SNJB's

Late Sau. Kantabai Bhavarlalji Jain

College of Engineering

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

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SNJB

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

To be implemented for 2024-28 Batch

(With Effect from Academic Year 2026-27)

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

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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 **Computer 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 Computer 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.	Fundamentals of Robotics
B.	E-Vehicle Technology

The detailed syllabus structure for the same is as follows:

Table 5A: Specialization Honors in Fundamentals of Robotics

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 E-Vehicle Technology

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 V

24-HOC-ME-3-03A: Embedded Systems in Robotics

Teaching Scheme: Theory: 3 Hours/Week	**Credits:** 3	**Examination Scheme:** **SEE** : 100 Marks

Prerequisites Courses: · 24-HOC-ME-2-01A Fundamentals of Robotics, 24-HOC-ME-2-02A Robot Kinematics & Dynamics

Companion Course: NA

Course Objectives:

- Introduce embedded systems concepts in the context of robotic applications.
- Familiarize students with microcontrollers and embedded platforms used in robots.
- Study sensors, actuators, signal conditioning and hardware interfacing for mechatronic systems.
- Develop embedded programming skills with interrupts, timers, PWM, ADC/DAC, and RTOS basics for robotic control.
- Understand communication protocols (UART, I^2C, SPI, CAN*), and networking considerations for robots.
- Explore embedded applications in manipulators, AGVs/AMRs, drones and service robots with case studies.

Course Outcomes:

After completion of the course, learners should be able to

CO No	CO	BL
1	**Explain** the role, architecture and design flow of embedded systems in robotics.	2
2	**Describe** microcontrollers/processors used in robotic systems and justify platform selection.	2
3	**Apply** interfacing techniques for sensors, actuators and signal conditioning in robots.	3
4	**Develop** and analyze embedded programs (interrupts, timers, PWM, ADC/DAC) and explain RTOS concepts for robotic control.	3
5	**Explain** and configure serial communication protocols (UART, I^2C, SPI; overview of CAN/Ethernet/Wi-Fi/ Bluetooth) for robot subsystems.	2
6	**Illustrate** integrated embedded solutions in industrial/service robots with safety and reliability considerations.	2

Course Contents

Unit I	**Introduction to Embedded Systems in Robotics**	**7 Hours**

Definitions and characteristics, embedded system building blocks (MCU/MPU, memory, clock, power, I/O), HW/SW co-design and design flow, timing and latency budgets, PLC vs MCU in robotic cells, basic safety and reliability (watchdog, brown-out), debugging and instrumentation basics,

#Exemplar/Case Studies: Line-following mobile robot demonstrating the sensing ⟶ decision ⟶ actuation loop and basic timing/latency budgeting.

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

Unit II	**Microcontrollers & Processors for Robotics**	**7 Hours**

MCU vs MPU and Cortex-M overview, core peripherals (GPIO, timers, ADC/DAC, DMA), motor driver interfaces (H-bridge/ESC), fixed vs floating-point for control, platform options (MSP430/STM32/AVR/Arduino/Raspberry Pi), boot/startup and memory map basics, rugged PCB/connectors for mech environments		
#Exemplar/Case Studies: Microcontroller vs microprocessor overview with ARM Cortex-M peripherals (timers, PWM, ADC) applied to motion control.		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Sensors, Actuators & Interfacing Techniques**	**7 Hours**
Proximity/encoder/IMU/force–pressure sensors, datasheet parameters and calibration, DC/BLDC/stepper/servo actuators, signal conditioning and protection, ADC/DAC interfacing and anti-alias filters, EMI/EMC practices (grounding/shielding/cabling), introductory sensor fusion		
#Exemplar/Case Studies: BLDC motor speed control with a rotary encoder, highlighting sensor signals, simple conditioning, and actuator behavior.		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Embedded Programming & RTOS for Robotic Control**	**7 Hours**
Embedded C/C++ structure and HAL use, FSM-based robot behaviors, interrupts/ISRs and timers, RTOS basics (tasks, priorities, scheduling), IPC primitives (queues/semaphores/mutex), latency–jitter measurement and tuning, watchdog and failsafe integration		
#Exemplar/Case Studies: FreeRTOS-based two-DOF arm showing tasks, priorities, ISR-driven control, and loop-jitter tuning.		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Communication Protocols & Networking in Robotics**	**7 Hours**
UART fundamentals and buffering, I^2C addressing and timing, SPI modes and chip-select handling, overview of CAN/RS-485/Ethernet, wireless links (Wi-Fi/Bluetooth) for telemetry, EMI/ESD and industrial cabling/connectors, robustness (CRC/retries/watchdog resets)		
#Exemplar/Case Studies: UART vs I^2C vs SPI comparison for a small robot, covering wiring, timing, throughput, and typical use-cases.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Embedded System Applications in Robotics**	**7 Hours**
Manipulator control stack (current/velocity/position), AGV/AMR controller integration, drone controller overview and failsafes, firmware maintenance (bootloader/DFU/logging), reliability for shop-floor conditions, safety/compliance checklist, system-level integration capstone,		
#Exemplar/Case Studies: Warehouse AGV/AMR case illustrating end-to-end embedded integration (perception–plan–act), watchdogs/failsafes, and maintenance via bootloader/DFU with logging.		
***Mapping of Course Outcomes**	**CO6**	

