Robotics and Artificial Intelligence

Subject Name	Code	L-T-P	Credit	Contact Hours
Semester-1				
Robotics	ME6L401	3-0-0	3	3
Artificial Intelligence	New Code	3-0-0	3	3
DE 1		3-0-0	3	3
DE 2		3-0-0	3	3
DE 3		3-0-0	3	3
Robotics Design and Synthesis Lab	ME6P450	0-0-3	2	3
Robotics and Programing Lab	New code	0-0-3	2	3
Total			21	23
Semester-2				
Advanced Robotics and AI	New code	3-1-0	3	3
Advanced Mechatronics	New code	3-0-0	4	4
DE 4	Elective	3-0-0	3	3
DE 5	Elective	3-0-0	3	3
Robotics and Mechatronics Lab	ME6P452	0-0-3	2	3
Robotics Vision Lab	New code	0-0-3	2	3
Total			17	18
Semester-3				
Thesis Part – II	ME6D002		15	-
Total			15	
Semester-4				
Thesis Part – III	ME6D003		15	-
Total			15	
Total Credits:			**68**	

***The students may opt for either an open elective or an elective from another department (with the consent of the teaching faculty and the faculty advisor) against any one of the department electives.**

Syllabus

Subject Code: ME6L401	Subject Name: Robotics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Applications of robot and sensors: Introduction to robots, Internal and external sensors;
Actuators: hydraulic, pneumatic, and electric actuators, programming of robots;
Homogeneous transformations, D-H parameter notation, direct & inverse kinematics of manipulators: examples of kinematics of some common manipulator configurations;
Jacobian, dynamics of manipulators; trajectory planning; and
Automation, types of automation, analysis of automated assembly systems, line balancing problems, analysis of automated material handling systems, automated storage and retrieval systems.

Recommended Books:

1. Robotics: Fundamental concepts and analysis By A. Ghosal, Oxford University Press, 2006.
2. Industrial RoboticsBy M P Groover, Pearson Edu, 2008.
3. Robotics and ControlBy R K Mittal & I J Nagrath, TMH, 2003.
4. Robotics: Control, sensing, vision and intelligence By K Fu, R Gonzalez, and C S G Lee, McGraw Hill, 1987.
5. Robotic Engineering By / Richard D. Klafter, Prentice Hall, 1989.
6. Introduction to Robotics By John J Craig, Pearson Edu. Prentice Hall, 2003
7. Robot Dynamics & Control By Mark W. Spong and M. Vidyasagar, John Wiley & Sons (ASIA) Pte Ltd, 1989.
8. Automation, Production Systems and Computer Integrated Manufacturing by M P Groover, Prentice Hall India, 1987.

Subject Code: New code	Subject Name: Artificial Intelligence	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction to Artificial Intelligence: What is AI? Related Fields, Agents and Environments Problem Solving: problem representation paradigms, state space, satisfiability vs optimality Search Techniques: Principles of search, uninformed search, informed search, constraint satisfaction problems, adversarial search and games

Knowledge Representation: First order and non-monotonic logic; rule based, frame and semantic network approaches, mixed representations, Theorem Proving, knowledge bases and inference

Uncertainty Treatment : formal and empirical approaches including Bayesian theory, belief functions, certainty factors

Fuzzy Logic: Tagaki-Sugeno Fuzzy Logic;, Mamdani Fuzzy Logic, Fuzzy Bayesian Decision Method, Membership Functions, Fuzzification and Defuzzification, Fuzzy system Modeling Planning and making decisions

Reinforcement learning: MDPs, Q-learning algorithm, applications, Bandits and Monte carlo tree search

Text Books:

1. Russell and Norvig. Artifiicial Intelligence: A Modern Approach. Pearson Education (Low Priced Edition), 2004.
2. Nils J. Nilsson, Artificial Intelligence - A New Synthesis, Morgan Kaufmann Publishers, 2000
3. George F.Luger and William A. Stubblefield, AI: Strcutures and Strategies for Complex problem solving, 2nd edition, Benjamin Cummins Publishers

Reference Books:

1. Mark Stefik, Introduction to Knowledge Systems, Morgan Kaufmann.
2. E. Rich and K.Knight, Artificial Intelligence, Tata McGraw Hill
3. E. Charniack and D. Mcdermott, Artificial Intelligence, Addison Wesley

Subject Code: ME6P450	Subject Name: Robotics Design and Synthesis Lab	L-T-P: 0-0-3	Credit: 2

Pre-Requisite(s): None

Course content:

This lab mainly focuses on the study of various sub-components, namely sensors, actuators, and microcontroller boards used in the design of a robotic mechanism. The experiments related to the measuring of various parameters, actuating the servomotor based on the signal received at the sensor, programming the microcontroller etc. This lab also focus on the study of serial as well as parallel manipulator configurations, and study of more flexible robot like snake like robot.

1. Study and understanding of the operation of sensors and actuators
   (i)To measure the distance of an obstacle by using Ultrasonic Sensor & Arduino Uno
   (ii)To detect motion of an object using IR Sensor
   (iii)To actuate Servomotor with the help of Ultrasonic Sensor
2. To design a custom casing for an Arduino Uno board using CAD software i.e Solid works & 3D Print the design using Bambu Lab 3D Printer
3. To fabricate micro feature using table top CNC milling machine
4. To perform pick & place operation for R-P-P Robotic manipulator Configuration using Fischer Technik manipulator & Robo Pro Software
5. To Perform basic Boolean operation using NI My RIO
6. To enhance the performance of any electronic component by minimizing errors and improving accuracy of motion sensing using feedback compensation in an IMU
7. To train a Convolutional Neural Network (CNN) to classify images from the MNIST dataset of handwritten digits (0-9)
8. Real time Human motion detection & analysis using IMU(Xsens MVN) sensors.
9. To design a snake-like robot/snake robot/serpentine robot to mimic the motions of biological robot.
10. Programming on RSS-type Stewart Parallel Manipulator
11. Estimation of Forward Kinematics Problem of 2DOF Planner Serial Manipulator using a simple feed forward Neural Network.

