**Introduction to Power Conversion**

Converting power with resistors, Converting power with switches, buck converter, boost converter, buck-boost Converter, Input filtering.

**Module-2**

**Non-isolated converters**

Buck converter, Boost converter, Buck-Boost converter, analysis design and simulation.

**Module-3**

**Offline Converters—the front end**

**Rectifier Bridge:**

Capacitor selection, Diode Conduction Time, Rms Current in the Capacitor, Current in the Diodes, Input Power Factor, Hold-Up Time, In-Rush Current

**Power Factor Correction**: Definition of Power Factor, Non-sinusoidal Signals, A Link to the Distortion, Why Power Factor Correction? Harmonic Limits, A Need for Storage, Passive PFC, Improving the Harmonic Content, The Valley-Fill Passive Corrector, Active Power Factor Correction, Constant on-time borderline mode (BCM), fixed- frequency continuous mode (CCM), Analytical control law

**Module-4**

**Isolated Converters**

Practical designs of flyback converters, an isolated buck-boost, flyback waveforms without parasitic elements, flyback waveforms with parasitic elements, clamping the drain excursion, designing the clamping network, two-switch flyback, simulations and practical designs of forward converters, an isolated buck converter, need for a complete core reset, a two-switch configuration, twoswitch forward and half-bridge driver.

**Module-5**

**Bidirectional Converter Topologies for Plug-In Electric Vehicles**

Introduction, Literature Survey, Bidirectional Converters, Bidirectional AC/DC Converters for Plug-In EV with Reduced Conduction Losses, Topology Explanation, Plug-In Charging Mode, Propulsion Mode, Boost Operation, Buck Operation, Regenerative Braking Operation, Boost Operation, Buck Operation.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**
   to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


1. B. Jayant Baliga, "Power Semiconductor Devices", 1st Edition, International Thompson Computer Press, 1995.
2. Christophe Basso, "Switch Mode Power Supplies : SPICE Simulations and Practical Designs", McGrawHill,2008.
3. L. Ashok Kumar, S. Albert Alexander, "Power Converters for Electric Vehicles", CRC Press, Taylor & Francis Group, 2021


**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

-

**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Analyze the operation of different power converters | L4 |
| CO2 | Design of non-isolated converters used in electric vehicles | L5 |
| CO3 | Design front end for practical offline converters. | L5 |
| CO4 | Analyze the operation of practical isolated converters | L4 |
| CO5 | Analyze the Bidirectional converter topologies used in Electric Vehicles | L4 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
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**Semester - II**

| Modeling & Simulation of EV | | | |
|---|---|---|---|
| Course Code | **MEVT202** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:2:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 hours Theory + 10-12 Lab slots | Total Marks | 100 |
| Credits | 04 | Exam Hours | 03 |

**Course objectives:**

- Interlinking performance parameters of sub-systems of EV
- Analysis of vehicle resistances and Battery parameters.
- Performance analysis of Drive train components
- Vehicular level performance analysis and simulation

**MODULE-1**

**Vehicular sub-systems Modeling**

Modeling of sub-systems - Battery, Motor, Vehicle Body, Drive cycles input, Performance outputs

**MODULE-2**

**Modeling of Vehicle Resistances and Battery Pack**

Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range -Driving cycles, Range modeling of battery electric vehicles, Constant velocity range modeling, Range modeling of fuel cell vehicles, Range modeling of hybrid electric vehicles

**MODULE-3**

**Drive train Characteristics**

Modeling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics Transmission and Drive train Characteristics-Regenerative Braking Characteristics-Driving Cycles

Modeling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion. Modelling and Analysis - Vehicle Braking Modelling and Analysis

**MODULE-4**

**Energy Flow analysis**

Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers – Rule-Based Control Strategies - Optimization-Based Control Strategies.

**MODULE 5**

**Vehicular Parameter Modeling and Simulation**

Modeling Vehicle performance parameters, Simulation of the speed, acceleration, range of an electric scooter, Simulation of the speed, acceleration, range of a small car. Simulation for weight reduction

**PRACTICAL COMPONENT OF IPCC***(May cover all / major modules)*

| Sl.NO | Experiments |
|---|---|
| 1 | Model the Batterry Management Systems to optimize Charging and Discharging Strategies for EV. |
| 2 | Simulate the battery cell chemistry to analyze capacity, discharge rate, and lifespan under varying temperatures using suitable software package. |
| 3 | Simulate the battery cell chemistry to analyze capacity, discharge rate, and lifespan under varying charge cycles using suitable software package. |
| 4 | Simulate and Study the impact of AC motor on performance of speed control using simulation using suitable software package. |
| 5 | Simulate and Study the impact of DC motor on performance of speed control using simulation using suitable software package. |
| 6 | Simulate and Study the impact of BLDC motor on performance of speed control using simulation using suitable software package. |
| 7 | Analyze the interaction between the electric motor, power converter, and transmission to optimize torque delivery and energy consumption using suitable software package. |
| 8 | Simulate vehicle acceleration, braking, and handling characteristics to assess overall performance under different road conditions using suitable software package. |
| 9 | Evaluate motor torque across different speed ranges using suitable software package. |
| 10 | Evaluate motor power delivery, and efficiency across different speed ranges using suitable software package. |
| 11. | Design a PID controller for a given system (any type of power converter). |

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

### CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

### CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**.

Marks of all experiments' write-ups are added and scaled down to **15 marks**.

