SNJB's

Late Sau. Kantabai Bhavarlalji Jain

College of Engineering

(An Autonomous Institute Affiliated to Savitribai Phule Pune University, Pune)

Shri Neminath Jain Brahmacharyashram (SNJB) (Jain Gurukul)

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ESTD - 1928

Curriculum and Evaluation Scheme for Second Year B. Tech. in Mechanical Engineering with Multidisciplinary Minor and Honor

To be implemented for 2024-28 Batch

(With Effect from Academic Year 2025-26)

CHAIRMAN
BOARD OF STUDIES MECHANICAL ENGINEERING
SNJB's
LSKBJ COLLEGE OF ENGINEERING
Chandwad Dist.Nashik

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(Nashik)
Pin-423101

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LSKBJ COLLEGE OF ENGINEERING
Chandwad Dist.Nashik

Vision of the Institute

Transform young aspirant learners towards creativity and professionalism for societal growth through quality technical education.

Mission of the Institute

1. To transfer the suitable technology, particularly for rural development.
2. To enhance diverse career opportunities among students for building a nation.
3. To acquire the environment of learning to bridge the gap between industry and academics.
4. To share values, ideas, and beliefs by encouraging faculties and students for the welfare of society.

Vision of the Mechanical Engineering Department

To impart quality technical education in the field of Mechanical Engineering for the benefits of society

Mission of the Mechanical Engineering Department

1. To provide quality education among the students through the curriculum and industrial exposure.
2. To develop a learning environment leading to innovations, skill development and professional ethics through curricular and extracurricular activities for societal growth.

Program Outcomes (POs) for an engineering graduate:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic

decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Program Specific Outcomes

1. **PSO1:** Graduates will have an ability to identify, analyze, and develop appropriate solution(s) to Mechanical Engineering Problems.
2. **PSO2:** Graduates will be able to use modern engineering tools for analyzing and solving practical problems of industry and society.
3. **PSO3:** Graduates will be able to learn and grow constantly, with good technical, spiritual, and ethical values with a zeal for life-long learning.

GENERAL COURSE STRUCTURE

A. Definition of Credit:

Table 1: Credit Definition

1 Hour Lecture (L) per week	1 Credit
1 Hour Tutorial (T) per week	1 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits: (B.Tech. or Equivalent) in Tech. with Multidisciplinary Minor:

In the light of the fact that a typical NEP Compliant Model Four-year Undergraduate degree program in Technology has about 176 credits, the total number of credits proposed for the four-year B.Tech. in **Mechanical Engineering** with Multidisciplinary minor degree is kept as **172.**

Table 2: Range of Credits

Course Category		Credits As PER NEP Guidelines	Proposed Credits
Basic Science Course	BSC/ESC	14-18	15
Engineering Science Course		16-12	14
Programme Core Course (PCC)	Program Courses	44-56	47
Programme Elective Course (PEC)		20	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses	14	17
Open Elective (OE) Other than a particular program		8	8
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	8	8
Ability Enhancement Course (AEC)	Humanities Social Science and Management (HSSM)	4	6
Entrepreneurship/Economics/ Management Courses		2	4
Indian Knowledge System (IKS)		2	2
Value Education Course (VEC)		4	5
Research Methodology(RM)	Experiential Learning Courses	4	4
Community Engagement Project (CEP)/ Field Project (FP)		2	2
Project		4	5
Internship/ OJT		12	12
Co-curricular Courses (CC)	Liberal Learning Courses	4	3
Total Credits		**160-176**	**172**

C. Semester wise Credit Distribution Structure for Four Year B. Tech in Mechanical Engineering with Multidisciplinary Minor:

