**Mukesh Patel School of Technology Management and Engineering**

**Mechanical Engineering Department**

**Course Policy**

|  |  |  |  |
| --- | --- | --- | --- |
| **Program/Branch/Semester** | **:** | RPA00001/RPA00002/ Sem VI | |
| **Academic Year** | **:** | 2021-22 | |
| **Course Code & Name** | **:** | MBME\_\_\_\_\_Electric Hybrid Automotive Technology | |
| **Credit Details** | **:** | |  |  |  |  | | --- | --- | --- | --- | | L | T | P | C | | 3 | 0 | 2 | 4 | | |
| **Course Coordinator Faculty** | **:** | Dr. Sunny Nanade | |
| **Contact No. & Email** | **:** | ​022-42330567  sunny.nanade@nmims.edu | |
| **Office** | **:** | SBMP Building, 3rd Floor | |
| **Office hours** | **:** | TBA | |
| **Other Course Faculty members teaching this course** | **:** | **Course Faculty 1:** Dr. Sunny Nanade  **Contact No. & Email:** sunny.nanade@nmims.edu  **Office:** SBMP Bldg. 3rd Floor  **Office Hours:** TBA | |
| **Course Faculty 1:**  **Contact No. & Email:**  **Office:**  **Office Hours:** | | | **Course Faculty 1:**  **Contact No. & Email:**  **Office:**  **Office Hours:** |
| **Course Faculty for Laboratory:**  **Contact No. & Email:**  **Office:**  **Office Hours:** | | | **Course Faculty for Tutorial:**  **Contact No. & Email:**  **Office:**  **Office Hours:** |
| ***Queries by Emails are encouraged.*** | | | |
| **Course link** | **:** | Portal Link  MS Teams Link | |

# Introduction to the Course

## Importance of the course

Electric vehicles are the future of transportation. Electric mobility has become an essential part of the energy transition, and will imply significant changes for vehicle manufacturers, governments, companies and individuals. The course will cover focus areas one by one such as vehicle dynamics, Motors, Power Electronics, Batteries, Charging, Autonomous Navigation etc. The most important part of this course will be that each topic will be analysed and demonstrated through MATLAB Simulink and Autonomous Navigation on ROS so that the grip of the subject will be strong and the knowledge acquired will be useable in real time applications.

## Objective of the Course

The objective of this course is to develop understanding of the environmental impact of a hybrid electric vehicle (HEV) and an electric vehicle (EV). To develop understanding of Plug‐In architecture, components, diagnostics, prognostics and reliability of HEVs and EVs. To understand the conceptual design of an HEV and an EV

## Pre-requisite

* Engineering Mathematics I, II, III (BTME01001, BTME02008, BTME03008) and
* Theory of Machines I, II (MBME04008, MBME05004)

# Course Outcomes (CO) and mapping with Program Outcomes (PO)

## Course Outcomes

After successful completion of the course, a student will be able to-

1. Understand environmental impact of HEV and the concept of hybridization
2. Demonstrate the understanding of HEV/EV architectures and dynamics of powertrain
3. Devise a mobile EV prototype by designing its battery and transmission systems using appropriate methods of analysis

## CO-PO Mapping

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO2 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO3 |  |  |  |  |  |  |  |  |  |  |  |  |

***Green- medium mapping Blue- high mapping***

# Syllabus, Pre-class activity and References

## Teaching and evaluation scheme

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture**  **Hours per week** | **Practical**  **Hours per week** | **Tutorial**  **Hours per week** | **Credit** | **Internal Continuous Assessment (ICA)**  **As per Institute Norms**  **(50 Marks)** | **Theory**  **(3 Hrs,**  **100 Marks)** |
| 3 | 0 | 1 | 4 | Marks Scaled to 50 | Marks Scaled to 50 |

