Exam.Code:0941
Sub. Code: 7054

1078

B.E. (Mechanical Engineering) Fifth Semester

MEC-503: Robotics

Time allowed: 3 Hours Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 (Part-A) which is compulsory and selecting two questions each from Part B-C. Supplement your answer with neat and labelled sketches wherever required.

x-x-x

PART-A

I (a) Is it true that any mechanism with three revolute joints and nonzero link lengths must have a locus of singular points interior to its workspace? (2)

(b) Fill in the blank: (2)
General mechanisms sometimes have certain configurations, called "_____," where the columns of the Jacobian become orthogonal and of equal magnitude.

(c) In a sentence or two, define workspace, and trajectory. (2)

(d) Make a chronology of major events in the development of industrial robots over the past 40 years. (2)

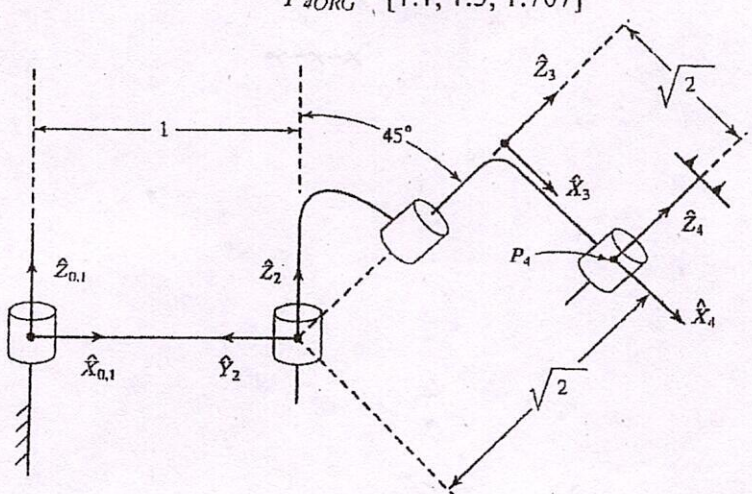
(e) How many individual cubics are computed when a six-jointed robot moves along a cubic spline path through two via points and stops at a goal point? How many coefficients are stored to describe these cubics? (2)

PART-B

II Explain the application of inverse of transformation matrices in robotics. (10)

III A 4R manipulator is shown next schematically. The nonzero link parameters are $a_1 = 1$, $\alpha_2 = 45°$, $d_3 = \sqrt{2}$, and $a_3 = \sqrt{2}$, and the mechanism is pictured in the configuration corresponding to $\Theta = [0, 90°, -90°, 0]^T$. Each joint has ±180° as limits. Find all values of θ_3 such that

$$^0P_{4ORG} = [1.1, 1.5, 1.707]^T$$



(10)

P.T.O

IV A certain two-link manipulator has the following Jacobian:

$$^{0}J(\Theta) = \begin{bmatrix} -l_1 s_1 - l_2 s_{12} & -l_2 s_{12} \\ l_1 c_1 + l_2 c_{12} & l_2 c_{12} \end{bmatrix}$$

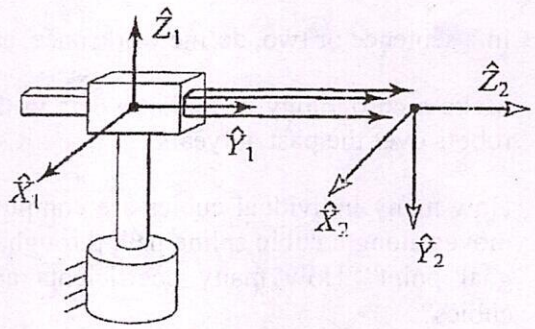
Ignoring gravity, what are the joint torques required in order that the manipulator will apply a static force vector $^{0}F = 10\hat{X}_0$? (10)

PART-C

V Derive the dynamic equations for the two-link manipulator shown in next figure. Link 1 has an inertia tensor given by:

$$C_1 I = \begin{bmatrix} I_{xx1} & 0 & 0 \\ 0 & I_{yy1} & 0 \\ 0 & 0 & I_{zz1} \end{bmatrix}$$

Assume that link 2 has all its mass, m_2, located at a point at the end-effector. Assume that gravity is directed downward (opposite $\hat{Z}_1$).



(10)

VI A single-link robot with a rotary joint is motionless at $\theta = -5°$. It is desired to move the joint in a smooth manner to $\theta = 80°$ in 4 seconds and stop smoothly. Compute the corresponding parameters of a linear trajectory with parabolic blends. Plot the position, velocity, and acceleration of the joint as a function of time. (10)

VII Write a robot program (in a language of your choice) to pick a block up from location A and place it down in location B if it is a good quality product; else in location C if it is a poor quality product. (10)

x-x-x