

Subject Code: ME60412 Subject: Mechanism and Robot Kinematics Date: 27/2/2018 (AN)
 Specialization: ME3, DD (ME3) + others Number of students: 34 Time: 2 hrs Full Marks 60

Instructions: Answer all questions. If any additional information is required the data may be assumed with adequate reasoning. Marks for each question are stated in brackets.

Q 1. Answer the following (5 x 4)

- i. Rotation matrix is orthogonal and Homogenous Transformation matrix is not. (True/False). Why is the Homogenous matrix useful?
- ii. Write down the rotation matrix for rotation about Z axis by angle ϕ followed by rotation about Y axis by angle α and another rotation about X axis by angle $-\theta$ in Fixed axes angle format and in Euler angle format.
- iii. How would you describe the Standard Denavit Hartenberg representation in terms of two screw operations?
- iv. Write the Euler parameters for rotation about an axis \vec{k} represented as $[k_x, k_y, k_z]$ by an angle ϕ . Why is it useful?
- v. Given $k = [a_x, a_y, a_z]^T$, what is \hat{k} ?

Q 2. A frame {B} is located initially coincident with a frame {A}. Rotate {B} about Z_B by 60 degrees, and then rotate the resulting frame about X_B by 30 degrees. Give the rotation matrix that will change the description of vectors from ${}^B p$ to ${}^A p$. How will you derive the velocity in frame {A} given that the angular velocity in {B} is given by the vector Ω ? (6+6)

Q 3. For the 3 link planar manipulator shown in Figure 1 below derive Jacobian for the reference point velocities $[\dot{x}, \dot{y}, \omega_x, \omega_y]$ vector in terms of input angles $[\dot{\theta}_1, \dot{\theta}_2, \dot{\theta}_3]$. (8)

Q 4. Given an axis \vec{k} as $[0 \ 1 \ 0]^T$ about which a body will rotate by an angle ϕ , obtain the rotation matrix $R(\vec{k}, \phi)$ using the Euler Rodrigues Formula? What will be the representation in the matrix exponential form? (6+4)

Q 5. For the manipulator shown in Figure 2: (5+3+2)

- a) Write down the table of DH Parameters.
- b) How do you represent the final transformation matrix at the last link?

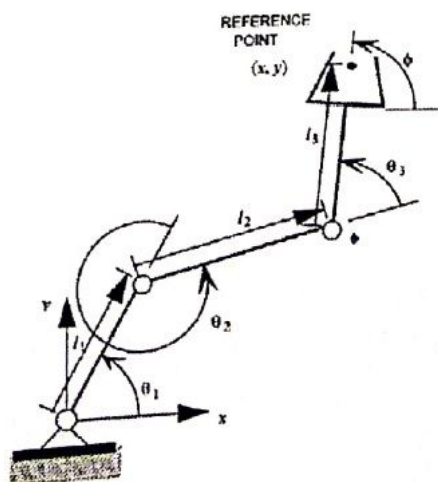


Figure 1

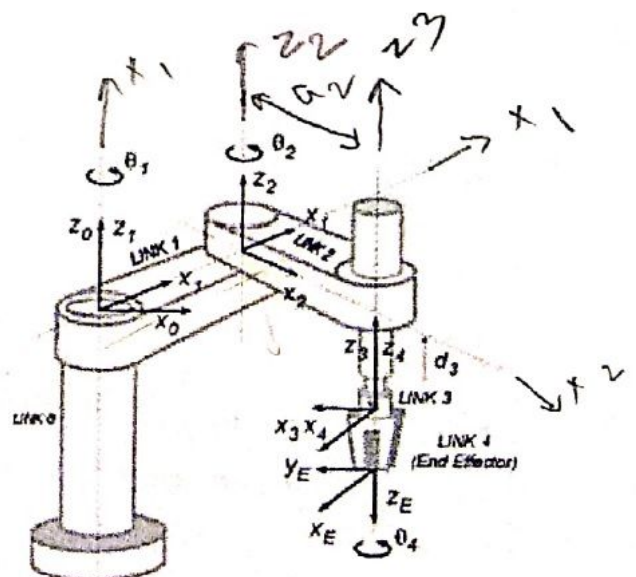


Figure 2