## 3.2 Syllabus

|  |  |  |
| --- | --- | --- |
| **Unit** | **Description** | **Duration** |
| 1 | **History of Modern Transportation:** Environmental impact of HEVs, hybridization concepts, HEV fundamentals, electric automotive technology | 08 |
| 2 | **Advanced HEV Architecture:** Hybrid electric and electric vehicle architectures, dynamics of power train and drive train, principles of planetary gear train | 08 |
| 3 | **Plug-in Hybrid Electric Vehicles:** Introduction, architectures, power management, fuel economy, component sizing | 08 |
| 4 | **Power supply:** Battery modeling, Nickel Metal Hydride battery,Lithium-ion battery, parameter estimation for battery models, PHEV/EV battery charger design | 08 |
| 5 | **Modeling and Simulation of Electric and Hybrid Vehicles:** Fundamentals of vehicle system modeling,HEV Modeling Using ADVISOR**,** HEV Modeling Using PSAT**,** Physics‐Based Modeling**,** efficient statistical validation of autonomous driving systems | 08 |
| 6 | **Case Studies:** General Motors EV-1**,** Nissan LEAF 2016**,** GM Volt 2016, Tesla Roadster**,** Honda FCX Clarity**,** Toyota Mirai**,** Honda Light Hybrids**,** Bosch Parallel Full-Hybrid**,** Volkswagen Golf GTE | 05 |
|  | **Total hours** | **45** |

## Pre-class activity

The students are expected to stay concurrent with the ongoing topic by reviewing the information regularly.

## References

|  |
| --- |
| **Text Books:**   1. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, Massachusetts Institute of Technology, 2nd Edition, 2011. 2. Arduino Applied: Comprehensive Projects for Everyday Electronics, Neil Cameron, Apress, 2018. |
| **Reference Books:**   1. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Chris Mi and M. Abul Masrur, 2nd Edition, Wiley, 2018. 2. Safe, Autonomous and Intelligent Vehicles, Huafeng Yu, Xin Li, Richard M. Murray, S Ramesh and Claire J. Tomlin, 1st Edition, Springer International Publishing, 2019. |

***Note: The latest edition of books should be referred.***

# Laboratory details

Not Applicable

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No.** | **Week No.#** | **List of Lab Exercises** | **Mapped CO** |
|  |  |  |  |

# Tutorial Plan

Tutorial work consist of learning to code and navigate an autonomous bot in Robot Operating System in online web-browser. Learn to model components in Simulink and simulate working of motor and battery charging

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No.** | **Week No.#** | **Tutorial exercises / activity** | **Mapped CO** |
| 1 | 1 | 1. Account Creation on [www.theconstructsim.com](http://www.theconstructsim.com) and enroll to course “Python 3 for Robotics: Noetic” 2. Introduction to Python and Navigation in the online course | CO1,2,3 |
| 2 | 2,3 | 1. Python Essentials:    1. Data Types and Variables 2. Use of Laser Function to get distance using LiDAR | CO1,2 |
| 2 | 3 | 1. Conditional Statements and Loops    1. If statement    2. While loop    3. For loop 2. Nesting | CO1,3 |
| 3 | 4,5 | 1. Functions and Classes 2. Declaring and Defining Functions and Classes 3. Create first code to load and navigate a bot | CO1,2,3 |
| 4 | 6 | 1. Help turtlebot get out of Maze | CO1,2 |
| 5 | 7,8 | 1. Installation of open-source ROS on individual laptop/computers for further learning | CO1,2 |
| 6 | 9 | 1. Account creation on Matlab.com for 1 month trial online Web use 2. Basic overview of MATLAB and Simulink | CO1,3 |
| 7 | 10,11 | 1. Motor Control for EV applications 2. DC Motor Control 3. Induction Motor Control 4. BLDC Motor Control 5. PMSM Motor Control | CO1,2,3 |
| 8 | 12 | 1. Battery Modeling in MATLAB Simulink | CO1,2,3 |

# Assessment Policy

## Component wise Continuous Evaluation Internal Continuous Assessment (ICA) and Term End Examination (TEE)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Component** | **ICA (100 Marks)**  **(Marks scaled to 50)**  **Class Parti** | | | | **TEE (100 marks)**  **(Marks scaled to 50)** |
|  | **Tutorial**  **Performance** | **Tutorial**  **Exam and Viva** | **Case Study Presentation** | **Class Test1 and Class Test 2** |  |
| **Weightage** | 10% | 10% | 10% (5+5) | 20% | 50% |
| **Marks** | 20 | 20 | 20 | 20+20 | 100 |

## Assessment Policy for Internal Continuous Assessment (ICA)

Assessment of ICA comprises of the following components.