- The laboratory test at the end /after completion of all the experimentsshall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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**SEE for IPCC**

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

**The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component**).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

**Suggested Learning Resources:**

**Books**

1. Amir Khajepour, SaberFallah and AvestaGoodarzi, "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach", John Wiley & Sons Ltd, 2014.
2. MehrdadEhsani, YiminGao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition", CRC Press, 2010.
3. Tutorials on MATLAB /SIMULINK for modeling and simulation
4. Tutorials on RICARDO for modeling and simulation

**Web links and Video Lectures (e-Resources):**

**Activity Based Learning (Suggested Activities in Class)/ Practical Based learning**

**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Model various subsystems of EV | L3 |
| CO2 | Model Vehicle Resistances and Battery pack | L3 |
| CO3 | Analysis Electric & Hybrid Electric Vehicles Propulsion and power train components | L4 |
| CO4 | Analyse Energy Flow and its management | L4 |
| CO5 | Model &Simulate vehicular parameters | L5 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
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**Semester- II**

| VEHICLE DYNAMICS | | | |
|---|---|---|---|
| Course Code | **MEVT203** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To enable students to gain knowledge and understanding of fundamentals of vehicle dynamics.
2. To study the ADAS, Autonomous driving concepts.
3. To study concepts of longitudinal, vertical and lateral dynamics.
4. To analyse ride, pitch, and roll performance of road vehicle using vertical dynamic response.

**Module-1**

**Introduction:** Definition of vehicle dynamics, ADAS, Autonomous driving, simulation tools, MBS tools, heavy trucks, smaller vehicles.

**Module-2**

**Vehicle Interactions:** Introduction, tyre terminology, tyre design, longitudinal, lateral and vertical properties of tyres, tyre wear, driver interactions with vehicle dynamics.

**Module-3**

**Longitudinal dynamics:** Introduction, steady state functions, functions over longer events, functions in shorter events, control functions.

**Module-4**

**Lateral dynamics:** Introduction, low speed maneuverability, steady state cornering at high speed, stationary steady oscillating steering, transient handling, lateral control functions.

**Module-5**

**Vertical dynamics:** Introduction, suspension system, road models, 1-D vehicle models, ride comfort, fatigue life, road grip, variation of suspension design, 2-D oscillations. State space and transfer function representations.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**

1. Bengt Jacobson, Vehicle dynamics, Chalmers University of Technology, Sweden, 2016.
2. Wong J.Y., Theory of ground vehicles, John Wiley and Sons, Inc., New York, 2001.
3. Gillespie T., Fundamentals of vehicle dynamics, SAE, 1992.

**Web links and Video Lectures (e-Resources):**

- .

**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Explain the definitions of vehicle dynamics and different types of vehicles. | L2 |
| CO2 | Comprehend the vehicle interactions especially with tyres. | L4 |
| CO3 | Analyze the dynamic concepts in relation to the longitudinal dynamics. | L4 |
| CO4 | Analyse lateral dynamic response of road vehicle during cornering. | L4 |
| CO5 | Analyze the dynamic concepts in relation to the vertical dynamics. | L4 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
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**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
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**Semester- II**

# EV MOTOR DRIVES AND CONTROL

| Course Code | **MEVT204** | CIE Marks | 50 |
|---|---|---|---|
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. Understand requirement of EV motors
2. Understand suitability of electric motor & their control
3. Understand speed control of Induction motor
4. Understand PWM techniques of Inverter for Induction motor
5. Understand different sensors and sensorless operation of motor

## Module-1

**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 quadrant operation

## Module-2

**DC Motor Dynamics & Control**

Current Loop Control, Speed Control Loop

**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 DOF Controller with Internal Model Control, Load Torque Observer, Feedback Linearization, Simplified Modeling of Practical Current Loop

## Module-3

**Induction Motor**

Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakage inductance, circle diagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor

**Induction Motor Speed Control**

Rotor Field oriented control, Stator Field Oriented Control, Field Weakening Control, Variable Voltage Variable Frequency Control, PWM Control.