Table3: Semester-wise Credit Distribution Structure

Semester		I	II	III	IV	V	VI	VII	VIII	Total Credits
Basic Science Course	BSC/ESC	8	7	-	-	-	-	-	-	15
Engineering Science Course		7	7	-	-	-	-	-	-	14
Programme Core Course (PCC)	Program Courses	-	3	11	8	9	4	9	3	47
Programme Elective Course (PEC)		-	-	-	-	6	5	6	3	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses	-	-	3	3	3	2	3	3	17
Open Elective (OE) Other than a particular program		-	-	-	3	2	3	-	-	8
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	2	2	-	2	-	2	-	-	8
Ability Enhancement Course (AEC)	Humanities Social Science and Management (HSSM)	1	-	1	2	2	-	-	-	6
Entrepreneurship/Economics/ Management Courses		-	-	2	2	-	-	-	-	4
Indian Knowledge System (IKS)		2	-	-	-	-	-	-	-	2
Value Education Course (VEC)		-	-	3	2	-	-	-	-	5
Research Methodology	Experiential Learning Courses	-	-	-	-	-	4	-	-	4
Community Engagement Project (CEP)/ Field Project (FP)		-	-	2	-	-	-	-	-	2
Project		-	-	-	-	-	2	3	-	5
Internship / OJT		-	-	-	-	-	-	-	12	12
Co-curricular Courses (CC)	Liberal Learning Courses	1	2	-	-	-	-	-	-	3
Total Credits (Major)		**21**	**21**	**22**	**22**	**22**	**22**	**21**	**21**	**172**

Students can opt for any of the following as per the rules and regulations given by the institute:

1. B. Tech with Multidisciplinary Minor = Total 172 Credits
2. B. Tech with Multidisciplinary Minor and Honor = Total 190 Credits

HONORS

- In addition to 172 credits of B. Tech Programmes (Bachelor of Technology) i.e. Major in which the student has taken admission, a student may opt for Honors in the same Tech. discipline/branch / Emerging Areas.
- A student is required to earn an additional 18 credits in the same Tech. discipline/ branch / Emerging Areas for Honors distributed over semesters III to VIII.
- The total number of credits required to complete the Honors in the same Tech. discipline/ Emerging Areas is 18 credits, in addition to 172 credits in Major.
- Students will have to compulsorily choose Honors from the same Tech. discipline/branch.
- Honors Degree in the Bachelor of Engineering programme shall be awarded to students earning additional total credits of all six semesters from the second year to final year, i.e., 18 Credits, in addition to 172 credits or 130 credits respectively. The student admitted in the first year must earn 172 credits and 130 credits admitted in lateral entry (admitted after Diploma or B.Sc.) in the second year.
- Minor Courses can be completed through an online platform.

The student has to choose One Honor out of the Two Honor groups provided below

Honors offered by Mechanical Engineering are as follows:

Table 4: Honors

Sr No	Name of Honors Offered by Department
A.	Robotics and Automation
B.	Electric Vehicle

The detailed syllabus structure for the same is as follows:

Table 5A: Specialization Honors in Robotics and Automation

Sr. No	Category	SEM	Course Code	Course Name	Teaching Scheme				
					Hours				Credits
					L	T	P	Total Hours	
01	HOC	III	24-HOC-ME-2-01A	Fundamentals of Robotics	3	-	-	3	3
02	HOC	IV	24-HOC-ME-2-02A	Robot Kinematics & Dynamics	3	-	-	3	3
03	HOC	V	24-HOC-ME-3-03A	Embedded Systems in Robotics	3	-	-	3	3
04	HOC	VI	24-HOC-ME-3-04A	Robot Vision & Motion Planning	3	-	-	3	3
05	HOC	VII	24-HOC-ME-4-05A	Robotics Programming & Controls	3	-	-	3	3
06	HOC	VIII	24-HOC-ME-4-06A	Intelligent Robots	3	-	-	3	3
Total					**18**	-	-	**18**	**18**

Table 5B: Specialization Honors in Electric Vehicle

Sr. No	Category	SEM	Course Code	Course Name	Teaching Scheme				
					Hours				Credits
					L	T	P	Total Hours	
01	HOC	III	24-HOC-ME-2-01B	e-Vehicle Technology	3	-	-	3	3
02	HOC	IV	24-HOC-ME-2-02B	EV Power Systems and Battery Technology	3	-	-	3	3
03	HOC	V	24-HOC-ME-3-03B	Electric DriveTrain and Propulsion Systems	3	-	-	3	3
04	HOC	VI	24-HOC-ME-3-04B	EV Charging Infrastructure	3	-	-	3	3
05	HOC	VII	24-HOC-ME-4-05B	Vehicle Dynamics and Control in EVs	3	-	-	3	3
06	HOC	VIII	24-HOC-ME-4-06B	e-Mobility: Sustainability and the Future	3	-	-	3	3
Total					**18**	-	-	**18**	**18**

#Note for NPTEL/SYAYAM: Approved courses and platforms will be enlisted timely by authorities along with rules and regulations

