GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (07)

ROBOTICS AND AUTOMATION

SUBJECT CODE: 2720724

SEMESTER: II

Type of course: Engineering

Prerequisite: Matrix Algebra, Calculus, Mechanics, Control System and Computer Programming

Rationale: This course provides fundamentals of mechanics and control strategies for robotics**.**

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2#	0	4	70	30	30	0	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction** Background, Laws of robotics, Anatomy of robotics, notations, basic structures, various types of links and joints, application	**03**	10
2	**Spatial description and Transformations** Coordinate frames, description of objects in Space, Transformation of Vectors, Inverting homogenous transform, rotation matrices, computational consideration	**07**	14
3	**Forward Kinematics** Link description, Manipulator kinematics, Denavit - Hartenberg notation, Kinematic relationship between Adjacent links, Manipulator Transformation Matrix	**05**	12
4	**Inverse Kinematics** Concept of inverse kinematics, difficulties in the inverse solution, inverse kinematic solution by direct approach, geometric approach and examples based on direct approach	**05**	12
5	**Robot Dynamics** Lagrange's equation, Lagrange-Euler formulation, Newton-Euler formulation, Comparison of these formulations	**04**	12
6	**Manipulator Differential Motion** Concept of linear and angular velocity, Relationship between transformation matrix and angular velocity, manipulator Jacobean, Jacobean for prismatic and revolute joint, Jacobean Inverse,Singularities. Control of Robot manipulator: joint position controls (JPC), resolved motion position controls(RMPC) & resolved motion rate control (RMRC).	**07**	15

7	**Trajectory Planning** Definitions and planning tasks, pick and place operations, straight line motion, continuous path motion, interpolated motion	**05**	10
8	**Control of Manipulator** Open and close-loop control, linear control scheme, joint actuators, PD and PID control schemes, Computed torque control, Force-control strategies, Hybrid position, Impedance force and torque control,	**10**	15

Reference Books:

1. Robotics and control by I. J. Nagrath and R. K. Mittal, Tata McGraw-Hill Publication
2. Introduction to Robotics mechanics and control by J. J. Craig 3rd edition Pearson Education International

Course Outcome:

After learning the course the students should be able to:

1. Understand various terminology and co-ordinate frame structures.
2. Design mapping from one space to another and coordinate transformation.
3. Understand modelling of both forward and inverse kinematics.
4. Carry out the dynamic modelling of manipulator to find the forces and torques to cause the motion of manipulator.
5. Design trajectory planning through specified points or paths.

List of Tutorials:

1. MATLAB programme to show the use of transformation.
2. MATLAB programme to show Homogenous transformation.
3. MATLAB programme to show Euler-angle rotation.
4. MATLAB programme to derive D-H parameter for 3-DOF 3R joints
5. MATLAB programme to derive inverse solution for problem 4.
6. MATLAB programme to calculate the velocity of the tip of the two-link, planar, RR manipulator arm.
7. MATLAB programme to find the manipulator jacobian matrix for the 3-DOF articulated arm.
8. MATLAB programme to show that the velocity coupling vector for one-axis robot is always zero.
9. MATLAB programme for the second joint of SCARA manipulator required to move from 30^0 to 150^0 in 5 second, find the cubic polynomial to generate the smooth trajectory for the joint.

Major Equipment:

Computers.

MATLAB Software.

List of Open Source Software/learning website:

NPTEL Stanford online MIT open course ware, UoM open course ware EDX

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.