## Module-4

**Permanent magnet ac motors**

PMSM and BLDC, PMSM dynamic modelling, PMSM torque equations, PMSM control methods, machine sizing, current, voltage and speed limits, extending constant power speed range, current control methods

## Module-5

**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

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**

1. K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019
2. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
3. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
4. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

**Web links and Video Lectures (e-Resources):**

- www.dreamtechpress.com/ebooks/AC-DC DRIVES
- www.nptelvideos.in/electricalengineering/AC-DC DRIVES
- www.learnerstv.com/free-engineering/AC-DC DRIVES

**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Describe the characteristics of the motors use in EV. | L2 |
| CO2 | Analyze dynamics of DC motor and different controllers used in their control | L4 |
| CO3 | Describe the speed control and PWM techniques used in the control of Induction motor | L2 |
| CO4 | Analyze the operation and control of permanent magnet ac motors. | L4 |
| CO5 | Analyze sensor-less control of 3-phase ac motors. | L4 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | |
| CO2 | | | | | | | | | | |
| CO3 | | | | | | | | | | |
| CO4 | | | | | | | | | | |
| CO5 | | | | | | | | | | |
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**Semester- II**

| EVS IN SMART GRID | | | |
|---|---|---|---|
| Course Code | **MEVT215A** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To explain the vehicle electrification and impact of charging strategies.
2. To analyze the influence of EVs on power system
3. To demonstrate the frequency control and voltage reserve from EVs.
4. To demonstrate the frequency control and voltage reserve from EVs.
5. To demonstrate the frequency control and voltage reserve from EVs.

**Module-1**

**Introduction**

Introduction, Impact of charging strategies, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid, effect of EV charging on generation and load profile, Smart charging technologies, Impact on investment.

**Module-2**

**Influence of EVs on Power System**

Introduction, identification of EV demand, EV penetration level for different scenarios, classification based on penetration level, EV impacts on system demand: dumb charging, multiple tariff charging, smart charging, case studies.

**Module-3**

**Frequency Control Reserves & Voltage Support From EVs**

Introduction, power system ancillary services, electric vehicles to support wind power integration, electric vehicle as frequency control reserves and tertiary reserves, voltage support and electric vehicle integration, properties of frequency regulation reserves, control strategies for EVs to support frequency regulation.

**Module-4**

**ICT Solutions to Support EV Deployment**

Introduction, Architecture and model for smart grid & EV, ICT players in smart grid, smart metering, information & communication models, functional and logical models, technology and solution for smart grid: interoperability, communication technologies.

**Module-5**

**EV Charging Facility Planning**

Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Microgrid, Design of V2G Aggregator.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**

1. Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Microgrid, Design of V2G Aggregator.
2. Crouse W.H, Anglin D.L, "Automotive Transmission and Power Train construction", McGraw Hill, 1976.
3. Harald Naunheimer , Bernd Bertsche , Joachim Ryborz , Wolfgang Novak "Automotive Transmission: Fundamentals, Selection, Design and Application", 2nd Edition, Springer, 2011.

**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Explain the vehicle electrification and impact of charging strategies. | L2 |
| CO2 | Analyze the influence of EVs on power system | L3 |
| CO3 | Demonstrate the frequency control and voltage reserve from EVs. | L3 |
| CO4 | Demonstrate the frequency control and voltage reserve from EVs. | L3 |
| CO5 | Demonstrate the frequency control and voltage reserve from EVs. | L3 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | |
| CO2 | | | | | | | | | | |
| CO3 | | | | | | | | | | |
| CO4 | | | | | | | | | | |
| CO5 | | | | | | | | | | |
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**Semester- II**

| ENERGY STORAGE SYSTEMS FOR EVs | | | |
|---|---|---|---|
| Course Code | **MEVT215B** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To analyse the different types of energy storage systems and their performances to electric vehicle.
2. To investigate the depth analysis of fuel cell technology and its integration into electric vehicle.
3. To design and analysis of battery parameters and its performance measures for various types of batteries.
4. To evaluate the battery sizing for real time driving pattern and investigate the battery testing and power management studies

**Module-1**

**Introduction to Energy Storage Requirements in Electric Vehicles**:

Different types of energy storage; Mechanical: Flywheel based energy storage; Chemical: Hydrogen production and storage; Electrical: Capacitors for EV, Super Capacitor, EDLC; Electrochemical: battery, fuel cell, biological, thermal; Magnetic Energy Storage, Superconducting Energy Storage systems, Hybridization of different energy storage devices. Modelling of various emerging storage systems – Simulation case studies.

**Module-2**

**Battery Characteristics & Parameters**

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; Electrical parameters- Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteriesMeeting battery performance criteria- setting new targets for battery performance.

**Module-3**

**Introduction and overview of fuel cells technology:** low, medium and high temperature fuel cells - Types of fuel cells, liquid and methanol types, proton exchange membrane fuel cell, solid oxide, Microbial fuel cell, Thermodynamics of fuel cells, Fuel cell modeling-simulation and case studies, system integration, Safety issues and cost expectation and life cycle analysis of fuel cells, Placement of storage systems. Battery technology, Type of battery: Lead acid, Li-ion, Li-Polymer, Ni-MH, Ni-Cd and other advanced batteries for EV's. Battery modeling-simulation and case studies.

**Module-4**

**Magnetic and Electric Energy Storage Systems:** Superconducting magnetic energy storage (SMES) systems; Capacitors; Ultra-capacitor - Basic principles - equivalent circuit. Ultra-capacitor technologies: Electrochemical double layer capacitor (EDLC) - principle of working - structure - performance and applications; Role of activated carbon and carbon nano-tubes in performance enhancement; Comparison of Ultra-capacitor characteristics with batteries - applications.