Honors Syllabus for SEM III and SEM IV

24-HOC-ME-2-01A: Fundamentals of Robotics

Teaching Scheme:	**Credit:** 3	**Examination Scheme:**
Theory: 3 Hours/Week		**CIE**: 20 Marks **MSE:** 20 Marks **SEE**: 60 Marks

Prerequisites Courses: (24-BSC-1-03) Linear Algebra And Differential Calculus , (24-BSC-1-01) Engineering Physics, 24-BSC-1-04 Statistics Probability and Integral Calculus, (24-PCC-ME-1-01) Mechanical Engineering Systems

Companion Course: NA

Course Objectives:

- To understand the basic principles and diverse applications of robotics across various domains.
- To analyze robot kinematics and perform motion analysis for robotic systems.
- To apply fundamental concepts of dynamics and control to robotic motion.
- To explore the working and significance of sensors and actuators in robotics
- To develop fundamental programming skills for robotic tasks and operations.
- To examine the ethical and social implications of robotics in modern society.

Course Outcomes:

After completion of the course, learners should be able to

CONo	**CO**	**BL**
CO1	Explain the basic concepts and practical applications of robotics in real-world scenarios.	2
CO2	Apply coordinate transformations to analyze the kinematics of robotic systems.	3
CO3	Apply dynamics and basic control principles to robotic motion to maintain stability and accuracy.	3
CO4	Describe the functions and roles of sensors and actuators in robotic systems.	2
CO5	Develop simple robot programs using basic programming concepts for performing standard tasks.	3
CO6	Understand the ethical and social impacts of robotics on modern society.	2

Course Contents

Unit I	**Introduction to Robotics and Applications**	**7 Hours**

Definitions of robotics, historical milestones (e.g., Unimate, 1961), Asimov's Three Laws and their implications, and modern applications across industries. Industrial uses (assembly lines, welding), healthcare (surgical robots), agriculture (harvesting robots), and service (cleaning, delivery). Examples: KUKA robots in manufacturing, da Vinci surgical system.

#Exemplar/Case Studies: Robotic Automation in Tesla's Gigafactory (USA)

***Mapping of Course Outcomes**	**CO1**

Unit II	**Kinematics of Robots**	**7 Hours**
Basic robotic components (joints, links), forward kinematics concepts, coordinate frames (base, tool). Joint types (revolute, prismatic), position and orientation representation, introduction to homogeneous transformations. Examples: 2R manipulator kinematics, calculating end-effector position.		
#Exemplar/Case Studies: Robotic Surgery with the da Vinci Surgical System (USA)		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Dynamics and Control Basics**	**7 Hours**
Forces and torques in robotic motion, open-loop vs. closed-loop control, introduction to control loops. Newton's laws applied to robot arms (e.g., F=ma for a link), basic feedback mechanisms, and stability concepts. Examples: Pendulum balancing using feedback, simple servo control system.		
#Exemplar/Case Studies: Boston Dynamics' Atlas Robot (USA)		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Sensors and Actuators in Robotics**	**7 Hours**
Sensor types (proximity, tactile, vision), actuator types (electric motors, pneumatic cylinders), selection criteria. Working principles of IR sensors, DC motors, and applications in pick-and-place tasks. Examples: Ultrasonic sensor for distance measurement, stepper motor for precise positioning.		
#Exemplar/Case Studies: Amazon Robotics in Fulfillment Centers (USA)		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Robot Programming Fundamentals**	**7 Hours**
Programming methods (teach pendant, offline), basic commands (move, grasp), and scripting basics. Lead-through programming, point-to-point motion, and simple syntax in robotic languages (e.g., VAL or Python basics like "move 10 cm"). Examples: Programming a robot to follow a square path in a simulation.		
#Exemplar/Case Studies: Autonomous Navigation of Self-Driving Cars (Waymo, USA).		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Ethical and Social Aspects of Robotics**	**7 Hours**
Safety standards (ISO 10218), societal impacts (job automation, economic shifts), and ethical design principles. Risk assessment for robotic systems, privacy concerns with service robots, designing for human-robot trust. Examples: Ethical dilemmas in autonomous vehicles (e.g., trolley problem).		
#Exemplar/Case Studies: Robo-Advisors in Financial Services (USA)		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		