Learning Resources
Text Books
T1. Raj Kamal. *Embedded Systems: Architecture, Programming and Design.* McGraw Hill Education. **T2.** K. V. Shibu. *Introduction to Embedded Systems.* McGraw Hill Education. **T3.** Nitaigour P. Mahalik, *Mechatronics: Principles, Concepts and Applications*, McGraw-Hill Education (India), 2nd ed. **T4.** K. Mittal & I. J. Nagrath, *Robotics and Control, McGraw-Hill Education (India), 2nd ed.*
Reference Books :
R1. Wayne Wolf, *Computers as Components: Principles of Embedded Computing System Design*, Morgan Kaufmann (Elsevier) **R2.** Elecia White, *Making Embedded Systems*, O'Reilly, 2nd ed. **R3.** D. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson India, 6th ed. **R4.** Ramesh S. Gaonkar, *Microprocessor Architecture, Programming and Applications with the 8085*, Penram/PHI India.
Additional Resources: (Books, e-Resources) Books: ● Joseph Yiu, The Definitive Guide to ARM Cortex-M3/M4/M7, Newnes (India reprint). ● Jonathan W. Valvano, Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers, ValvanoWare.
MOOC Courses links : ● **Embedded System Design with ARM – IIT Kharagpur** https://nptel.ac.in/courses/106105193 NPTEL ● **Embedded Sensing, Actuation and Interfacing Systems – IIT Kharagpur** https://nptel.ac.in/courses/108105376 NPTEL ● **Mechatronics – IIT Roorkee** https://nptel.ac.in/courses/112107298 NPTEL ● **Real-Time Systems – NIT Rourkela (NPTEL)** https://onlinecourses.nptel.ac.in/noc22_cs104/preview NPTEL Online Courses ● **Microprocessors and Microcontrollers – IIT Kharagpur** https://nptel.ac.in/courses/108105102 NPTEL ● **Introduction to Embedded System Design – NSUT & IIT Jammu** https://nptel.ac.in/courses/108102169 NPTEL

24-HOC-ME-3-03B: Electric DriveTrain and Propulsion Systems

Teaching Scheme: Theory: 03 Hours/Week	**Credit:** 03	**Examination Scheme:** **SEE** : 100 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-HOC-ME-2-01B) E-Vehicle Technology, (24-HOC-ME-2-02B) EV Power Systems and Battery Technology

Companion Course: -

Course Objectives:

- To provide foundational knowledge of electric vehicle drivetrain architecture and its components.
- To understand the construction, operating principles, and selection of electric traction motors used in EV propulsion.
- To develop an understanding of drivetrain components, transmission systems, gear mechanisms, and torque distribution methods.
- To develop skills in modelling, simulation, and optimisation of complete EV powertrains using forward- and backwards-facing approaches.
- To understand suspension, wheel, and braking system integration with electric propulsion, including regenerative braking
- To explore advanced propulsion layouts, multi-motor systems, torque vectoring, and e-axle technologies for next-generation EVs..