**Module-5**

**Design and Applications of Energy Storage:**

Battery sizing and stand-alone applications, Constant current and constant voltage charging methods, Hybrid Methods, Inductive chargers, Battery power testing for various vehicles, Battery testing for urban and highway driving cycles, Battery management systems and controls, control of charge discharge cycles. Case studies. Combination of super capacitor and battery – the application perspective.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


1. D. A. J. Rand, R. Woods, and R. M. Dell, "Batteries for Electric Vehicles," Society of Automotive Engineers," Warrendale PA, 2003.
2. F. A. Silva and M. P. Kazmierkowski, "Energy Storage Systems for Electric Vehicles [Book News]," in IEEE Industrial Electronics Magazine, vol. 15, no. 4, pp. 93-94, Dec. 2021.
3. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), 2011.
4. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
5. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley& Sons Ltd., 2016.
6. T R Crompton, "Battery Reference Book", Reed Educational and Professional Publishing Ltd., 2000.
7. James Larminie and John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd., 2003.
8. John Warner, "The Handbook of Lithium Ion Battery Pack Design", Elsevier Inc., 2015.
9. Rufer, Alfred. Energy storage: systems and components. CRC Press, 2017


**Web links and Video Lectures (e-Resources):**

- https: //nptel.ac.in/content/storage2/courses/108103009/download/M9.pdf
- https://archive.nptel.ac.in/courses/113/105/113105102
-

**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Illustrate different types of energy storage systems. | L2 |
| CO2 | Select battery packs to suit customer requirements | L3 |
| CO3 | Apply the theory of ultra capacitors for energy storage | L3 |
| CO4 | Compare different fuel cell technologies for energy storage. | L4 |
| CO5 | Design of battery packs for Electric Vehicles in various applications. | L4 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
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**Semester- II**

| THERMAL MANAGEMENT OF ELECTRIC VEHICLES | | | |
|---|---|---|---|
| Course Code | **MEVT215C** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To analyse steady-state and transient conduction, evaluate convective processes, and understand non-dimensional numbers' significance.
2. To comprehend fin equations, heat sink design, and advanced cooling technologies, applying them effectively in electric vehicle thermal management.
3. To understand thermal comfort, vehicle indoor climate, HVAC principles, and integration of air conditioning systems in vehicle cabins.
4. To apply battery thermal management techniques, understand thermal issues, and predict temperature distribution using modeling, preparing for future technologies.
5. To develop numerical models, conduct simulations and experiments, and set up vehicle-level experimentation for battery thermal management systems.

**Module-1**

Introduction to heat transfer- modes of heat transfer- basic laws of heat transferimportance of various thermo- physical properties- combined heat transfer mechanism. One dimensional steady state heat conduction – analysis of plane wall, cylindrical and spherical configurations - thermal resistance- critical radius- conduction with heat generation. Transient conduction. Convection heat transfer: Newton’s law of coolingLaminar and Turbulent flow- Free and forced convection for internal and external configurations-Importance of various non- dimensional numbers.

**Module-2**

Fins and Heat Sinks: Fin Equation, Infinitely Long Fin, Adiabatic Fin Tip, Convection and Radiation from Fin Tip, Constant Temperature Fin Tip, Fin Thermal Resistance, Effectiveness, and Efficiency with Variable Cross Sections. Heat Sink Thermal Resistance, Effectiveness, and Efficiency, Advanced Cooling Technologies in EVs: Heat Pipe Applications in Electronic Cooling, Thermosyphons, Liquid Cooling. Phase Change Materials.

**Module-3**

Cabin Climate Control: Definition of Thermal Comfort, Human Thermo-Physiology, Body Energy Balance, Skin Sensible Losses and Latent Losses, Respiratory Losses. Vehicle Indoor Climate - Mean Radiant Temperature, Operative Temperature, Equivalent Temperature, Local and Whole-Body Equivalent Temperature. Control of Vehicle Indoor Climate and Air Stratification. Evaluation of Thermal Comfort - PMV Approach, Cabin Thermal Loads- Energy Transfer Mechanisms Involved in a Vehicle Cabin, Heat Transfer Through the Cabin Body - Heat Transfer Through the Glazing. Ventilation - Internal Gains, HVAC Unit Components and Working Principle, Working Principle of a VaporCompression Refrigerator - Integration of the Air-Conditioning Loop into the Vehicle.

**Module-4**

Battery thermal management systems: Liquid cooling systems, Air cooling systems, Phase change materials (PCM) and their role in thermal management. Comparison of different thermal management approaches, Thermal issues associated with lithium-ion batteries. Factors influencing battery temperature. Strategies for battery thermal management: active cooling, passive cooling, and thermal insulation. Future BTM Technologies. Thermal modeling and simulation techniques for predicting battery temperature distribution. Case studies of battery thermal management systems implemented in commercial electric vehicles.

