DETAILS OF THE COURSE

Course Code	Course Title	Credits	L	T	P	Studio
22MET926	**Control of Robots and Automation Systems**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: None

COURSE OUTCOMES:

CO1	Understand the basics of control systems.
CO2	Understand the fundamental concepts and principles of robot control systems and industrial automation.
CO3	Model and Analyse the robotic systems.
CO4	Integrate sensors for perception and feedback control in robotics and automation applications.
CO5	Analyse and design motion planning algorithms for robots operating in different environments.
CO6	Apply optimization techniques for trajectory planning and system performance enhancement.

COURSE CONTENTS:

Introduction to Advanced Control in Robotics and Automation: Overview of advanced control concepts, Challenges and opportunities in robot control and automation systems, Review of control systems engineering principles Kinematics and Dynamics of Robotic Systems: Forward and inverse kinematics, Jacobian matrix and manipulability analysis, Lagrange's equations and dynamic modeling, Control-oriented representation of robot dynamics.

Advanced Control Techniques for Robotic Manipulators: PID control and tuning methods, Adaptive control for uncertain systems, Robust control and H-infinity control, Nonlinear control techniques (e.g., feedback linearization, sliding mode control) Mobile Robot Control: Motion planning and trajectory generation for mobile robots Localization and mapping techniques, Navigation and path-following control, Sensor fusion for mobile robot perception.

Sensing in Robotics and Automation: Sensor integration for robotic systems, Vision-based perception and object recognition, Force and tactile sensing for robot-environment interaction, Sensor fusion and data fusion techniques.

Optimization Methods in Robotics and Automation: Trajectory optimization and motion planning, Optimal control and model predictive control (MPC), Multi-objective optimization for robot performance enhancement, Parameter optimization and system identification.

Emerging Trends in Robotics and Automation: Collaborative robotics and human-robot interaction, Swarm robotics and collective behavior, Adaptive control and learning-based control methods, Industrial automation systems and smart factories Case Studies Integration of state-of-the-art control methods into practical robotics and automation scenarios, Identifying the needs of a given robotics application, and designing an appropriate control system, Assessing and bettering control performance

TEXT BOOKS/ REFERENCE BOOKS

1. Modern Control Systems, R. C. Dorf and R. H. Bishop, Pearson Publication, 2016.
2. Automatic Control Systems, F. Golnaraghi and B. C. Kuo, John Wiley & Sons INC, 2014.
3. Microprocessors and Microcontrollers, Architecture, Programming and Interfacing S. K. Mandal, Tata McGraw Hill Education Private Limited, 2017.
4. Feedback Control of Dynamic Systems, G.F. Frenklin, J. D. Powell, A. Emami-Naeini, Pearson Publicatio, 2018.
5. Introduction to Autonomous Robots: Kinematics, Perception, Localization, and Planning, Nikolaus Correll, Sven Koenig, and Vijay Kumar,
6. Mobile Robots: Navigation, Control and Remote Sensing, Gerald Cook, Wiley, 2011.

DETAILS OF THE COURSE: Honours Robotics and Automation

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET931	**Kinematics and Dynamics of Robotic Manipulators**	**3**	**2**	**1**	**0**	**0**

PREREQUISITE : None

COURSE OUTCOMES

CO1	Understand the basics of manipulator and its applications
CO2	Model forward and inverse kinematics of robot manipulators.
CO3	Analyze forces in links and joints and dynamic modeling of a robot
CO4	Program a robot to perform tasks in industrial applications

COURSE CONTENTS

Manipulators and Their Application: Types of Manipulators, Application of robot in welding, machine tools, material handling, and assembly operations parts sorting and parts inspection..
Transformations: Robot architecture, Pose of rigid body, Coordinates Transformation, DH parameters, DH parameters of Euler angles.
Kinematics: Forward and inverse position analyses, Velocity analysis- Jacobian matrix, Link velocities, Jacobian computation, DeNoC, Forward and Inverse velocity analysis, Acceleration analysis.
Statics and Manipulator Design: Force and moment balance, Recursive calculations, Equivalent joint torques, Role of Jacobian, Manipulator design.
Dynamics: Inertia properties, Euler-Lagrange formulation, Newton-Euler formulation,, Recursive Newton-Euler algorithms, Dynamic algorithms
Motion Planning: Joint space planning, Cartesian space planning, path primitives, Cartesian trajectories.

TEXT BOOKS/ REFERENCE BOOKS

1. Introduction to Robotics, S.K. Saha, McGraw Hill Education (India) PvtLted, New Delhi, 2014
2. Dynamics and Balancing of Multibody Systems, Himanshu Chaudhary, S.K. Saha, Springer, 2009
3. Introduction to Robotics: Mechanics and Control, John Craig, Pearson/PrenticeHallEducation, 3rdEdition, 2005
4. Introduction to Autonomous Mobile Robots, R.Siegwart,et.al, Prentice Hall of India,3rd Edition,2005.
5. Robotics and control. Mittal, R.K., and I.J. Nagrath, TataMcGraw-Hill,2003.

