Exam.Code:0941
Sub. Code: 6723

2074
B. E. (Mechanical Engineering)
Fifth Semester
MEC-503: Robotics

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: ***Attempt <u>five</u> questions in all, including Question No. I which is compulsory and selecting two questions from each Part.***

x-x-x

1 a) What is PUMA? How many DOF of PUMA 560 robot?
b) What do you mean by dextrous workspace?
c) Define Cartesian space trajectory.
d) What is the working principal of Proximity sensor?
e) How robots are specified? 5x2

Part A

2 a) Calculate the matrix representing Rot $(x, 40^o)^{-1}$. 5

b) The co-ordinate of a point $P_{abc} = (5, 4, 3)^T$ in the body co-ordinate frame OABC is rotated 30° about OZ-axis. Determine the co-ordinate of the vector P_{xyz} with respect to base reference co-ordinate frame. 5

3 a) Find the jacobian of the linear velocities of the RRR manipulator as shown in the fig. 1 5

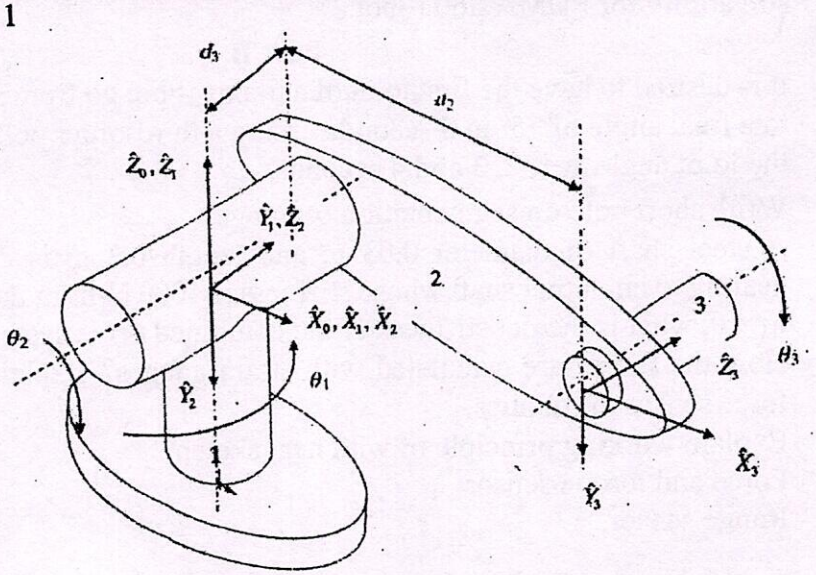

Fig. 1

b) The hand frame of a 5-DOF robot, its numerical Jacobian for this instance and a set of differential motions are given. The robot has a 2RP2R configuration. Find the new location of the hand after the differential motion. 5

$$T_6 = \begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 0 & -1 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}; J = \begin{bmatrix} 3 & 0 & 0 & 0 & 0 \\ -2 & 0 & 1 & 0 & 0 \\ 0 & 4 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} d\theta 1 \\ d\theta 2 \\ ds1 \\ d\theta 4 \\ d\theta 5 \end{bmatrix} = \begin{bmatrix} 0.1 \\ -0.1 \\ 0.05 \\ 0.1 \\ 0 \end{bmatrix}$$

P.T.O.

4 a) A six joint robotic manipulator equipped with a digital TV camera is capable of continuously monitoring the position and orientation of an object. The position and orientation of an object w.r.t. camera is expressed by a matrix $[T_1]$, the origin of robot's base co-ordinate w.r.t camera is given by $[T_2]$, the position and orientation of the gripper w.r.t. the base co-ordinate frame is given by $[T_3]$. 5

$$[T1] = \begin{bmatrix} 0 & 1 & 0 & 5 \\ 1 & 0 & 0 & 6 \\ 0 & 0 & -1 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}, [T2] = \begin{bmatrix} 1 & 0 & 0 & -20 \\ 0 & -1 & 0 & 10 \\ 0 & 0 & -1 & 12 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

$$[T3] = \begin{bmatrix} 1 & 0 & 0 & 8 \\ 0 & 1 & 0 & 6 \\ 0 & 0 & 1 & 6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Determine the position and orientation of the object w.r.t. the base co-ordinate.

b) How solvability plays important role in PUMA 560 robot? Write equation of solvability for PUMA 560 robot. 5

Part B

5 a) It is desired to have the first joint of a 6-axis robot go from initial angle of 30° to a final angle of 75° in 5 seconds. Using a third-order polynomial, calculate the joint angle at 1, 2, 3 and 4 seconds. 5

b) Write short note on segmentation of image. 5

6 a) A steel shaft of diameter 0.03 m and length 0.3 m is connected through gearing to an output shaft whose stiffness is 4000 N-m/radian. If the gear ratio $\eta = 10$, what is the net stiffness of the combined drive system? 5

b) How the forces are calculated with strain gauges? Explain the positions of force sensor in robotics. 5

7 Explain working principle of with neat sketch

a) Force and torque sensor 5

b) Range sensor 5

x-x-x