GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING (08)

ROBOTICS PROGRAMMING AND APPLICATIONS

SUBJECT CODE: 2160808

B.E. 6th SEMESTER

Type of course: Multidisciplinary Engineering Course of Robotic Systems.

Prerequisite: Advance Engineering Mathematics, Fundamentals of Control Theory

Rationale: Today's industrial assembly line is equipped with robots and man vs. machine interface has been replaced by automation. Many industrial machines and plants are available with variety automatic controls. It is therefore need of the day for students to learn Robotics for working in modern industry. This course therefore attempt to build required skills to understand the basic principles, design, analysis, and synthesis of robotics system.

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	20	150

Content:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Fundamentals:** What is Robot?, Classification of Robots, What is Robotics?, History of Robotics, Advantage and Disadvantages of Robots, Robot Components, Robot Sensing, Robot Degree of Freedom, Robot Joints, Robot Coordinates, Robot Reference Frames, Programming Modes, Robot Programming Language, Robot Applications	**4**	**12**
2.	**Robot Arm Kinematics:** Robots as Mechanisms, Conventions, Matrix Representation: Representation of a Point in Space; Representation of a Vector in Space, Representation of Rigid Body, The Direct Kinematics Problem, The Inverse Kinematics Solution	**4**	**12**
3.	**Robot Arm Dynamics:** Lagrange-Euler Formulation, Newton-Euler Formation, Effective Moments of Inertia, Generalized D'Alembert Equation of Motion,	**3**	**9**
4.	**Panning of Manipulator Trajectories:** Path versus Trajectory, Basics of Trajectory Planning, General Consideration on Trajectory Planning, Joint-interpolated Trajectories, Planning of Manipulator Cartesian Path Trajectories	**4**	**12**
5.	**Control of Robot Manipulators:** Characteristics of Actuating Systems, Comparison of Actuating Systems, Hydraulic Actuators, Pneumatic Devices, Electric Motors: AC Motors; DC Motors; Servomotors; Stepper Motors, Microprocessor Control of Electric	**8**	**20**

	Motors, Magnetostrictive Actuators, Speed Reduction, Other Systems		
6.	**Sensors:** Sensor Characteristics, Sensor Utilization, Position Sensors: Potentiometers; Encoders; LVDT; Resolves; LMDT; Hall-effect Sensors, Velocity Sensors: Encoders; Tachometers; Differentiation of Position Signals, Acceleration Sensors, Force and Pressure Sensors: Piezoelectric; Force Sensing Resistor; Strain Gauge, Torque Sensors, Microswitches, Visible Light and Infrared Sensors, Touch Sensors, Proximity Sensors, Range Finder, Sniff Sensors, Vision System, Voice Recognition Devices, Voice Synthesizers.	**8**	**20**
7.	**Robot Programming Languages:** Characteristics of Robot Level Languages, A brief about AL and AML robot programming languages, Position Specification, Motion Specification, Sensing and Flow of Control, Programming Support, Characteristics of Task Level Languages, World Modeling, Task Specification, Robot Program Synthesis, Concluding Remarks	**5**	**15**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	**28**	**28**	**-**	**-**	**-**

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. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill Education (India Ed.)
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Application 2/E", Wiley India Edition
3. S.K. Saha, "Introduction to Robotics 2/E", McGraw Hill Education (India Ed.)
4. R.K. Mittle, I.J. Nagrath, " Robotics and Control", McGraw Hill Education (India Ed.)
5. Thomas R. Kurfess, " Robotics and Automation Handbook", CRC Press
6. Ashitava Ghosal, "Robotics: Fundamental Concepts and Analysis 1/E", Oxford University Press

Course Outcome: After learning the course the students will be able to:

1. Students will be able to learn fundamental mathematical concepts and analytical tools required to develops the relevant theory and algorithms.
2. Students will be able to understand fair amount of mechanics and kinematics of robots.
3. Students will learn microprocessor applications, control systems, vision systems, sensors and actuators.
4. Students will learn fundamentals of intelligent/smart control systems and programming of robotics.

List of Experiments:

1. Configure the working of robots
2. Demonstrate the different types of sensor in robotics
3. Interface sensors using Microprocessor or Microcontroller
4. Measure various parameters of Electro-Mechanical Instruments Pressure, Flow, Speed and Moisture
5. Interface Actuators using Microprocessor or Microcontroller
6. Interface Drives using Microprocessor or Microcontroller
7. Interface Stepper Motor using Microprocessor or Microcontroller
8. Use robot trainer to perform different tasks
9. Develop a Program for Line Follower Configuration.
10. Develop a Program for coffee maker configuration

Design based Problems (DP)/Open Ended Problem:

Following is the list of proposed student activities:

1. Prepare journals based on practical performed in laboratory.
2. Do assignments on modeling robotics.
3. List various Robot controlling parameters and find how they affect the performance of Robots
4. List two different types of Robots and their application.
5. Download free simulation software and check program on it.
6. Visit Industries having robots and prepare specification list, understand operational and maintenance practices.
7. Download videos of robotic applications

Major Equipments:

1. Experimental study with Software Tool: MATLAB.
2. Programmable Robot trainer [Minimum 3 linkages, Minimum 4 degree of freedom, mechanical end effect or with servo control Interfacing card (RC servo output, sensors input)].

List of Open Source Software/learning website:

1. Learning Resource by NPTEL, http://www.nptel.ac.in/courses/112101099/, Contributors: Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. Kurien Issac, Prof. B. Seth, and Prof. C. Amarnath, Dept. of Mechanical Engg., IIT, Bombay
2. Learning Resource by NPTEL, http://www.nptel.ac.in/courses/112108093/, Contributors: Prof. Ashitava Ghosal, Dept. of Mechanical Engg., IISc, Bangalore
3. https://www.youtube.com/watch?v=fH4VwTgfyrQ, "ABB Robotics - 10 most popular applications for robots", ABB Robotics, You Tube - Channel.
4. http://www.robotics.org/, Online Resource for Industrial Robotics.

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.