**Module-5**

Simulation and Experimental Investigation of Battery TMSs: Numerical Model Development for Cell and Submodules, Numerical Study of PCM Application, Initial and Boundary Conditions and Model Assumptions, Material Properties and Model Input Parameters, Governing Equations and Constitutive Laws, Model Development for Simulations. Simulations and Experimentations on Cell Level, Submodule Level. Instrumentation of the Cell, Submodule, Heat Exchanger. Preparation of PCMs and Nano-Particle Mixtures. Setting up the Test Bench. Vehicle Level Experimentation Set Up and Procedure- Setting Up the Data Acquisition Hardware and Software. Vehicle Level Experimentations.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


1. Dincer, I., Hamut, H.S. and Javani, N., 2016. Thermal management of electric vehicle battery systems. John Wiley & Sons.
2. Bergman, T.L., Lavine, A.S., Incropera, F.P. and DeWitt, D.P., 2011. Introduction to heat transfer. John Wiley & Sons.
3. Lemort, Vincent, Gérard Olivier, and Georges de Pelsemaeker. Thermal Energy Management in Vehicles. John Wiley & Sons, 2023.
4. Younes Shabany," Heat Transfer: Thermal Management of Electronics" 2010, CRC Press


**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Analyse steady-state and transient conduction, evaluate convective processes, and understand non-dimensional numbers' significance. | L4 |
| CO2 | Comprehend fin equations, heat sink design, and advanced cooling technologies, applying them effectively in electric vehicle thermal management. | L4 |
| CO3 | Understand thermal comfort, vehicle indoor climate, HVAC principles, and integration of air conditioning systems in vehicle cabins. | L2 |
| CO4 | Apply battery thermal management techniques, understand thermal issues, and predict temperature distribution using modeling, preparing for future technologies. | L3 |
| CO5 | Develop numerical models, conduct simulations and experiments, and set up vehicle-level experimentation for battery thermal management systems. | L4 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
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| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
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**Semester- II**

| ELECTRIC CHARGING SYSTEMS FOR ELECTRICAL VEHICLES | | | |
|---|---|---|---|
| Course Code | **MEVT215D** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To understand the various components of Electric vehicle charging system
2. To comprehend the different types of Electric vehicle chargers and their standards
3. To interpret the various communication protocols used in Electric vehicle charging
4. To familiarize with the recent trends in Electric vehicle charging

**Module-1**

**Introduction to EV charging**

Electric Vehicle Charging; Charging Modes; Electric Vehicle Supply Equipment (EVSE): Types, Components of EV Battery Chargers; Challenges in Electric Vehicle Charging

**Module-2**

**Charger sizing and standards**

Charger Classification; Slow Charging and Fast Charging; DC Charging and AC Charging; Selection and Sizing of Chargers: Charger Connectors and Cables; Charging Standards: Connectors, Supply Equipment; EMI/EMC; Testing Methods for Chargers and EVSE

**Module-3**

**EV charger communications protocols**

Open Charge Point Protocol (OCPP); Open System Interconnection Layer Model (OSI); Adapted PWM Signal based Low-level Communication; PLC based High-level Communication; CAN Communication; Billing and Authentication

**Module-4**

**Public charging infrastructure**

Location, Planning and Implementation of Public Charging Stations; Components; Selection and Sizing - HT/LT Equipment & Cables; Protection; Safety Standards: Policy and Regulatory Aspects; EV Charging Station and their Business Models; Economic Aspects; Major Challenges

**Module-5**

**Future frontiers in EV charging**

Bulk Charging; Battery Swapping; Wireless Charging; EVs as Distributed Storage Resources: Grid to Vehicle (G2V) and Vehicle to Grid (V2G), V2X Concept, Integration of Charging Station with Renewable Sources and its Impact on the Grid

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


1. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", 3rd Edition, CRC Press, 2021
2. Code of Practice for Electric Vehicle Charging Equipment Installation, 4th Edition, IET, 2020.
3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", 1st Edition, Springer, 2013.
4. Tom Denton, "Automotive Electrical and Electronic Systems", 5th Edition, Routledge, 2018
5. Wolfhard Lawrenz, "CAN System Engineering: From Theory to Practical Applications", Springer, 2nd Edition, 2013


**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Understand the various components of Electric vehicle charging system | L2 |
| CO2 | Comprehend the different types of Electric vehicle chargers and their standards | L4 |
| CO3 | Interpret the various communication protocols used in Electric vehicle charging | L3 |
| CO4 | Familiarize with the recent trends in Electric vehicle charging | L3 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
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**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | |
| CO2 | | | | | | | | | | |
| CO3 | | | | | | | | | | |
| CO4 | | | | | | | | | | |
| CO5 | | | | | | | | | | |
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**Semester- II**

| AUTOMOTIVE ELECTRONICS FOR EVs | | | |
|---|---|---|---|
| Course Code | **MEVT216A** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To understand the electrical and electronic systems in e-vehicles
2. To understand the principles of networking
3. To explain requirements and types of bus systems
4. To comprehend the lighting systems in vehicles
5. To understand the auxiliaries and chassis electric systems in automobiles

**Module-1**

**Electrical And Electronic Systems in the Vehicle:**

Overview, Motronic engine management system, Electronic diesel control, Lighting technology, Electronic stability program, Adaptive cruise control, Infotainment System.