Text Books

T1. M.P. Groover, *"Industrial Robotics: Technology, Programming, and Applications"*, McGraw-Hill, 2nd Edition, 2012.
T2. R.K. Mittal and I.J. Nagrath, *"Robotics and Control"*, McGraw-Hill, 1st Edition, 2003.
T3. John J. Craig, *"Introduction to Robotics: Mechanics and Control"*, Pearson, 3rd Edition, 2004.
T4. *Debashis Bose, "Fundamentals of Robotics: A Comprehensive Introduction", Wiley, 2018.*

Reference Books :

R1. Siciliano, B., and Khatib, O., *"Springer Handbook of Robotics"*, Springer, 2nd Edition, 2016.
R2. Spong, M.W., Hutchinson, S., and Vidyasagar, M., *"Robot Modeling and Control"*, Wiley, 2nd Edition, 2020.
R3. S.R. Deb and Sankha Deb, *"Robotics Technology and Flexible Automation"*, Tata McGraw-Hill, 2nd Edition, 2010)
R4. K. Madhava Krishna, *"Introduction to Robotics"*, Narosa Publishing, 2017.

Additional Resources: (Books, e-Resources)

- Bansal R. K., "*Introduction to Robotics and Industrial Automation*", Laxmi Publications, 2018

MOOC Courses links :

- Introduction to Robotics - https://nptel.ac.in/courses/107106090
- Ethics in Engineering Practice - https://nptel.ac.in/courses/110105097

24-HOC-ME-2-02A: Robot Kinematics & Dynamics

Teaching Scheme:	**Credit:** 3	**Examination Scheme:**
Theory: 3 Hours/Week		**CIE** : 20 Marks **MSE :** 20 Marks **SEE** : 60 Marks

Prerequisites Courses: (24-BSC-1-03) Linear Algebra And Differential Calculus , (24-BSC-1-01) Engineering Physics, 24-BSC-1-04 Statistics Probability and Integral Calculus, (24-PCC-ME-1-01) Mechanical Engineering Systems, (24-HOC-ME-2-01A) Fundamentals of Robotics

Companion Course: NA

Course Objectives:

- To understand the types of robotic joints and mechanisms and their role in robotic design.
- To apply forward and inverse kinematic principles to model robotic systems.
- To analyze workspace configurations and develop trajectory planning strategies.
- To understand the foundational concepts of robot dynamics using Newton-Euler and Lagrangian formulations.
- To explain the principles of forces, torques, and motion modeling in robotic systems.
- To apply mathematical models to real-world robotic scenarios and optimize their performance.

Course Outcomes:

After completion of the course, learners should be able to

CONo	**CO**	**BL**
CO1	Identify and classify types of robotic joints and mechanisms used in industrial applications.	2
CO2	Apply forward kinematics principles to model robotic configurations and calculate end-effector positions.	3
CO3	Apply inverse kinematics techniques to solve robotic positioning problems using analytical and numerical methods.	3
CO4	Perform basic workspace analysis and describe trajectory planning strategies.	2
CO5	Explain the fundamental concepts of forces, torques, and dynamic stability in robotic systems.	2
CO6	Explain basic control strategies used in robotic systems and their real-world applications..	2

Course Contents

Unit I	**Types of Robotic Joints and Mechanisms**	**7 Hours**

Types of robotic joints: Prismatic, revolute, spherical, helical. Serial and parallel manipulators. Degrees of Freedom (DoF) and mobility in robotic mechanisms. Kinematic structures and their influence on robot motion. Examples: SCARA, Delta, Cartesian robots.

