

Birla Institute of Technology & Science, Pilani
First Semester 2023-24 (Mid-semester Examination - Regular)

ME G511 (Mechanism and Robotics)

Total Marks: 30

Date: 13/10/2023

OPEN BOOK

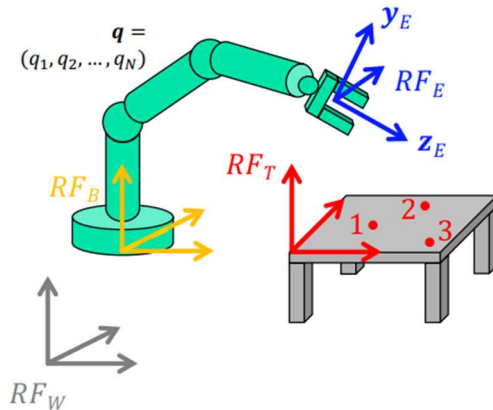
Total Duration 1.5hrs

Q1.

- (a) For a Four bar mechanism with the ground link d and a, b, c , being the link lengths including angles θ_2, θ_3 , and θ_4 . Determine the relation between input and output (θ_2 and θ_4 ,) if the second joint of the mechanism is powered (θ_3 , is a variable). [6]
- (b) Determine the rotation matrix $R_{RPY}(\phi, \theta, \psi)$ and discuss the steps to determine the value of ϕ, θ, ψ when the $R_{RPY}(\phi, \theta, \psi)$ is known. [4]

Q2.

- (a) Refer to the figure shown and provide the various homogenous transformation matrices required to obtain the absolute definition of task $\{RF_T\}$ with respect to world frame $\{RF_W\}$. [3]
- (b) What are the steps required to obtain ${}^{i-1}T_i$ matrix if the D-H link and joint parameters of a robot are $a_i, \alpha_i, \theta_i, d_i$.? Then determine the $({}^{i-1}T_i)^{-1}$. [3]
- (c) Consider the matrix



$$R(k, \theta) = \begin{bmatrix} 0 & -\frac{\sqrt{3}}{2} & 1/2 \\ 1/2 & -\frac{\sqrt{3}}{4} & -3/4 \\ \frac{\sqrt{3}}{2} & 1/4 & \frac{\sqrt{3}}{4} \end{bmatrix}$$

Determine the equivalent axis k and the angle θ . Discuss the

importance of Unit quaternion over this representation

[3]

Q3. For the 3 DOF TRP manipulator derive the Kinematic Model using DH convention. Also determine the joint parameters for the known task space information.

- (a) Assign frames to the arm
 (b) Determine link and joint parameters
 (c) Obtain KM and Inverse KM.
 (d) If another robot is placed at $(L, 0, 0)$ and used to hold the object with the current one with same orientation then what will be its transformation matrix. [2+2+6+2]