**Basic principles of networking**

Network topology, Network organization, OSI reference model, Control mechanisms.

**Module-2**

**Bus systems**

CAN bus: Applications, Topology, Data transmission system, CAN protocol , data transfer sequence, standardization, characteristics. LIN bus: Overview, Applications, Data transfer, Bus access, LIN protocol, network management, example.

MOST bus: Introduction, features, data transfer, administrative functions, application layer

**Module-3**

Bluetooth: Overview, applications, Bluetooth versions, transmission technology, power classes, topology, physical data channel, physical connections, Architecture.

**Lighting system**

Lighting fundamentals Lighting circuits, Gas discharge and LED lighting, Case studies, Diagnosing lighting system faults, Advanced lighting technology, New developments in lighting systems

**Module-4**

**Auxiliaries in vehicles**

Windscreen washers and wipers, signalling circuits, Other auxiliary systems, Case studies, Diagnosing auxiliary system faults Advanced auxiliary systems technology, new developments in auxiliary systems

**Module-5**

**Chassis Electrical systems**

Anti-lock brakes, Active suspension, Traction control , Automatic transmission, Other chassis electrical systems, Case studies, Diagnosing chassis electrical system faults, Advanced chassis systems technology, New developments in chassis electrical systems

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


1. Robert Bosch GmbH, "Bosch Automotive Electrics and Automotive Electronics", 5th Edition. John Wiley & Sons Ltd, 2007.
2. William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Elsevier, 2003.
3. Tom Denton: "Automobile Electrical and Electronic Systems", 3rd Edition, Elsevier Butterworth-Heinemann Publication, 2004.


**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Identify various electrical & electronic systems in vehicles and understand their working. | L2 |
| CO2 | Discuss the basic principles of networking requirements in an automotive | L3 |
| CO3 | Explain requirements and types of bus systems | L2 |
| CO4 | Comprehend the lighting systems in vehicles | L3 |
| CO5 | Understand the auxiliaries and chassis electric systems in automobiles | L2 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
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**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | |
| CO2 | | | | | | | | | | |
| CO3 | | | | | | | | | | |
| CO4 | | | | | | | | | | |
| CO5 | | | | | | | | | | |
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**Semester- II**

| MICROCONTROLLERS AND EMBEDDED SYSTEM FOR EVs | | | |
|---|---|---|---|
| Course Code | **MEVT216B** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To discover the different Microprocessor/ Controller Architectures and can choose appropriate architecture for the given application.
2. To understand the process of interfacing different peripheral devices and memory.
3. To design Program and Evaluate the functionality at different levels.
4. To compare and follow Embedded Communication Standards.
5. To discuss and apply the test processes and planning.

**Module-1**

**Introduction:**

General Processor Architecture Microprocessors and Controllers (PIC, AVR and ARM), ARM Processor Fundamentals, ARM and THUMB Instruction Set.

**Module-2**

**Memory-Mapped Peripherals**:

UART, D/A converter, Configuring GPIOS, Keyboard, LED,LCD Interfacing

**Module-3**

**Efficient Programming Overview of C Compilers and Optimization** :

Basic C Data Types, C Looping ,Structures , Register Allocation, Function Calls, Pointer Aliasing, Structure Arrangement, Bit-fields, Unaligned Data and Endianness , Division, Floating Point ,Inline Functions and Inline Assembly, Portability Issues, Writing Assembly Code , Profiling and Cycle Counting , Instruction Scheduling , Register Allocation , Conditional Execution, Looping Constructs, Bit Manipulation, Efficient Switches, Handling Unaligned Data

**Module-4**

**Embedded Communication Standards in Automotive Communication Systems:**

Characteristics and Constraints ,In- Car Embedded Networks ,Middleware Layer,Open Issues for Automotive Communication Systems, Flex Ray Communication, Flex Ray Protocol , Flex Ray Application; Data Consistency Issues, CAN centrate and Re CAN centrate: Star Topologies for CAN , CANEL y ,FTT-CAN: Flexible Time-Triggered Communication on CAN , Flex CAN: A Deterministic, Flexible, and Dependable Architecture for Automotive Networks , Other Approaches to Dependability in CAN.