#Exemplar/Case Studies: ABB IRB 6700 Industrial Robot - Joint and Mechanism Design		
***Mapping of Course Outcomes**	**Mapping to CO1**	
Unit II	**Forward Kinematics of Robots**	**7 Hours**
Kinematic chains and configurations. Homogeneous transformation matrices and coordinate transformations. Forward kinematics equations for serial and parallel robots. Denavit-Hartenberg (DH) parameters and their applications. Representation of robotic arms using transformation matrices.		
#Exemplar/Case Studies: KUKA KR 210 - Forward and Inverse Kinematics in Automotive Assembly		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Inverse Kinematics: Analytical and Numerical Methods**	**7 Hours**
Mathematical formulation of inverse kinematics. Analytical methods: Geometric and algebraic approaches. Numerical techniques: Iterative and optimization-based methods. Handling redundancy and singularities. Inverse kinematics challenges in multi-DOF systems.		
#Exemplar/Case Studies: FANUC M-2000iA/1700L - Heavy-Duty Robotic Handling		
***Mapping of Course Outcomes**	**CO 3**	
Unit IV	**Workspace Analysis and Trajectory Planning**	**7 Hours**
Definition and classification of workspaces: Reachable, dexterous, and total workspace. Workspace analysis techniques. Trajectory generation: Point-to-point and continuous path planning. Polynomial and cubic spline interpolation for motion control. Basic constraints in workspace design and their impact on robot motion.		
#Exemplar/Case Studies: Boston Dynamics' Spot Robot - Dynamic Stability and Motion Control		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Basics of Robot Dynamics and Motion Modeling**	**7 Hours**
Introduction to robot dynamics: Forces and torques in robotic systems, Simple explanations of motion equations without deriving complex formulas, Introduction to dynamic stability and its importance in robotic systems, Concept of energy-based motion analysis without detailed Lagrangian mechanics, Applications of dynamics in basic robotic manipulator design		
#Exemplar/Case Studies: Mitsubishi RV-F Series Robots - Force and Torque Control in Assembly		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Control Strategies for Robotic Systems**	**7 Hours**
Basics of control theory in robotic systems. PID control and feedback loops. Joint space and Cartesian space control. Adaptive control and compliance control basics. Introduction to control system tuning and stability considerations.		
#Exemplar/Case Studies: Robotic Surgery with the da Vinci Surgical System		

***Mapping of Course Outcomes**	**CO6**

Learning Resources

Text Books

T1. John J. Craig, *"Introduction to Robotics: Mechanics and Control"*, Pearson, 4th Edition, 2017.
T2. R.K. Mittal and I.J. Nagrath, *"Robotics and Control"*, McGraw-Hill, 2nd Edition, 2017.

Reference Books :

R1. Siciliano, B., and Khatib, O., *"Springer Handbook of Robotics"*, Springer, 2nd Edition, 2016.
R2. Spong, M.W., Hutchinson, S., and Vidyasagar, M., *"Robot Modeling and Control"*, Wiley, 2nd Edition, 2020.
R3. S.R. Deb and Sankha Deb, *"Robotics Technology and Flexible Automation"*, Tata McGraw-Hill, 2nd Edition, 2010.
R4. K. Madhava Krishna, *"Introduction to Robotics"*, Narosa Publishing, 2017.

Additional Resources: (Books, e-Resources)

- Bansal, R.K., *"Introduction to Robotics and Industrial Automation"*, Laxmi Publications, 2018.
- Mukherjee, Amitabha, *"Robotics and Artificial Intelligence"*, Prentice Hall India, 2019.
- K.S. Fu, R.C. Gonzalez, C.S.G. Lee, *"Robotics: Control, Sensing, Vision, and Intelligence"*, McGraw-Hill, 2012.

MOOC Courses links :

NPTEL Courses:

- Introduction to Robotics, IIT Kanpur: https://nptel.ac.in/courses/112104298

24-HOC-ME-2-01B: E-Vehicle Technology

Teaching Scheme:	**Credit:** 03	**Examination Scheme:**
Theory: 03 Hours/Week		**CIE** : 20 Marks **MSE :** 20 Marks **SEE** : 60 Marks

Prerequisites Courses: (24-BSC-1-03) Linear Algebra And Differential Calculus, (24-BSC-1-02) Engineering Chemistry, (24-ESC-1-01) Basic Electrical and Electronics Engineering, (24-PCC-ME-1-01) Mechanical Engineering Systems

Companion Course: -

Course Objectives:

- To understand the fundamentals of electric vehicles, their components, and their role in sustainable mobility.
- To explain the types, classifications, and working principles of hybrid electric vehicles.
- To understand energy storage systems and their applications in electric vehicles.
- To apply the concepts of power electronics and motor drive systems for controlling electric vehicle operations.
- To understand drive systems in electric vehicles for motor selection and sizing.
- To explore advancements in electric vehicle technology for IoT integration and intelligent transport systems.

Course Outcomes:

After completion of the course, learners should be able to

CONo	**CO**	**BL**
CO1	**Understand** the fundamental principle of electric vehicles and their key components.	2
CO2	**Classify** various types of hybrid electric vehicles based on architecture and working principles.	2
CO3	**Demonstrate** energy storage systems used in electric vehicles for batteries, fuel cells, and ultracapacitors.	2
CO4	**Apply** the principle of power electronics for motor control electric vehicles.	3
CO5.	**Select** motor selection and drive system principles to optimize electric vehicle performance.	3
CO6	**Describe** advancements in EV technology, including IoT and smart battery management.	2

Course Contents

Unit I	**Introduction to Electric-vehicle**	**6 Hours**

History and evolution of Electric Vehicles, Necessity of electric vehicles, Comparison of Electric with Internal Combustion Engine Vehicles, Limitations of IC Engine Vehicles (ICEV), EV Technology, Significance of e-Vehicle, Types of electric vehicles and their components, Autonomous Vehicles, Government Policies about electric vehicles.