Course Outcomes:

After completion of the course, learners should be able to

CO No	CO	BL
CO1	Compare EV drivetrain architectures (BEV, HEV, PHEV, FCEV) with IC engine systems	2
CO2	Calculate peak torque and peak power using vehicle dynamics equations.	3
CO3	Identify and classify transmission components, gear ratios, and various differential types used in electric vehicles.	2
CO4	Apply powertrain modelling techniques (forward and backwards-facing models) for EV performance evaluation	3
CO5	Integrate appropriate wheel, tyre, and braking system with traction motors.	3
CO6	Compare single-motor, multi-motor, and e-axle propulsion layouts	2

Course Contents

Unit I	**Introduction to Electric Vehicles drivetrain Architecture**	**6 Hours**

Overview of electric vehicle architecture, Types of electric drivetrains: BEV, HEV, PHEV, FCEV, Functional requirements of EV propulsion systems, Comparison with conventional IC engine drivetrains, Role of drivetrain in vehicle dynamics and performance

#Exemplar/Case Studies : Drivetrain Layout of a Basic Electric Scooter

***Mapping of Course Outcomes**	**CO1**	
Unit II	**Electric Machines for Propulsion**	**8 Hours**
Requirements of EV traction motors, DC motors, induction motors, PMSM, BLDC motors, Motor torque and power rating calculation, Motor selection for EV applications,EV Motor sizing, Efficiency maps.		
#Exemplar/Case Studies: Selection of BLDC Motor for Hero Electric Optima Based on City-Ride Requirements		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Electric Vehicle Drivetrain**	**8 Hours**
EV Transmission Configurations, Transmission Components, Gears, Gear ratio(GR), Automobile Differential, Differential Classification and Types (Open, Locked, Spool/Welded, Limited Slip, Torsen, Active, Torque Vectoring)		
#Exemplar/Case Studies: Use of Differential System in Mahindra Treo E-Rickshaw for Passenger Transport		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Powertrain Optimization**	**8 Hours**
Powertrain Modelling Techniques, Forward-facing Vehicle Model, Backwards-facing Vehicle model, Comparison of forward and backwards-facing models, Powertrain Simulation Method, Software-Defined Powertrain & OTA		
#Exemplar/Case Studies: Powertrain energy optimization for Tata Nexon EV during daily commute		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Suspension and Braking System**	**8 Hours**
Topology design and Types of Front and Rear Suspension Systems, Design of Shock Absorbers, Coil Springs and linkages. Types of wheels/Tyres and Braking Systems, Integration of Wheel with traction motor, Regenerative Braking.		
#Exemplar/Case Studies: Regenerative Braking and Suspension Performance in TVS iQube During City Riding		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Advanced Propulsion Layouts in Electric Vehicles**	**7 Hours**
Introduction to Advanced Propulsion Architectures, Limitations of conventional single-motor drivetrains, Multi-Motor Propulsion Systems(Dual-Motor & Tri-Motor Setups), Architecture of e-axles(motor, inverter and reduction gear integration)		
#Exemplar/Case Studies: Dual-Motor Propulsion System for Off-Road Electric ATV Applications		
***Mapping of Course Outcomes**	**CO6**	
Learning Resources		
Text Books		
1. Mehrdad Ehsani, Yimi Gao, Sefano Longo, Kambiz Ebrahimi, (2019), "Modern Electric, Hybrid Electric and Fuel Cell		

Vehicles: Fundamentals, Theory and Design," CRC Press,
2. "Electric Vehicle Technology Explained" by James Larminie and John Lowry
3. Electric Motor drives – Modelling, Analysis & Control, R. Krishnan, PHI India, Ltd.

Reference Books :

1. Iqbal Hussein, (2021), "Electric and Hybrid Vehicles: Design Fundamentals," CRC Press, ISBN: 9780367693930
2. Power Electronics: Converters, Applications, and Design" by Ned Mohan
3. Denton, Tom, (2020), "Electric and Hybrid Vehicles," 2nd Ed., Routledge, ISBN:9780367273248
4. John Lowry, James Larminie, (2012), "Electric Vehicle Technology Explained," Wiley, ISBN: 9781119942733

MOOC Courses links :

- https://onlinecourses.nptel.ac.in/noc25_ee33/ EV - Vehicle Dynamics and Electric Motor Drives(By Prof. Amit Jain, Prof. Avanish Tripathi | IIT Delhi)
- https://onlinecourses.swayam2.ac.in/nou25_ec06/preview Introduction to Electric and Hybrid Electric Vehicle (By Dr. R. N. Patel and Dr Lalit Kumar Sahu | Chhattisgarh Swami Vivekanand Technical University, Bhilai)

Honors Syllabus for SEM VI

24-HOC-ME-3-03A: Robot Vision & Motion Planning

Teaching Scheme: Theory: 3 Hours/Week	**Credits:** 3	**Examination Scheme:** **SEE** : 100 Marks

Prerequisites Courses: · 24-HOC-ME-2-01A Fundamentals of Robotics, 24-HOC-ME-2-02A Robot Kinematics & Dynamics

Companion Course: NA

Course Objectives:

- Introduce image formation and computer-vision basics for robotic perception.
- Develop camera geometry, calibration, and pose estimation understanding.
- Cover features, segmentation and tracking for manipulation/navigation tasks.
- Explain configuration-space concepts and classical motion-planning methods.
- Plan feasible paths for wheeled (non-holonomic) mobile robots and analyze tracking.
- Integrate perception with planning for industrial and mobile-robot case studies.