Details of the Course : B. Tech Honors (Robotics and Automation)

Course Code	Course Title	Credits	L	T	P	Studio
22MET951	**Robot Vision and Sensing**	**3**	**3**	**0**	**0**	**0**

Prerequisite: None

Course Outcomes:

CO1	Understand and apply fundamentals of computer vision
CO2	Understand the principle of sensors and their characteristics
CO3	Understand and apply vision-based motion estimation.
CO4	Understand and apply machine learning to robot vision

Course Contents:

Robotic vision sensors and their interfacing

Fundamentals of Computer Vision: Image accusation and representation, image transformation, filtering, restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC

Position and Orientation: Feature based alignment; Pose estimation; Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment

Localization and Mapping: Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation, geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (MonoSLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth), Analysis and parameter studies.

Recognition and Interpretations: Concepts of machine learning and deep learning, sequence modeling, Learning for robotic vision: Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation, Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics.

Text Books/ Reference Books

1. Sensors for Mobile Robots: Theory and Application, H. R. Everett, A K Peters/CRC Press, 1995.
2. Robotic Tactile Sensing, Dahiya, Ravinder S., Valle, Maurizio, Springer, 2013.
3. Robotics Technology and Flexible Automation, S. R. Deb, Sankha Deb, 2nd edition, McGraw Hill Education, 2017.
4. Image Processing, Analysis and Machine Vision, Milan Sonka, Vaclav Hlavac and Roger Boyle, Cengage, 2013

DETAILS OF THE COURSE B. Tech Honors (Robotics and Automation)

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET955	**Artificial Intelligence for Robotic Systems**	**3**	**2**	**1**	**0**	**0**

PREREQUISITE: None

Course Outcomes:

CO1	Learn about the different parts of a robotic system, including sensors, actuators, and controllers
CO2	Gain knowledge on the basics of Artificial Intelligence and Machine Learning
CO3	Develop the ability to critically evaluate the effectiveness of different AI techniques in robotics and identify areas for improvement
CO4	Understand the practical assumptions required to develop an autonomous robotic system

Course Contents:

Introduction to Robotics and Artificial Intelligence: Overview of Robotics and its components, introduction to Artificial Intelligence and Machine Learning, Types of AI and ML algorithms

Perception in Robotics: Introduction to perception in Robotics, techniques for image processing (segmentation, and feature extraction), object recognition and tracking using AI and ML techniques, planning and control in Robotics**.**

Introduction to Planning and Control in Robotics: Reinforcement learning techniques for motion planning and control, state estimation, feedback control, and trajectory planning.

Human-Robot Interaction: Overview of human-robot interaction, social robotics and the role of AI in human-robot interaction, ethics of human-robot interaction and future directions

Emerging Trends in Robotics: Overview of emerging trends in robotics, swarm robotics and multi-robot systems, autonomous vehicles and the role of AI in transportation.

Text Books/ Reference Books

1. Artificial Intelligence: A Modern Approach, Russell and Norvig, Pearson, 2022,
2. Learning Robotics Using Python, Lentin Joseph, Pearson, 2018,

Online/E Resources

1. Learning Python for Robotics: tinyurl.com/2xpr55ya

DETAILS OF THE COURSE B. Tech *Honors (Robotics and Automation)*

Course Code	Course Title	Credits	L	T	P	Studio
22MEP953	**Programming, Control, and Automation Lab**	**3**	**0**	**0**	**6**	**0**

PREREQUISITE: None

COURSE OUTCOMES:

CO1	Understand and Apply the PLC, SCADA programming
CO2	Interface hardware and software of automated systems
CO3	Understand and Apply various robot programming languages
CO4	Design the controller for robotic systems

COURSE CONTENTS:

S. No.	Name of Lab Experiment
	Control
1.	Introduction to MATLAB and Simulink.
2.	Introduction to LabVIEW software
3.	Analysis of a typical spring-mass-damper mathematical model of a mechanical system using LabVIEW.
4.	Steering control of a mobile robot using LabVIEW.
5.	Designing and tuning a PID controller in MATLAB.
6.	Simulation of Legged walking robots in MATLAB environment.
7.	Interfacing and controlling of stepper motor with a microcontroller.
8.	Design and construct a microcontroller-based DC motor speed control system.
	Automation
9.	Speed Control circuits for double acting cylinder (Automation)
10.	A synchronization circuit for two cylinders
11.	Continuous reciprocation of the double acting cylinder
12.	Sequencing of two-cylinder circuits
13.	Cascading circuit for trapped signals-2 groups
14.	Logic Circuits AND / OR
15.	Basic Electro Pneumatic Circuits: Continuous reciprocation of cylinder (with timer and counter) Sequencing of two cylinders
16.	Force, Velocity calculations in Hydraulic Linear actuation
17.	Speed Control of AC Servo Motor using open and closed loop control
18.	Run A Stepper Motor: For Required Angle
19.	Experimentation on PLC Application Trainer
20.	PLC Control Pneumatic/ Hydraulic linear actuator circuits, Water Level Controller using PLC, PLC Controlled Material Handling System, Process Control using Virtual Instrumentation, Pick and place operation of Robot in Manual Mode, PLC Controlled Material Handling System, Process Control using Virtual Instrumentation
21.	Characteristics of Inductive, capacitive and photoelectric proximity sensors
22.	Operating a simple load using relays, switches and pushbuttons using PLC
	Programming
23.	Programming the PLC Via Ladder logic, Temperature sensing using SCADA, Robot teaching using VAL II Programming, Plan mobile robot paths using RRT in MATLAB, Control of a mobile robot using gesture in Python

TEXT BOOKS/ REFERENCE BOOKS

1. Programmable Logic Controller, W. Bolton, Newnes Publisher, 2015.
2. Practical SCADA for industry, D. Bailey and E. Wright, Newnes Publisher, 2003.
3. Automation Studio Catalogue
4. Microprocessors and Microcontrollers, Architecture, Programming and Interfacing S. K. Mandal, Tata McGraw Hill Education Private Limited, 2017.

DETAILS OF THE COURSE: Honours Robotics and Automation

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEW982	**Mini Project on Robotics and Automation**	**3**	**0**	**0**	**6**	**0**

PREREQUISITE: None

COURSE OUTCOMES

CO1	To develop understanding related to Automation and Robotics system
CO2	To be able to select and plan for implementation of Robotics in say manufacturing system.
CO3	To be able to do calculations related to Robotics.
CO4	To be able to develop PoC and present use of Robotics in real word application.

COURSE CONTENTS

- Project on Robotics and Automation in any real-life automation system like the cases shown below: -
- **Robotic exoskeleton:** Create rehabilitation tools, such as robotic exoskeletons or wearable sensors that track and analyze movement patterns, to help patients recover from injury or surgery.
- Create assistive technology tools, including wheelchair attachments or communication aids, to enable individuals with disabilities carry out daily tasks.
- Advanced prosthetic limbs can be designed and built that are robotics-controlled, enabling the user to move more naturally and intuitively.
- Robots for Agriculture: Develop machines that can help with agricultural operations including planting, harvesting, and crop monitoring in order to save time and increase productivity.
- Drones for Search & Rescue: Create drones with cameras and sensors so they can look for and locate individuals in dire circumstances like accidents or natural catastrophes.
- Biomechanical modelling and simulation: Use mechanical engineering principles to model and simulate human body mechanics, such as joint movements or cardiovascular dynamics, to inform medical device and therapy design.
- Exploration on soft robotics involves the creation of robots that are designed and built with soft materials, allowing them to interact with their surroundings more flexibly and naturally compared to conventional rigid robots.
- Investigate the design and construction of a surgical robot that can aid in surgical procedures, enhancing accuracy and safety for patients.
- Research on autonomous assistive robots for elderly care aims to develop robots that can provide assistance to elderly patients with daily tasks, such as dressing or grooming, thereby reducing their dependence on human assistance.
- Automation of assembly lines: Create COBOT technologies that can aid human employees on assembly lines in repetitive or hazardous jobs.
- Material handling: Create COBOT systems that can transport goods between warehouses and workplaces, obviating the requirement for manual labour.

Recommended Readings

1. https://www.djkasiagroup.com/business/ai.html?gclid=EAIaIQobChMImp7E0uSy_gIVAT8rCh1d1QgMEAAYAiAAEgJcovD_BwE
2. https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article
3. https://www.uma.es/medical-robotics/cms/base/ver/base/basecontent/75284/proyectos/?set_language=en
4. https://www.asme.org/topics-resources/content/top-6-robotic-applications-in-medicine

SOURCE: PROJECT IDEAS INSPIRED BY INTEL, ASME, ETC….

1. https://www.asme.org/topics-resources/content/top-6-robotic-applications-in-medicine
2. https://www.intel.in/content/www/in/en/healthcare-it/robotics-in-healthcare.html
3. https://robotnik.eu/applications-of-robotics-in-medicine/
4. https://medrobotics.ri.cmu.edu/content/current-projects
5. https://www.analyticsinsight.net/top-100-robotics-projects-for-engineering-students/
6. https://www.geeksforgeeks.org/top-7-projects-in-robotics-for-beginners-and-intermediates/ (for Drone)
7. https://circuitdigest.com/robotics-projects