#Exemplar/Case Studies: Tesla Model S - Revolutionizing Electric Mobility

***Mapping of Course Outcomes**	**CO1**

Unit II	**Hybrid Electric Vehicle**	**8 Hours**
Introduction of Hybrid Electric Vehicle(HEV), Classification of HEV (Architecture, Construction, Working, Advantages and Limitations), Conventional HEV and its type, Griddable HEV and its type, Tractive force, Power and Energy requirements for standard drive cycles of HEV Hybrid Electric Drive-Trains: Basic concept of Hybrid Traction, Fuel Efficiency Analysis.		
#Exemplar/Case Studies: Toyota Prius - The Pioneering Hybrid Vehicle		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Energy Storage Systems in Vehicle**	**8 Hours**
Classification and types of energy storage systems, Battery Basics, Types of batteries and their Construction, Working, Battery Parameters, Battery Capacity. Alternative energy sources include fuel cells, fuel cell characteristics, alternators, Dynamometer ultracapacitors, and types of ultra flywheel.		
#Exemplar/Case Studies: Nissan Leaf - Battery Technology and Range Optimization		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Power Electronics and Motor Drive**	**8 Hours**
Introduction to Power Electronics in EVs, Importance of Power Electronics and Motor Drives in EVs, Power Electronics Converters, Electric Drive Components, Drive Controller, Power Electronic Switches, Diode, Power Transistors, Power MOSFETs,I GBT, Integrated circuits, Challenges in motor control: Stability, efficiency, and noise reduction.		
#Exemplar/Case Studies: BYD Electric Buses - Power Electronics for Heavy-Duty EVs		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Motor and drive system**	**8 Hours**
Introduction to drive systems in EV, Types of motors, selection and size of motors, Classification and general characteristics, Motor drives and principle of operation and performance, Mechanical and electrical connections of motors.		
#Exemplar/Case Studies: Mahindra eVerito - Motor Drive and Efficiency		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Advancement in e-vehicle**	**7 Hours**
Integration of IoT in e-vehicle, Wireless sensor networks for autonomous vehicles, Intelligent Transport Systems, Degradation and disposal of batteries, Modes of fast and efficient charging, and Availability of charging stations as per Indian road conditions. Types of standards, Safety rules and regulations.		
#Exemplar/Case Studies: Rivian R1T - Intelligent Electric Pickup Truck		
***Mapping of Course Outcomes**	**CO6**	

Learning Resources
Text Books
T1. Ehsani, Mehrdad, et al. *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design.* CRC Press, 2019. **T2.** Larminie, James, and John Lowry. *Electric Vehicle Technology Explained.* Wiley, 2003.
Reference Books :
R1. Hussein, Iqbal. *Electric and Hybrid Vehicles: Design Fundamentals.* CRC Press, 2021. ISBN: 9780367693930. **R2.** Larminie, James, and John Lowry. *Electric Vehicle Technology Explained.* 2nd ed., Wiley, 2012. ISBN: 9781119942733.
Additional Resources: (Books, e-Resources): - ● Chau, K.T. *Electric Vehicle Machines and Drives: Design, Analysis and Application.* Wiley, 2015. ● Emadi, Ali. *Advanced Electric Drive Vehicles.* CRC Press, 2014.
MOOC Courses links : ● https://onlinecourses.nptel.ac.in/noc25_ee33/ EV - Vehicle Dynamics and Electric Motor Drives ● https://onlinecourses.swayam2.ac.in/nou25_ec06/preview Introduction to Electric and Hybrid Electric Vehicle

24-HOC-ME-2-02B: EV Power Systems and Battery Technology

Teaching Scheme:	**Credit:** 03	**Examination Scheme:**
Theory: 03 Hours/Week		**CIE**: 20 Marks **MSE:** 20 Marks **SEE**: 60 Marks