1. **Class test 1 and 2** 
   1. Two class tests will be held as per the academic calendar.
   2. It may be conducted online/ offline for 20 marks each

1. **Tutorial performance evaluation (20 marks)**
   1. Tutorial experiments (20 marks)
      1. Continuous assessment for laboratory experiments will be practiced. There are 08 exercises, each carrying 10 marks. At the end of the course, average of total marks will be calculated to obtain the average.
      2. Discussion of your work with your peers is allowed. However each student is expected to submit his/her original work. Submissions which are very similar will be marked zero. Assessment of the lab work will be carried out based on parameters like timely completion of lab work, understanding of the experiment performed, originality of the work, involvement of the student, regularity, discipline etc. during the session. There is a 30% penalty on late submission.
2. **Lab test and viva (10 marks) -** Lab test and Viva will be held on the concepts learnt during the course.
3. **Case Study Presentation (20 marks)**
   1. Students are divided into groups of 3.
   2. The topic will be assigned in the class.
   3. The groups will be graded according to the effort and quality of the written report, results, technical maturity and the quality of oral communication

## Assessment Policy for Term End Examination (TEE)

A written examination of 100 marks for\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ duration will be held for the course as per the academic calendar.

# 7. Lesson Plan

|  |  |  |  |
| --- | --- | --- | --- |
| **Session**  **No.** | **Topics** | **Mapped CO** | **Reference** |
| 1 | History of Modern Transportation | 1 | TB1, TB2 |
| 2 | Environmental impact of HEVs | 1 |  |
| 3 | Hybridization concepts - I | 1 |  |
| 4 | Hybridization concepts - II | 1 |  |
| 5 | HEV fundamentals – I | 1 |  |
| 6 | HEV fundamentals – II | 1 | TB1, TB2 |
| 7 | Electric automotive technology – I | 1 |  |
| 8 | Electric automotive technology – II | 1 |  |
| 9 | Advanced HEV Architecture | 1,2 |  |
| 10 | Hybrid electric and electric vehicle architectures | 2 |  |
| 11 | Vehicle Architecture Types | 2 |  |
| 12 | Dynamics of power train and drive train - I | 2 |  |
| 13 | Dynamics of power train and drive train - II | 1 |  |
| 14 | Class Test 1 |  |  |
| 15 | Principles of planetary gear train - I | 1 |  |
| 16 | Principles of planetary gear train - II | 1 | TB1, TB2 |
| 17 | Plug-in Hybrid Electric Vehicles | 1,2 |  |
| 18 | PHEV Basics | 2 |  |
| 19 | Architectures - I | 2 |  |
| 20 | Architectures - II | 2 |  |
| 21 | Power management - I | 1 |  |
| 22 | Power management - II | 1 |  |
| 23 | Fuel economy | 1,2 |  |
| 24 | Component sizing | 1,2 | TB1,TB2 |
| 25 | Power supply | 1,2 |  |
| 26 | Battery modeling - I | 1,2 |  |
| 27 | Class Test 2 |  |  |
| 28 | Battery modeling - II | 2,3 |  |
| 29 | Nickel Metal Hydride battery | 2,3 | TB1, TB2 |
| 30 | Lithium-ion battery | 2,3 |  |
| 31 | Parameter estimation for battery models - I | 2,3 |  |
| 32 | Parameter estimation for battery models – II | 2,3 |  |
| 33 | Parameter estimation for battery models - III | 2,3 |  |
| 35 | PHEV/EV battery charger design - I | 2,3 |  |
| 36 | PHEV/EV battery charger design - II | 2,3 |  |
| 37 | Modeling and Simulation of Electric and Hybrid Vehicles | 3 |  |
| 38 | Fundamentals of vehicle system modeling | 3 |  |
| 39 | HEV Modeling Using ADVISOR | 3 | TB1, TB2 |
| 40 | HEV Modeling Using PSAT | 3 |  |
| 41 | Physics‐Based Modeling, efficient statistical validation of autonomous driving systems – I | 3 |  |
| 42 | Physics‐Based Modeling, efficient statistical validation of autonomous driving systems – II | 3 |  |
| 43 | Physics‐Based Modeling, efficient statistical validation of autonomous driving systems – III | 3 |  |
| 44 | Case Study – I | 1,2,3 |  |
| 45 | Case Study - II | 1,2,3 | TB1, TB2 |

# Teaching-learning methodology

The students will be divided into the groups of 2 or 3 for group activities such as class participation, project, presentation etc. The norms adhered to for lecture and laboratory sessions are as follows.

1. **Lectures:** 
   * Students are responsible for the regular review of ongoing topics to effectively grasp the concepts.
   * Deeper concepts and applications will be explained through Presentation and Video Lectures.
   * Numerical problems based on concept will be solved during the class on *smart board* or *MS OneNote.*
   * Some practical applications will be simulated in class.
2. **Laboratory:**
   * Lab manual consisting of theory and algorithm to support the lab experiment will be uploaded on student portal.
   * Regular lab assessment and grading will be practiced. Students will be marked based on parameters such as timely completion of lab assignment, originality, logic developed, interaction during the lab, submission, punctuality and discipline.

