Code: **17MEMD2T4**

PVP 17

I M.Tech - II Semester – Regular/Supplementary Examinations
July 2019

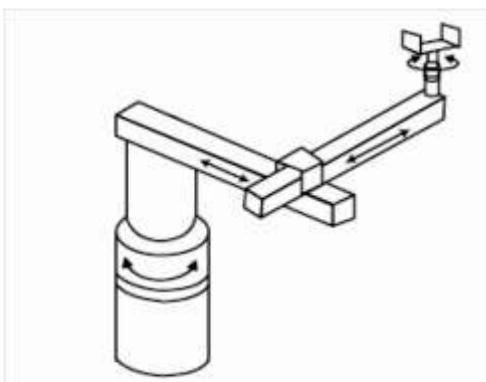
ADVANCED ROBOTICS
(MACHINE DESIGN)

Duration: 3 hours Max. Marks: 60

Answer the following questions.

1. a) Incise the applications, limitations of a robot in industrial scenario. 5 M

   b) Draw the approximate workspace for the following robot. Assume the dimensions of the base and other parts of the structure of the robot are as shown. 5 M



   c) A point p $(2,3,4)^T$ is attached to a rotating frame. The frame rotates 90^0 about the x-axis of the reference frame. Find the coordinates of the point relative to the reference frame after the rotation, and verify the result graphically. 5 M

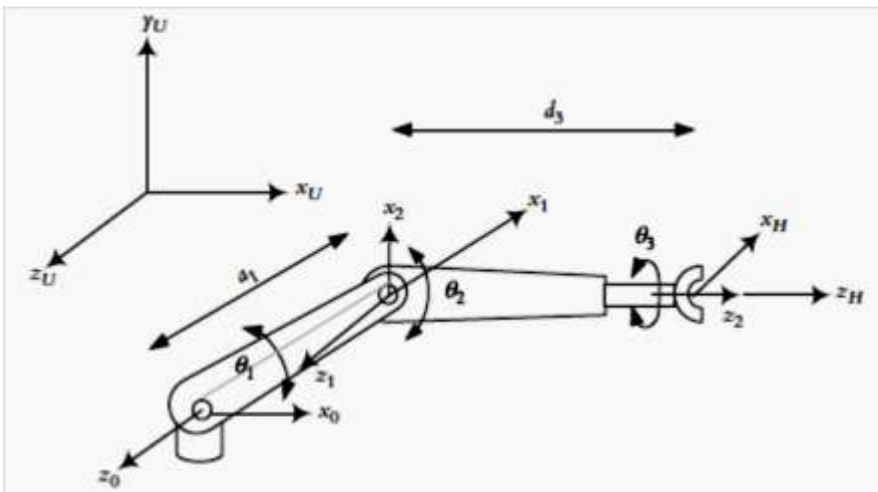
(OR)

2. a) Carve a short note on the different components of industrial robotics with a neat sketch. 5 M

   b) Illustrate two basic robot configurations as per the coordinate system. 5 M

c) A point $p(7,3,1)^T$ is attached to a frame F_{noa} and is subjected to the following transformations. Find the coordinates of the point relative to the reference frame at the conclusion of transformations. (i) Rotation of 90^0 about the z-axis, (ii) Followed by a rotation of 90^0 about the y-axis, (iii) Followed by a translation of [4,-3,7]. 5 M

3. a) Assign the necessary frames to the robot of Figure below and derive the forward kinematic equation of the robot. 7 M

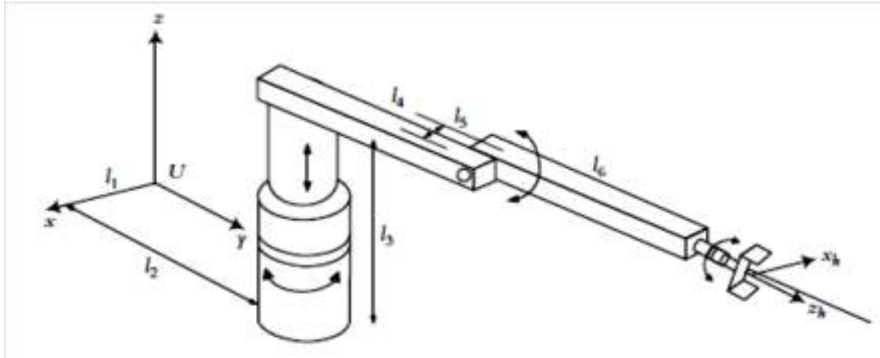


b) The hand frame of a 5-DOF robot, its numerical Jacobian for this instance, and a set of differential motions are given. The robot has a 2RP2R configuration. Find the new location of the hand after the differential motion. 8 M