Subject Code: New code	Subject Name: Robotics and Programing Lab	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s):			

Course content:

1. Introduction: why Python
2. Ecosystem: installation, workflow, data types, control flow, functions, scripts and modules, input, output, standard library, Numpy arrays, Pandas Basic, Generators, List Comprehensions, Multiple Function Arguments, Regular Expressions, Exception Handling, Sets, Serialization, Partial functions, Code Introspection, Closures, Decorators, Map, Filter, Reduce,
3. Visualization with Matplotlib, Libraries for AI.
4. Introduction to image processing
5. Open CV library

Textbooks/References

Python Data Science Handbook, O'REILLY

Subject Code: New code	Subject Name: Advanced Robotics and AI	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction to Image Processing and Computer Vision, Introduction to Robotic Vision, Introduction to Python and Keras, Image Processing and Edge Detection in Images,
Introduction to Deep Learning and Neural Networks, Convolutional Neural Networks (CNNs)
Basics of Convolution, Padding, and Strided Convolution, Types of Layers and Data Augmentation
Image Recognition, Network Architecture, Transfer Learning,
Object Segmentation, Semantic Segmentation,
Object Detection
Physics informed neural networks
ML models for classification and clustering
Machine health monitoring using ML techniques

Textbooks /References

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 2016
2. Michael Nielsen, Neural Networks and Deep Learning, 2016
3. Yoshua Bengio, Learning Deep Architectures for AI, 2009

Subject Code: New code	Subject Name: Advanced Mechatronics	L-T-P:3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction: Definition of Mechatronics, Components of Mechatronics,

Application of Mechatronics in Products and Systems, Review of engineering dynamics- Newton Euler Equation

Basic electrical components and circuits,

Basic signal processing, transducers and sensors, common sensors like LIDAR, sonar, strain gauge, and ultrasonic sensors,

Actuation systems, and actuators, common actuation systems like pneumatic, hydraulic, and electrical actuation systems, digital signal processing (DSP), Analog to Digital Converters,

Data Acquisition Systems, Microprocessors and Microcontrollers, and common microcontrollers like Atmeag 16, Arduino, ESP32, etc.

System Modelling: Modeling electromechanical systems and hydrothermal systems, control system design, dynamic response of systems, transfer function and frequency response, and closed loop controllers - PID, LQR, and LQG.

Design and automation: PLCs and introduction to industrial automation, Computer-based modular design, remote monitoring, and control; Practical application of mechatronics, design issues, industrial techniques, etc.

Recommended Books:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. Alciatore, D. G. and Histrand, M. B., “Introduction to Mechatronics”, Tata McGraw Hill. 2003
3. Shetty, D. and Richard, A.K., “Mechatronics System Design”, PWS Pub. Boston. 1997
4. Bolton, W., “Mechatronics: A Multidisciplinary Approach”, 4th Ed., Prentice Hall. 2009

Subject Code: ME6P452	Subject Name: Robotics and Mechatronics Lab	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s):			

Course content:

This lab focuses on providing hands-on experience in designing various modules related to the design of an automated system. The activity includes designing mechanisms suitable to automate a particular process after using pneumatic, hydraulic, and mechatronics kits. This also focuses on the study of kinematics, dynamics, trajectory planning, and programming aspects of a 6-DOF industrial manipulator.

List of experiments:

1. To design & develop a feeder station for modular manufacturing system using Mechatronics Kit.
2. To assemble the Dispenser module of the feeder station and control the actuation by double-acting Cylinder, using a solenoid-operated Direction direction-controlled valve through Siemens PLC on a Mechatronics Kit.
3. To design and develop a rotary actuator module & control the actuation of compact type double acting cylinder to pick and place an object from dispenser module on Mechatronics Kit by using Siemens PLC
4. Study of the operations of various sensors mounted on the PLC Trainer
5. Study to use the Siemens Step 7 remote programming software
6. Automatic Part sorting based upon the presence of holes using PLC trainer
7. Hydraulics Kit Experiment
8. Electro hydraulics Experiments
9. Study of the components & features of 6DOF Industrial Manipulator
10. Determination of Forward & Inverse Kinematics of 6 DOF Industrial Manipulator

Subject Code: ME6P453	Subject Name: Robotics Vision Lab	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s):			

Course content:

Object Detection & Tracking
Objective: Identify and track objects in real-time.
Experiments:
Object detection using YOLO, SSD, and Faster R-CNN.
Object tracking using Kalman Filter and DeepSORT.
Color-based object tracking with HSV color space.
Tools: OpenCV, TensorFlow/PyTorch.

Robot Perception & Path Planning
Objective: Use vision for robot localization and navigation.
Experiments:
Visual SLAM (Simultaneous Localization and Mapping) using ORB-SLAM.
Line following using color segmentation and PID control.
Object avoidance using LiDAR and depth camera.
Tools: ROS, Gazebo, OpenCV

Robotic vision:
Aerial Vision: Drones, UAVs
Underwater Vision: ROVs, AUVs, sonar imaging
Terrestrial Vision: Ground-based robots, autonomous vehicles, surveillance systems

AI-Powered Machine Health Monitoring
Acoustic Signal Processing for Machine Health
Image Processing for Machine Health
Acoustic Vibration Monitoring for Machine Health