**10. Active learning techniques**

Active learning is a method of learning in which students are actively or experientially involved in the learning process. Following active learning techniques will be adopted for the course.

1. **Muddiest topic:** The instructor will find out the least understood point/topic in the session. This topic is then further explained to ensure that it is understood well.
2. **The "One Minute Paper":** The instructor will ask students to take out a blank sheet of paper, pose a question (either specific or open-ended), and give them one (or perhaps two - but not many) minute(s) to respond.
3. **Wait Time:** Rather than choosing the student who will answer the question presented, this variation has the faculty WAITING before calling on someone to answer it.
4. **Blended Learning:** Students will be introduced to the topic through self-study while the in-depth analysis, applications and numerical problems will be discussed by the instructor in the lecture session. Outline for background study to for each unit will be provided prior to commencement of each unit. Preliminary study material (video links, presentation, notes etc) will be made available on the student portal.
5. **Frame a question: S**tudents will be asked to design and frame their own questions pertaining to the topic being taught. The idea is to stimulate students’ curiosity, engage the students in collaborative teaching and learning, and motivating students to develop deeper understating of the topic.
   * Frame questions for each unit of the course: At the beginning of each using, the faculty will create a new page in *OneNote Class Notebook* in collaborative section where every student will post his/her question.
   * Frame a question in lab: As discussed in section 6.2, student will be asked to design one unique lab problem based on the course syllabus.
6. **Brainstorming: S**tudents will be asked to generate ideas on a certain topic, category or question while the faculty will facilitate and record the answers on the blackboard/whiteboard.

**11. Course Material**

Following course material is uploaded on the student portal: [(give](https://sites.google.com/a/nirmauni.ac.in/2cs101-computer-programming/) student portal link)

* Course Policy
* Lecture Notes
* Lecture Videos
* Lecture Presentations
* Books / Reference Books / NPTEL video lectures link
* Assignments
* Lab Manuals, Test images database link
* List of Program Outcomes

**12. Course Outcome Attainment**

Following means will be used to assess attainment of course learning outcomes.

* Use of formal evaluation components of continuous evaluation, assignments, laboratory work, term end project, viva and semester end examination
* Informal feedback during the course

**13. Academic Integrity Statement**

Students are expected to carry out assigned work under Internal Continuous Assessment (ICA) independently. Copying in any form is not acceptable and will invite strict disciplinary action. Evaluation of corresponding component will be affected proportionately in such cases. Plagiarism detection software will be used to check plagiarism wherever applicable. Academic integrity is expected from students in all components of course assessment.

**14. List of Program Outcomes**

**Annexure- I**

|  |  |  |
| --- | --- | --- |
| **Programme Outcomes (PO)** | | |
|  | PO1 | Apply the knowledge of mathematics, science, engineering fundamentals for the solution of complex engineering problems in mechanical engineering domain. |
|  | PO2 | Identify, formulate, research literature, and analyse complex mechanical engineering problems reaching substantiated conclusions using first principles of mathematics and mechanical engineering sciences. |
|  | PO3 | Design and develop solutions for complex mechanical engineering problems by considering public health and safety, and cultural, societal and environmental considerations. |
|  | PO4 | Use research based knowledge including Design of experiments, analysis and interpretation of data to solve mechanical engineering related product problems. |
|  | PO5 | Select, create and apply current techniques/ tools and resources in mechanical engineering challenges. |
|  | PO6 | Apply reasoning using contextual knowledge on contemporary issues and the impact of professional practice. |
|  | PO7 | Apply the broad education necessary to understand the impact of mechanical engineering solutions on environment and for sustainable development in society. |
|  | PO8 | Apply ethical principles and commit to professional ethics, and norms and best practices of mechanical engineering. |
|  | PO9 | Function effectively as an individual and a team member in multidisciplinary settings to provide solutions to problems. |
|  | PO10 | Effectively communicate within the mechanical engineering community in particular and society in general. |
|  | PO11 | Demonstrate knowledge and understanding of mechanical engineering sciences principles and apply these to one’s own work as a member and a leader to manage projects. |
|  | PO12 | Engage in independent and lifelong learning to adapt technological changes in mechanical engineering field. |