$$T_6 = \begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 0 & -1 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad J = \begin{bmatrix} 3 & 0 & 0 & 0 & 0 \\ -2 & 0 & 1 & 0 & 0 \\ 0 & 4 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} d\theta_1 \\ d\theta_2 \\ ds_1 \\ d\theta_4 \\ d\theta_5 \end{bmatrix} = \begin{bmatrix} 0.1 \\ -0.1 \\ 0.05 \\ 0.1 \\ 0 \end{bmatrix}$$

(OR)

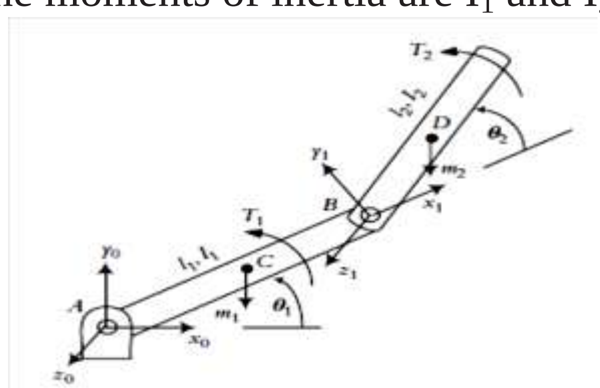
4. a) For the given 4-DOF robot: (i) Assign appropriate frames for the Denavit-Hartenberg representation. (ii) Fill out the D-H parameters table. (iii) Write an equation in terms of A matrices that shows how ${}^{U}T_{H}$ can be calculated. 7 M



b) A camera is attached to the hand frame T of a robot as given. The corresponding inverse Jacobian of the robot at this location is also given. The robot makes a differential motion, as a result of which, the change in the frame dT is recorded as given. (i) Find the new location of the camera after the differential motion. (ii) Find the differential operator. (iii) Find the joint differential motion values associated with this move. (iv) Find how much the differential motions of the hand frame (T_D) should have been instead, if measured relative to frame T, to move the robot to the same new location as in part (i). 8 M

$$T = \begin{bmatrix} 0 & 1 & 0 & 3 \\ 1 & 0 & 0 & 2 \\ 0 & 0 & -1 & 8 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad J^{-1} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & -1 & 0 & 0 & 0 \\ 0 & -0.2 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad dT = \begin{bmatrix} -0.03 & 0 & -0.1 & 0.79 \\ 0 & 0.03 & 0 & 0.09 \\ 0 & -0.1 & 0 & -0.4 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

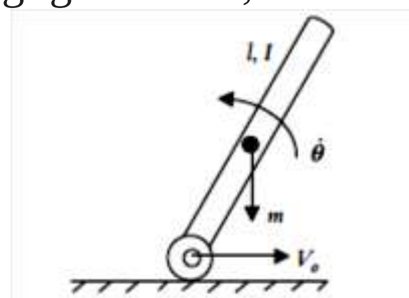
5. a) Using the Lagrangian method, derive the equations of motion for the 2-DOF robot arm, as shown in Figure below. The center of mass for each link is at the center of the link. The moments of inertia are I_1 and I_2. 7 M



b) A fifth-order polynomial is to be used to control the motions of the joints of a robot in joint-space. Find the coefficients of a fifth-order polynomial that will allow a joint to go from an initial angle of 0^0 to a final joint angle of 75^0 in 3 seconds, while the initial and final velocities are zero and initial acceleration and final decelerations are $10^0 / sec^2$. 8 M

(OR)

6. a) Calculate the total kinetic energy of the link AB, attached to a roller with negligible mass, as shown. 7 M



b) Enumerate the third order Polynomial Trajectory Planning. 8 M

7. a) Enlighten about Proportional Plus Integral Controllers. 7 M

b) Brief out the characteristics of actuating system in robots. 8 M

(OR)

8. a) For the following system, find the roots, the gain, and steady-state error for the fastest response and a settling time of less than 2 seconds and an overshoot of less than 4%.

$$GH = \frac{K}{(s+1)(s+3)}$$ 7 M

b) Elucidate the details of pressure and proximity sensors with respect to robotics. 8 M