Prerequisites Courses: (24-BSC-1-03) Linear Algebra And Differential Calculus, (24-BSC-1-02) Engineering Chemistry, (24-ESC-1-01) Basic Electrical and Electronics Engineering, (24-PCC-ME-1-01) Mechanical Engineering Systems, (24-MDM-ME-2-01) E-Vehicle Technology

Companion Course: -

Course Objectives:

- To understand the components, configurations, and design principles of EV powertrains.
- To calculate motor torque and power ratings and apply motor selection criteria for EV applications.
- To explore the role of motor control, battery management, and sensor systems in electric vehicles.
- To classify battery technologies, describe their working principles, and calculate battery power ratings.
- To study the design and construction of battery compartments in electric vehicles.
- To understand the concepts and functions of Battery Management Systems (BMS).

Course Outcomes:

After completion of the course, learners should be able to

CONo	CO	BL
CO1	**Explain** EV powertrain components and transmission systems.	2
CO2	**Evaluate** motor torque and power specifications of electric motors at different conditions.	3
CO3	**Describe** control systems used in electric vehicles.	2
CO4	**Calculate** battery ratings and power requirements for different battery types.	3
CO5	**Explain** the construction and testing methods of EV battery packs.	2
CO6	**Describe** charging methods, standards, and the role of battery management systems (BMS) in EVs.	2

Course Contents

Unit I	Powertrain and Transmission Systems	8 Hours

EV Transmission Configurations, Transmission Components, Gear-Box, Automobile Differential, Clutch, Brakes, Ideal Gearbox: Steady State Model, Gear Ratio (GR), Torque-Speed Characteristics, EV Drive Layout - One/Two / Four/All-wheel Drive Layout, Transmission System Component design.

#Exemplar/Case Studies: Tesla Model 3 Powertrain Architecture.		
***Mapping of Course Outcomes**	**CO1**	
Unit II	**Motor drive technology**	**8 Hours**
Motor Drives for EV (using DC Motor Drives, Induction Motor Drives, Permanent Magnet Brushless and Switched Reluctance Motor Drives), Motor Selection Criteria, Structural Configuration of motor layout (single motor, dual motor, in wheel/Hub motor, Planetary Geared Motors, etc) for EV, Motor Safety and Maintenance, Motor Torque and Power Rating calculation.		
#Exemplar/Case Studies: Nissan Leaf Motor Sizing and Efficiency Optimization.		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Electric Vehicles Control System**	**6 Hours**
Motor Control System, Modes of Control, Electronic Control Unit [ECU], Battery/Cell Control System, Modes of Control, Battery Control Unit [BCU], Sensors used in EV, Sensor Management and Integration, EV and EHV configuration based on power electronics.		
#Exemplar/Case Studies: BYD Blade Battery - Safety and Efficiency Innovations.		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Battery Technologies**	**8 Hours**
Introduction to Battery Technologies in EVs, Battery types, Lead-acid, Lithium-ion (Li-ion) battery construction and working. Alternative Batteries: Nickel-Cadmium Battery, Nickel-Metal-Hydride (NiMH) Battery, Zinc-Air Battery, Sodium-Sulfur Battery, Sodium-Sulfur Battery. Calculation of power rating for standard drive cycle of batteries.Battery balancing and its type.		
#Exemplar/Case Studies: Mahindra Electric's Power Electronics for e-Verito.		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Introduction to battery testing and analysis**	**8Hours**
Layout specific Battery Location Selection, Constructional details of Batteries (Battery Pack Structure), Battery Analysis, Introduction of battery testing(Electrical, Thermal and Mechanical), Vent Management System, Pack Cooling System, Battery life analysis, Mechanism of Battery Degradation and Remedies.		
#Exemplar/Case Studies: Battery Management in Tata Nexon EV.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Battery Charging and Battery Management System**	**7 Hours**

Basic Requirements for Charging System, Charging Methods and Standards, Necessity of Battery Management Systems, Typical Structure of BMSs, Key points of BMSs in Future Generation, Hazard/Safety Management	
#Exemplar/Case Studies: Electrify America - Building a Nationwide EV Charging Network (USA).	
***Mapping of Course Outcomes**	**CO6**

Learning Resources

Text Books:

T1. Ehsani, Mehrdad, et al. *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design.* CRC Press, 2019.

T2. Larminie, James, and John Lowry. *Electric Vehicle Technology Explained.* Wiley, 2003.

Reference Books :

R1. Hussein, Iqbal. *Electric and Hybrid Vehicles: Design Fundamentals.* CRC Press, 2021. ISBN: 9780367693930.