Course Outcomes:

After completion of the course, learners should be able to

CONo	CO	BL
1	Explain image formation, sampling and the basic vision pipeline for robots.	2
2	Apply camera models, stereo geometry and calibration to estimate geometry/pose.	3
3	Use features/segmentation/matching for object/scene understanding.	3
4	Explain and apply configuration-space and classical motion-planning methods.	3
5	Plan and analyze paths for non-holonomic mobile robots with basic tracking control.	3
6	Integrate perception and planning for industrial/mobile applications with safety context.	3

Course Contents

Unit I	**Vision Foundations for Robotics**	**7 Hours**

Definitions: image, pixel, intensity, resolution, dynamic range, histogram, pinhole camera model, focal length, principal point, field of view, Image formation and basic radiometry for industrial scenes, Sampling and quantization; aliasing considerations, Gray-level transforms; histogram equalization (overview),
Spatial filtering: smoothing and sharpening, Edge detection (Sobel/Canny) and basic morphology (erode/dilate/open/close).

#Exemplar/Case Studies: Part orientation on a conveyor using threshold + edges.

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

Unit II	**Camera Geometry & Calibration**	**7 Hours**

Definitions: intrinsics (fx, fy, cx, cy), extrinsics (R, t), homography, distortion, Single-view geometry and homography for planar scenes, Checkerboard calibration workflow; reprojection error, Lens distortion models and undistortion, Epipolar geometry and stereo rectification, Disparity to depth; triangulation and scale handling, Intro to PnP pose estimation; accuracy checks and error sources.		
#Exemplar/Case Studies: Hand–eye calibration for a fixed-camera pick-and-place arm.		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Features, Segmentation & Pose**	**7 Hours**
Definitions: corner, blob, keypoint, descriptor, inlier/outlier, segmentation, Local feature detectors (Harris/FAST, DoG) and descriptors (SIFT/SURF/ORB concepts), Feature matching; ratio test; RANSAC model fitting, Color spaces (RGB/HSV) and thresholding for part detection, Region segmentation; contours and shape descriptors, Marker/fiducial pose estimation (ArUco/AprilTag) for grasping, Optical flow / basic target tracking in conveyor/AGV scenarios.		
#Exemplar/Case Studies: Marker-based grasp pose for bin-picking.		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Motion Planning Fundamentals**	**7 Hours**
Definitions: configuration, DOF, workspace vs configuration space (C-space), obstacle, roadmap, C-space construction and obstacle modeling for manipulators, Graph/cell decomposition methods (visibility, grids), Sampling-based planning concepts: PRM, RRT (variants at a glance), **Potential-field planning:** intuition and limitations, Path smoothing and basic time-parameterization, **Collision checking: r**esolution vs compute trade-offs.		
#Exemplar/Case Studies: Collision-free joint-space path for a 3-DOF arm.		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Mobile Robot Planning & Navigation**	**7 Hours**
Definitions: non-holonomic constraint, differential-drive, Ackermann steering, odometry, slip, Kinematics of wheeled robots (differential-drive and car-like), **Mapping:** occupancy grids and costmaps (inflation radius), Global path planning on grids (Dijkstra/A*), Local/reactive avoidance (VFH/Bug family – overview), Localization overview and odometry fusion (EKF idea), Path-tracking controllers (pure-pursuit / PID basics).		
#Exemplar/Case Studies: Aisle navigation and path tracking for an AGV in a factory.		
***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Vision-in-the-Loop & Applications**	**7 Hours**
Definitions: visual servoing (IBVS vs PBVS), hand–eye calibration, perception–plan–act loop, Closed-loop vision control (overview) and integration pipeline, **Robustness:** lighting, glare, blur; validation datasets/metrics, **Safety in vision cells:** guarding, interlocks, false-negative handling, **Deployment:** calibration SOPs and re-calibration triggers, Maintenance and logging for shop-floor robots, **Case consolidation:** inspection cell; AGV pallet pickup and placement.		
#Exemplar/Case Studies: Vision-guided pallet pickup with safety interlocks.		

