GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL ENGINEERING
ROBOTICS
SUBJECT CODE: 2181919
B.E. 8TH SEMESTER

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: To impart widespread acquaintance of robotic system along with different configurations, their kinematics, singularity problems, dynamics, Trajectory planning and real field applications of them.

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)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**General considerations of Robotic Manipulator** Robot anatomy: Links, Joint and joint notations scheme, Degrees of freedom; Arm and wrist configurations, End effectors; Coordinate frames, Mapping between: Rotated frames, Translated frames, rotated and translated frames; Description of robotic pose in a space; Homogeneous transformation and inverting a homogeneous transformation; Orientation with RPY and Euler angles (Forward and inverse formulations)	**09**	**20%**
2	**Kinematics of Robotic Manipulators** Direct Kinematics, Kinematic Modelling of the Manipulator; Denavit-Hartenberg (DH) Representation; Inverse Kinematic; Manipulator Work space, Solvability of inverse kinematic models: Existence of Solution, Multiplicity of Solutions; Solution Techniques, Guidelines for Closed form Solution	**08**	**20%**
3	**Differential Motion and Statics** Linear and Angular Velocity of a rigid body; Relation between transformation matrix and angular velocity; Mapping velocity vectors; Linear and Angular velocity of a link; Manipulator Jacobian; Jacobian Singularities; Static analysis of robots	**08**	**20%**
4	**Dynamic Analysis** Langrangian mechanics; Lagrange- Euler formulation; Velocity of point on the manipulator; The inertia Tensor; The kinetic Energy; Newton-Euler Formulation: Kinematic of Links; Link Acceleration; Concept of inverse dynamics	**06**	**10%**

5	**Robotics Sensors, Grippers and Vision** Sensors in robotics: Acoustic, Optic, Pneumatic, Force/ Torque sensors; Properties of Sensors, Robotic Vision systems, Industrial Applications of Vision based robotic systems. Robotic grippers and their design criteria	**06**	**15%**
6	**Trajectory Planning** Steps in trajectory planning; various terminologies; Joint space techniques; point to point motion with via points; Linear function with parabolic blends; Cartesian space techniques, Parametric description of straight and circular path	**05**	**10%**
7	**Robot Applications** Industrial, Material Handling, Processing, Assembly : Peg in hole, Compliance, Inspection, Surgical, Space and Military applications; Principles for robot application and application planning	**03**	**5%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
12	20	18	10	10	-

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, S K Saha, Tata McGraw Hill, 2008
2. Robotics and control, R K Mittal, I J Nagrath, Tata McGraw Hill 2003
3. Introduction to robotics, John J Craig, Pearson/Prentice Hall, 2005, Third edition
4. Introduction to Robotics: Analysis, Control, Applications , Saeed Niku, John Wiley & Sons
1. A Robot Engineering Textbook , Mohsen Shahinpoor, Harper and Row, Publisher, New York
2. Industrial Robotics, Technology, Programming and Applications, Mikell P Groover, Tata McGraw Hill, 2008

Course Outcome:

After learning the course, the students should be able to:

1. Know basic anatomy of robotics system
2. Learn various configuration with different joints
3. Apply the concept of DH convention for forward and inverse kinematics
4. Know various approaches for dynamics of robotic system and their trajectory planning
5. Learn the different real time applications of various robots

List of Experiments:

1. Introduction of Robotic system, various configurations and DOF calculations
2. Basic robot Joints and its simulation using high end computer software
3. Direct kinematics for open/closed loop configurations analytically/simulation/coding
4. Inverse kinematics for open/closed loop configurations analytically/simulation/coding
5. Coding/simulation of direct kinematics for open/closed loop configurations along with work space generation using high end software
6. Formulation of DH parameters of robot configuration and its simulation using open source software
7. Lagrangian formulation of the given configuration along with its coding/ validation using simulation software

8. Newtonian formulation of the given formulation along with its coding/ validation using simulation software
9. Design of trajectory for a specific task as given by instructor
10. Simulation/ performance of a trajectory planning of a robot
11. Study of various robotic sensors along with specifications and their applications area

Design based Problems (DP)/Open Ended Problem:

1. Design of robot for a given degree of freedom and required pay load capacity
2. Static force analysis of any robot or robotic arm configuration under consideration
3. Trajectory planning for a robot for a given industrial requirement

Major Equipment:

- Robot kits
- MATLAB/ High end Simulation software for mechanisms/robots

List of Open Source Software/learning website:

- http://www.roboanalyzer.com/

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.