Additional Resources: (Books, e-Resources): -

- Chau, K.T. *Electric Vehicle Machines and Drives: Design, Analysis and Application.* Wiley, 2015.
- Emadi, Ali. *Advanced Electric Drive Vehicles.* CRC Press, 2014.

MOOC Courses links :

- https://onlinecourses.nptel.ac.in/noc25_ee33/ EV - Vehicle Dynamics and Electric Motor Drives
- https://onlinecourses.swayam2.ac.in/nou25_ec06/preview Introduction to Electric and Hybrid Electric Vehicle.

Mid Semester Examination (MSE: <<MonthYear>>)

Programme: AIDS/Civil/Computer/E&TC/Mechanical/MBA-I	
Class:	**Pattern:**
Course Name:	**Course Code:**
AY:	**Semester:**
Time:	**Maximum Marks:** 20

Instructions to the candidates:

1. *Solve Q.1 OR Q.2, Q.3 OR Q.4, Q.5 OR Q.6*
2. *Bold-faced figures to the right indicate full marks.*
3. *Assume the suitable data if necessary*
4. *Any other instruction required for particular course may be added by subject/course chairman*

QN	Question	Mark
1a)	Q 1 can be bifurcated to maximum two sub questions	07
1b)		
	OR	
2	Q 2 can be bifurcated to maximum two sub questions	07
3	Q 3 can be bifurcated to maximum two sub questions	07
	OR	
4	Q 4 can be bifurcated to maximum two sub questions	07
5	Q 5 can be bifurcated to maximum two sub questions	06
	OR	
6	Q 6 can be bifurcated to maximum two sub questions	06

Shree Neminath Jain Brahmacharyashram's
Late Sau. Kantabai Bhavarlalji Jain College of Engineering
Neminagar, Chandwad -423 101 Dist. Nashik.
An Autonomous Institute, Affiliated to Savitribai Phule Pune University, Pune

Semester End Examination (Regular) <<MonthYear>>

Programme: Class:

Course and Code: Semester:

Academic Year: Pattern:

Time: 2Hr 30 Min Examination: SEE (MonthYear) Max. Marks: 60

Instructions to the candidates:

1. *Solve Q.1 OR Q.2, Q.3 OR Q.4, Q.5 OR Q.6, Q.7 OR Q.8*
2. *Bold-faced figures to the right indicate full marks.*
3. *Assume the suitable data if necessary, but Justify it.*
4. *Draw the neat labelled diagrams, wherever necessary.*

QN	Question	Marks
1 a)	Unit I	6
1 b)	Unit II	7
1 c)	Unit III	7
	OR	
2 a)	Unit I	6
2 b)	Unit II	7
2 c)	Unit III	7
3 a)	Unit IV	7
3 b)	Unit IV	7
	OR	
4 a)	Unit IV	7
4 b)	Unit IV	7
5 a)	Unit V	7
5 b)	Unit V	6
	OR	
6 a)	Unit V	7
6 b)	Unit V	6
7 a)	Unit VI	7
7 b)	Unit VI	6
	OR	
8 a)	Unit VI	7
8 b)	Unit VI	6

Supporting Document

Sr. No.	Syllabus Contains	Short Answer	Yes / No	Page No. (In Syllabus)
1	अभ्यासक्रम	Enclosed in Syllabus	Yes	1
2	पात्रता	(As per the Rules and Regulations mentioned in MoM)	Yes	23
3	अभ्यासक्रमाची उद्दिष्टे	Enclosed in Syllabus	Yes	9
4	विषयाचे नाव	Enclosed in Syllabus	Yes	7
5	घटकांचा तपशील	Enclosed in Syllabus	Yes	7
6	तासिका	Enclosed in Syllabus	Yes	7
7	श्रेयांक पद्धत	Enclosed in Syllabus	Yes	7
8	संदर्भ साहित्य	Enclosed in Syllabus	Yes	11
9	संदर्भ ग्रंथ	Enclosed in Syllabus	Yes	11
10	प्रश्नपत्रिकेचे स्वरूप	Enclosed in Syllabus	Yes	21
11	अंतर्गत मूल्यमापनाचे स्वरूप	Enclosed in Syllabus	Yes	7
12	सत्र परीक्षेचे स्वरूप	Enclosed in Syllabus	Yes	22
13	गुणांकन	Enclosed in Syllabus	Yes	7