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

Learning Resources

Text Books

T1. R. Szeliski, *Computer Vision: Algorithms and Applications* Springer.
T2. *R. C. Gonzalez & R. E. Woods, Digital Image Processing,* Pearson.
T3. *Howie Choset et al., "Principles of Robot Motion", MIT Press.*
T4. *J.-C. Latombe, "Robot Motion Planning", Springer.*

Reference Books :

R1. D. A. Forsyth & J. Ponce, "Computer Vision: A Modern Approach", Pearson.
R2. R. Siegwart, I. R. Nourbakhsh & D. Scaramuzza, "Introduction to Autonomous Mobile Robots", MIT Press.
R3. Peter Corke, "Robotics, Vision and Control", Springer
R4. Steven M. LaValle, "Planning Algorithms", Cambridge University Press.

MOOC Courses links :

- Embedded System Design with ARM – IIT Kharagpur https://nptel.ac.in/courses/106105193 NPTEL
- Embedded Sensing, Actuation and Interfacing Systems – IIT Kharagpur https://nptel.ac.in/courses/108105376 NPTEL
- Mechatronics – IIT Roorkee https://nptel.ac.in/courses/112107298 NPTEL
- Real-Time Systems – NIT Rourkela (NPTEL) https://onlinecourses.nptel.ac.in/noc22_cs104/preview NPTEL Online Courses
- Microprocessors and Microcontrollers – IIT Kharagpur https://nptel.ac.in/courses/108105102 NPTEL
- Introduction to Embedded System Design – NSUT & IIT Jammu https://nptel.ac.in/courses/108102169 NPTEL

Additional Resources / MOOCs

NPTEL: Computer Vision (IIT Kharagpur); Digital Image Processing (IIT Kharagpur); Robot Motion Planning (IIT Kanpur); Wheeled Mobile Robots (IIT Madras & IIT Palakkad); CV & Image Processing: Fundamentals & Applications (IIT Guwahati).

24-HOC-ME-3-04B: EV Charging Infrastructure

Teaching Scheme: Theory: 03 Hours/Week	**Credit:** 03	**Examination Scheme:** **SEE** : 100 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-HOC-ME-2-01B) E-Vehicle Technology, (24-HOC-ME-2-02B) EV Power Systems and Battery Technology,24-HOC-ME-3-03B: Electric DriveTrain and Propulsion Systems

Companion Course: -

Course Objectives:

- To provide foundational knowledge of electric vehicle charging concepts, standards, and requirements.
- To understand the type of chargers, power electronics, and communication protocols used in EV charging systems.
- To explain AC–DC and DC–DC conversion, battery charging profiles, power quality issues, and challenges in fast charging.
- To develop an understanding of how to plan and design EV charging stations, including technical, safety, and cost-related aspects.
- To understand charger–vehicle and charger–network communication protocols, smart grid concepts like V2G/V2H, IoT integration, and cybersecurity requirements.
- To make students familiar with the operation, maintenance, and safety practices involved in managing EV charging stations and upcoming technologies.

Course Outcomes:

After completion of the course, learners should be able to

CONo	Course Outcomes (CO)	BL
CO1	Explain the fundamentals of electric vehicles and charging infrastructure, including standards, policies, and regulations.	2
CO2	Differentiate between various charger types, modes, connectors, and evaluate their suitability for different applications.	2
CO3	Describe AC–DC and DC–DC conversion, battery charging profiles, power quality issues, and challenges in fast charging.	2
CO4	Apply planning and design principles to evaluate site selection, estimate electrical load, prepare layouts, and assess safety and cost requirements for EV charging stations.	3
CO5	Describe charger–vehicle and charger–network communication protocols, smart grid concepts like V2G/V2H, IoT integration, and cybersecurity requirements.	2
CO6	Apply operation and maintenance procedures, safety standards, testing methods, and business model concepts to manage EV charging stations effectively.	3