**Module-5**

**Testing :**

Dynamic Testing ,Current Practice, Structuring the Testing Process, Model versus Code-Based Testing, Test Activities and Testing Techniques, Testing in the Development Process, Test Planning

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**

1. Andrew N. Sloss "ARM System Developer's Guide Designing and Optimizing System Software", Elsevier Inc., ISBN :1-55860-874-5
2. William Hohl, "ARM Assembly Language Fundamentals and techniques", Springer, ISBN 13: 978-1-4822-2986-8
3. Richard Zurawski ,"Automotive Embedded Systems Handbook", CRC Press, ISBN 13: 978-0-8493-8026-6
4. M. Kathiresh, R. Neelaveni ,"Automotive Embedded Systems: Key Technologies, Innovations, and Applications", Springer, ISBN: 978-3-030-59896-9

**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Discover different Microprocessor/ Controller Architectures and can choose appropriate architecture for the given application. | L3 |
| CO2 | Interface different peripheral devices and memory. | L3 |
| CO3 | Design Program and Evaluate the functionality at different levels. | L4 |
| CO4 | Compare and follow Embedded Communication Standards. | L3 |
| CO5 | Discuss and apply the test processes and planning | L3 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
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**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | |
| CO2 | | | | | | | | | | |
| CO3 | | | | | | | | | | |
| CO4 | | | | | | | | | | |
| CO5 | | | | | | | | | | |
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**Semester- II**

| IOT AND VEHICLE COMMUNICATION | | | |
|---|---|---|---|
| Course Code | **MEVT216C** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To discuss the basics of IoT, enabling technologies and its domain applications.
2. To analyze and CompareIoT design methodologies, case studies on IoT and describe python programming environment for IoT.
3. To describe the basic theories and principles, technologies, standards, and system architecture of vehicular ad-hoc networks (VANET) or inter-vehicle communication networks.
4. To analyze, Design, and Evaluate vehicular communication platforms for various kinds of safety and infotainment applications.
5. To Assimilate new technological development in VANNET related fields.

**Module-1**

**Introduction to Internet of Things:**

Introduction, Definition characterization of IoT, Physical Design of IoT , Logical Design of IoT, IoT Enabling Technology, loT Levels and Deployment Templates

**Module-2**

**Domain Specific loTs:**

Introduction, Home Automation, Smart Cities, Environment, smart Energy, Logistics, Agriculture, Industry, Health and life style.

**Module-3**

**IoT Platforms Design Methodology :**

loT Design Methodology , Case Study on loT System for Weather Monitoring , Importance of Python in IoT, loT Systems Design using Python , Python Data Types , Data Structures , Control flow, Functions, Modules, Packages and File handling, Data Operations, Classes.

**Module-4**

**Introduction to VANET and Vehicular Safety Applications:**

Basic Principles and Challenge, Past and Ongoing VANET Activities, Introduction to Vehicular Safety Applications, Enabling Technologies, Cooperative System Architecture, Mapping for Safety Applications, VANET-enabled Active Safety Applications.

**Module-5**

**Information Dissemination in VANETs:**

Introduction, Obtaining Local Measurements, Information Transport, Summarizing Measurements, Geographical Data Aggregation.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


**1)** Vijay Madisetti ,ArshdeepBahga, Adrian McEwen (Author), Hakim Cassimally, "Internet of Things A Hands-on-Approach" Arshdeep Bahga& Vijay Madisetti, 2014.

**2)** Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, StamatisKarnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.

**3)** H. Hartenstein and K. P. Laberteaux, VANET: Vehicular Applications and Inter Networking Technologies, Wiley, 2010.

**4)** P. H. J. Chong, I. W. H. Ho, Vehicular Networks: Applications, Performance Analysis and Challenges, Nova Science Publishers, 2019.


**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

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**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Discuss the basics of IoT, enabling technologies and its domain applications | L3 |
| CO2 | Analyze and CompareIoT design methodologies, case studies on IoT and describe python programming environment for IoT | L3 |
| CO3 | Describe the basic theories and principles, technologies, standards, and system architecture of vehicular ad-hoc networks (VANET) or inter-vehicle communication networks. | L2 |
| CO4 | Analyze, Design, and Evaluate vehicular communication platforms for various kinds of safety and infotainment applications. | L3 |
| CO5 | Assimilate new technological development in VANNET related fields. | L3 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
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**Semester- II**

| SENSORS FOR EV SYSTEMS | | | |
|---|---|---|---|
| Course Code | **MEVT216D** | CIE Marks | 50 |
| Teaching Hours/Week (L:P:SDA) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |

**Course Learning objectives:**

1. To familiarize with electrical measuring systems and understand the static and dynamic performance characteristics sensors.
2. To understand various sensors and transducers used for electric vehicles.
3. To analyse signal conditioning circuits for industrial measurement systems.
4. To design Nano and micro sensors for EV.
5. To evaluate and Design machine-learning algorithm.

**Module-1**

Review of functional blocks of measurement System-Principles of sensors and transducers – Differences Measurement and Error-Accuracy and precision- Types of errors- Systematic and random errors, propagation of errors- Classification of Transducers-Static characteristics: Accuracy, precision, resolution, sensitivity, Linearity-Dynamic characteristics - Design of Zero order and first order systems using mathematical modelling- Time response of first order system using simulation tool.

