GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160317
Semester – VI
Introduction to Robotics

Type of course: Open Elective - II

Prerequisite: Fundamentals of Basic Physics, Basic Mechanics, Higher engineering Mathematics.

Rationale: The Purpose of this course is to focus on the basics of robotics, modeling, dynamics and control of robotic manipulators and its applications.

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	2	3	70	30	30	20	150

Content:

Sr. No.	Contents	Total Hrs	Weightage %
1	**Introduction to Robotics**: Definition, robot anatomy, Classification of Robots, Advantages and Disadvantages of Robots, Laws of robotics, Spatial coordinates, geometric configurations and work envelope; Machine intelligence; Applications and robot selection, safety, economic justification, future of robotics.	04	24%
2	**Spatial Descriptions and Transformation:** Descriptions: positions, orientations, and frames, Mappings: changing descriptions from frame to frame, Operators: translations, rotations, and transformations, Transformation arithmetic, Transform equations, Representation of orientation, Transformation of free vectors. **Manipulator Forward Kinematics**: Link Description, Link-Connection, Convention for Affixing Frames to Links, Manipulator Kinematics, Actuator Space, Joint Space, And Cartesian Space, Frames with Standard Names. **Manipulator Inverse Kinematics**: Solvability, Algebraic and Geometric Approaches, Degeneracy and Dexterity, Pieper's Solution When Three Axes Intersect, The Standard Frames, Solve-Ing A Manipulator, Repeatability and Accuracy.	11	26%
3	**Jacobians: velocities and static forces:** Velocities, Linear and rotational velocity of rigid bodies, Angular velocity, Motion of the links of a robot, velocity "propagation" from link to link,	08	26%

	Jacobians, Singularities, Static forces in manipulators, Jacobians in the force domain, cartesian transformation of velocities and static forces. **Trajectory generation**: general considerations in path description and generation, joint-space schemes, cartesian-space schemes, path generation at run time, description of paths with a robot programming language, planning paths when using the dynamic model, collision-free path planning. **Control of Robot Manipulator**: Open and closed loop control system, Control system concepts, linear control schemes, PID control system, types of motion control, electric drives and motor control, planning of trajectories.		
4	**Actuators**: Characteristics of Actuating Systems, Comparison of Actuating Systems, Hydraulic and Pneumatics Devices, Electric Motors in Robotics. **Sensors**: Sensor Characteristics, Position Sensors, Velocity Sensors, Acceleration Sensors, Touch and Tactile Sensors, Proximity Sensors, Range Finder. **End effectors:** General design considerations, mechanical grippers, vacuum pads, electromagnets; End effector power sources.	**07**	**24%**
	Total	**30**	**100%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20%	**30%**	**20%**	**20%**	**10%**	**0%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Introduction to Robotics: Mechanics and Control, John J. Craig, Addison-Wesley Publishing Company, 3rd Edition, 2003.
2. Robotics Modelling, Planning and Control, **Siciliano**, B., **Sciavicco**, L., **Villani**, L., **Oriolo**, G., Springer,2009.
3. Introduction to robotics, analysis, control, applications, Saeed Benjamin Niku.
4. Introduction to Robotics, Subir Kumar, Saha, Tata McGraw-Hill Education, 2014.

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Course Outcomes:

After learning this subject, students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the basics of robotic systems.	**24%**
CO-2	Formulate forward kinematics for design of basic robotics system.	**13%**
CO-3	Formulate inverse kinematics for design of basic robotics system.	**13%**
CO-4	Learn the math and computational methods necessary for controls of robot manipulators.	**26%**
CO-4	Familiarize with the most common robot Sensors & Actuators.	**24%**

List of Experiments:

Sr. No.	**Name of Experiments**	**Duration (Hours)**
1.	Study of Medical & Industrial robots and its applications.	**2**
2.	Simulation of Joint control stately for a desired end-effector position.	**4**
3.	Design/Simulate Robot dynamics (the forces acting on a robot and the resulting motion of the robot)	**2**
4.	Design/Simulate Rigid Body Tree Robot Model.	**4**
5.	Design/Simulate Pick and Place industrial manipulation application.	**4**
6.	Plan and execute task- and joint-space trajectories in MATLAB.	**2**
7.	Design/Simulate different robot kinematics models in an environment.	**4**

Major Equipment/Components: 2 DOF Robot, Rotary Servo Base Unit, Microcontroller Board, various motors and control unit, sensor kit