BMEE316E	Industrial Robotics	L	T	P	C
		3	0	2	4
Pre-requisite	BMEE207L, BMEE207P	Syllabus version			
		1. 0			

Course Objectives

1. To impart knowledge on the fundamentals of industrial robot types and their positioning systems.
2. To impart the mathematic foundation of robot manipulators, trajectory planning, and control.
3. To provide knowledge to design, fabricate, and control the manipulator robotics with gripper system.

Course Outcome

At the end of the course, the student will be able to

1. Specify various types of Robots for industrial applications with sound knowledge of the positioning system.
2. Represent the rigid body motion and its transformation mathematically.
3. Solve and model the kinematics equations of various manipulator configurations.
4. Solve and model the differential motion and dynamics of various manipulator configurations.
5. Compute the collision-free trajectory planning.
6. Identify the challenges and control problems in manipulator robotics.
7. Design and fabricate the gripping system for selected robot applications.

Module:1	Anatomy and Positioning System of robot	5 hours

Introduction to Industrial robotics – Manipulator configuration (examples with product specification): two link planar, Cartesian, Cylindrical, Polar, Articulated, SCARA, Delta and Stewart platform – CAD modelling of manipulator configuration (students by own) – Analysis of Positioning Systems (Actuator + Gear reduction unit): open-loop study with stepper motor, Closed-loop study with servo motor – Precision in Positioning system: control resolution, accuracy and repeatability– Harmonic drives in robotic manipulators.

Module:2	Configuration space and Rigid body motion	4 hours

DOF – C-space: Topology and representation, velocity constraints – Rigid body Motion: Description of position, orientations and frames – Changing descriptions from frame to frame (Homogeneous matrix) – Operation: Translation, rotation (rotation and Euler matrix) and transformation – Denavit-Hartenberg representation – Numerical.

Module:3	Robot kinematics	8 hours

Forward and Inverse kinematics: Two link planar (RR), cylindrical robot (RPP) and articulated arm (RRR) with Modelling and 3D virtual realization – other manipulators configurations: 6DOF articulated robotic arm, SCARA and Stewart platform.

Module:4	Differential motion and dynamics of robot	8 hours

Angular velocity – Velocity kinematic: Jacobian for 2 link planar (RPP), cylindrical robot (RPP) and articulated arm (RRR) – Forward and inverse dynamics of simple pendulum, double stage pendulum and two link planar.

Module:5	Manipulator Trajectory planning	7 hours

Path Planning – Trajectory planning – Classification of Trajectory planning - Join space schemes: Cubic polynomials – Cubic polynomials via point – Higher order polynomials – Linear function with parabolic blends – Cartesian space schemes: Geometric problems with Cartesian paths – two link planar trajectory planning.

Module:6	Manipulator control	5 hours

Linear control of manipulator: second-order linear system, control of second order system trajectory following control, disturbance rejection – Non-linear control: Control problems in manipulators, multi-input and multi-output control system – Lyapunov stability analysis –

adaptive control.		
Module:7	**Gripper Design**	**6 hours**
Gripper definitions and conceptual basics – Grasping in Natural system – Prehension strategy – Gripping procedure, conditions and force – Gripper Flexibility – Gripper classification – Requirements and gripper characteristics – Planning and selection of grippers – Impactive mechanical grippers: Single and multi-grippers– Ingressive gripper – Astrictive prehension – Special grippers: Micrograppers, soft grippers, compliance gripper.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**
Text Book		
1.	Craig, John. J. (2008), Introduction to Robotics: Mechanics and Control, Second Edition, Pearson Education, New Delhi.	
Reference Books		
1	Bruno Siciliano (2010) Robotics Modelling, Planning and Control, Springer-Verlag London Limited 2010.	
2	Mikell P. Groover, Mitchell Weiss (2013), Industrial Robotics Technology – Programming and Applications, McGraw Hill Edition 2.	
3	F. C. Park and K. M. Lynch (2017), Introduction To Robotics Mechanics, Planning, And Control, First Edition, Cambridge University Press.	
4	Gareth J.Monkman, Stefan Hesse (2007) Robot Grippers, WILEY-VH Verlag GmbH & Co, KGaA, Weinheim.	
Mode of Evaluation: CAT / written assignment / Quiz / FAT		
Indicative Experiments		
1.	Develop the code to realize the Forward kinematics equation for the selected manipulator configuration. Matlab: Minimum 2DOF to Maximum of 4DOF.	3 hours
2.	Develop the code to realize the Inverse kinematics equation for the selected manipulator configuration. Matlab: Minimum 2DOF to Maximum of 4DOF	3 hours
3.	Develop the code to realize the trajectory planning of single link arm using cubic polynomial equation and plot the response of position, velocity and acceleration. Matlab/Python	3 hours
4.	Develop the code to realize the trajectory planning of single link arm using linear function with parabolic blend (LFPB) and plot the response of position, velocity and acceleration. Matlab/Python	3 hours
5.	Realization of selected manipulator configuration in the virtual environment. [Coppeliasim, gazebo simulator, Sim-Mechanics (Matlab-Simulink) and any other virtual simulator].	3 hours
6.	Teach the industrial robot with appropriate Tool Centre Point (TCP) valve and USER Frame valve for the given tool and targeted location using three point teaching approach. [Simulation/Robo machine].	3 hours
7.	Program the Industrial robot to execute a 2D profile in a selected plane by recording the vertices of the 2D geometry profile using target teaching approach. [Simulation/Robo machine].	3 hours
8.	Program the Industrial robot to execute a 2D profile in a selected plane using position register, offset and other special functions (Target calculation approach). [Simulation/Robo machine].	3 hours
9.	Interface an End of Arm Tool (EOAT) for the selected industrial robot and establish the Digital Input connection to communicate the EOAT. [Simulation/Robo machine].	3 hours
10.	Design the robotic work cell for the given application along with all system integration components. Estimate the cycle time info with task profile. [Simulation only].	3 hours
	Total Laboratory Hours	**30 hours**

Textbook			
Lab Manual prepared by the Faculty member.			
Mode of assessment: Viva-voce examination, Lab performance & FAT			
Recommended by Board of Studies	09-03-2022		
Approved by Academic Council	No. 65	Date	17-03-2022