**Module-2**

Resistance Transducer: Potentiometer, strain gauge, resistance thermometer, thermistor, hotwire anemometer. Inductance Transducer: Hall effect transducer, LVDT. Capacitance Transducer: Principle, capacitive displacement transducer, practical capacitor pickups: Equibar differential pressure transducer

**Module-3**

Speed measurement - Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling - Optical tachometer, stroboscopic tachometer -Acceleration measurement: capacitive accelerometer, angular accelerometer, velocity sensor - Density measurement: Hydrometer, ultrasonic and sonic densitometer. Viscosity measurement: Capillary viscometer, efflux cup viscometer - Humidity measurement: Dew point hydrometer, electrolytic hygrometer - pH meter - Safety measures in industrial environment. Sensor data management, linearity, data processing, MEMS, error estimation, voltage drop stack up.

**Module-4**

Direct and indirect measurement - capacitive level sensors, optical level sensors, conductivity level sensor, vibrating sensor, float switch sensor, continuous level measurement sensor, ultrasonic sensor, microwave sensor - Analog and Digital filter design and Adaptive filter design- design of amplifiers, antialiasing filters. Classical parameter estimation: Cramer-Rao bound, Minimum mean squared error estimation, Minimum variance unbiased estimation, Best Linear Unbiased Estimation, Maximum Likelihood estimation, Method of Moments. Bayesian parameter estimation: Minimum mean squared error (MMSE) estimation, Maximum a posteriori estimation, Linear MMSE estimation, Sequential linear MMSE estimation, Kalman Filter.

**Module-5**

Film sensor: Thick film sensors, Thin film sensors- Semiconductor IC Technology-Micro electro mechanical system (MEMS)- Nano electro mechanical system (NEMS). Sensor data Acquisition-Feature Extraction-Supervised Learning-Unsupervised Learning-Learning from sensor data- Performance evaluation- Comparison with deep learning- Integration point of machine learning Algorithms-Tools for machine learning. Linear regression assignment, logistic regression, model selection: practical considerations

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

## Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks** or **one Skill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

**CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

## Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

**Suggested Learning Resources:**

**Books**


1. Patranabis.D, "Sensors and Transducers", 2nd Edition, Prentice Hall of India, 2021.
2. Michael Stanley and Jongmin Lee, "Sensor analysis for the Internet of Things", 1st Edition, Morgan Claypool publishers, 2018.
3. D. Patranabis, "Principles of Industrial Instrumentation", 4th Edition, Tata McGraw Hill, New Delhi,2017.
4. Anupama Prashar, Pratibha Bansal, "Industrial safety and Environment", S.K. Kataria &sons, 2009.
5. R. K. Jain, "Mechanical and Industrial Measurements", 12th Edition, Khanna publishers, 2015.
6. Randy Frank, Understanding Smart Sensors, Artec House Boston. London, 2000
7. Alan S. Morris and Reza Langari, 2nd ed., Measurement and Instrumentation, Theory and Application, Academic Press, 2015.
8. Bela G. Liptak, Instrument Engineers' Handbook Process Control and Optimisation, 3rd ed., vol. 2, CRC Press, 2012.
9. K. Krishnaswamy, S.Vijayachitra, "Industrial Instrumentation", 2nd Edition, New age International Private limited, 2011.


**Web links and Video Lectures (e-Resources):**

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**Skill Development Activities Suggested**

- 

**Course outcome (Course Skill Set)**

At the end of the course the student will be able to :

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Getting familiarized with electrical measuring systems and understand the static and dynamic performance characteristics sensors. | L2 |
| CO2 | Understand various sensors and transducers used for electric vehicles. | L2 |
| CO3 | Analysis of signal conditional circuits for industrial measurement systems. | L3 |
| CO4 | Design Nano and micro sensors for EV. | L4 |
| CO5 | Evaluate and Design machine-learning algorithm. | L4 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
| | | | | | | | | | | |
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| EV Motor drives and control Lab | | | |
|---|---|---|---|
| Course Code | MEVTL207 | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 0:2:2 | SEE Marks | 50 |
| Credits | 02 | Exam Hours | 03 |

**Course objectives:**

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

| Sl.NO | Experiments |
|---|---|
| 1 | Model the DC motor and study the effect of field weakening on the speed. |
| 2 | For a DC motor design suitable current PI gains so that current control bandwidth is 150 Hz and the damping coefficient is 0.7. |
| 3 | For a DC motor, demonstrate four quadrant operation. |
| 4 | Study 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 |
| | **Demonstration Experiments ( For CIE ) if any** |
| 9 | Speed control of BLDC Motor and finding performance. |
| 10 | Speed control of PMSM Motor and finding performance. |

**Course outcomes (Course Skill Set):**

At the end of the course the student will be able to:

1. Demonstrate the effect of field weakening in DC motor control
2. Demonstrate the open loop and closed loop control of DC motor.
3. Demonstrate the PWM generation and control of 3-phase induction motor.
4. Demonstrate the significance of dead time in PWM generation.
5. Demonstrate the control of BLDC and PMSM motor

**Assessment Details (both CIE and SEE)**

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

**Continuous Internal Evaluation (CIE):**

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marksis scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

**Semester End Evaluation (SEE):**

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly

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| by examiners.<br>General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)<br>Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.<br>The duration of SEE is 03 hours |
| **Suggested Learning Resources:**<br>• K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019 |