Course Contents		
Unit I	**Introduction to EV Charging Infrastructure**	**6 Hours**
Overview of Electric Vehicles & Energy Needs, Charging Requirements in BEV and HEV, Importance of Charging Infrastructure in EV Ecosystem, Global and Indian EV Charging Landscape, Standards, Policies, and Regulatory Environment (BIS, IEC, AIS, Bharat Chargers)		
#Exemplar/Case Studies: Development of Bharat EV Charging Infrastructure: Role of Standards, Policies, and Government Initiatives in India		
***Mapping of Course Outcomes**	**CO1**	
Unit II	**Fundamentals of EV Charging Systems**	**8 Hours**
Classification of Chargers: AC Chargers: Slow & Fast (Level 1, Level 2), DC Chargers: DC Fast, Ultra-Fast (Level 3), Components of Charging System: Cables, Connectors, Power Electronics, Charger Control, Communication Basics, and Protection Systems, Charging Modes (Mode 1–4) and Plug Standards (CCS2, CHAdeMO, Type-2, GB/T)		
#Exemplar/Case Studies: Comparative Analysis of AC Level-2 and DC Fast Chargers Used in Urban Public Charging Stations		
***Mapping of Course Outcomes**	**CO2**	
Unit III	**Charging Technology & Power Electronics**	**8 Hours**
AC–DC Conversion, DC–DC Conversion, On-Board vs Off-Board Chargers, Power Quality, Harmonics, Power Factor, Smart Charging, Load Management, Peak Shaving, Battery Technologies and Their Charging Profiles,Fast Charging Challenges: Thermal, Battery Aging, High Current Flow		
#Exemplar/Case Studies: Fast Charging Technology for Tata Motors Electric Vehicles in India		
***Mapping of Course Outcomes**	**CO3**	
Unit IV	**Charging Infrastructure Planning & Design**	**8 Hours**
Site Selection Criteria (Residential, Commercial, Highway), Load Estimation and Transformer Sizing, Electrical Layout Design & Safety Requirements, Civil, Structural, and Installation Considerations, Cost Estimation and Economic Analysis (CAPEX, OPEX)		
#Exemplar/Case Studies: Design of Highway Fast Charging Stations for Tata Nexon EV		
***Mapping of Course Outcomes**	**CO4**	
Unit V	**Communication Protocols & Smart Grid Integration**	**8 Hours**
Charger–Vehicle Communication Protocols (CAN, PLC), Charger–Network Communication Standards (OCPP 1.6 / 2.0.1), IoT-Based Charging Infrastructure, Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H), Energy Storage Integration, Cybersecurity in EV Charging Networks		
#Exemplar/Case Studies: Smart Charging and OCPP-Based Network Used by Tesla Supercharger System		

***Mapping of Course Outcomes**	**CO5**	
Unit VI	**Operation & Maintenance (O&M) of Charging Stations**	**7 Hours**
Operation & Maintenance (O&M) of Charging Stations, Remote Monitoring, Diagnostics & Control, Safety, Testing & Certification of Charging Equipment, Business Models: Public Charging, Subscription, Fleet Charging, Future Trends: Wireless Charging, Battery Swapping, Mega-Chargers		
#Exemplar/Case Studies: Operation, Maintenance, and Business Models of a Public EV Charging Network		
***Mapping of Course Outcomes**	**CO6**	

Learning Resources

Text Books

T1. Mehrdad Ehsani, Yimi Gao, Sefano Longo, Kambiz Ebrahimi, (2019), "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design," CRC Press.

T2. Larminie, James, and Lowry, John. *Electric Vehicle Technology Explained*. 2nd ed., John Wiley & Sons, 2012.

T3. Electric Motor drives – Modelling, Analysis & Control, R. Krishnan, PHI India, Ltd.

Reference Books :

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

R2. Power Electronics: Converters, Applications, and Design" by Ned Mohan

R3. Denton, Tom, (2020), "Electric and Hybrid Vehicles," 2nd Ed., Routledge, ISBN:9780367273248

R4. John Lowry, James Larminie, (2012), "Electric Vehicle Technology Explained," Wiley, ISBN: 9781119942733

MOOC Courses links :

- https://onlinecourses.nptel.ac.in/noc25_ee33/ EV - Vehicle Dynamics and Electric Motor Drives(By Prof. Amit Jain, Prof. Avanish Tripathi | IIT Delhi)
- https://onlinecourses.swayam2.ac.in/nou25_ec06/preview Introduction to Electric and Hybrid Electric Vehicle (By Dr. R. N. Patel and Dr Lalit Kumar Sahu | Chhattisgarh Swami Vivekanand Technical University, Bhilai)