Birla Institute of Technology & Science, Pilani
First Semester 2022-23 (Comprehensive Examination - Regular)
ME G511 (Mechanism and Robotics) **Weightage - 40% (40M)**
Date: 27/12/2022 **Duration - 3 hrs**

(Every symbol and abbreviation has its usual meaning as per the text book)

One Hour PART A 15 Marks

Q1. What do you mean by normalized time trajectory planning with cubic polynomial. Determine the unknown coefficients in the polynomial. [1]

Q2. Explain the impact of Gearbox on controllability of the One DOF link actuator system. [1]

Q3. How arm is different from Manipulator? Discuss the impact of redundancy on handling objects. [1]

Q4. Discuss differences between equivalent axis –angle representation and Euler parameter method to represent the orientation of an object. [1]

Q5. Discuss the importance of inverse dynamics and forward dynamic approaches for multibody systems. How is it different from the torque relation obtained from static equilibrium scenario. [1]

Q6. Discuss the use of transmission angle and toggle configuration of the four-bar mechanism. [1]

Q7. What do you understand by wrist singularity, and work space boundary & interior singularity? [1]

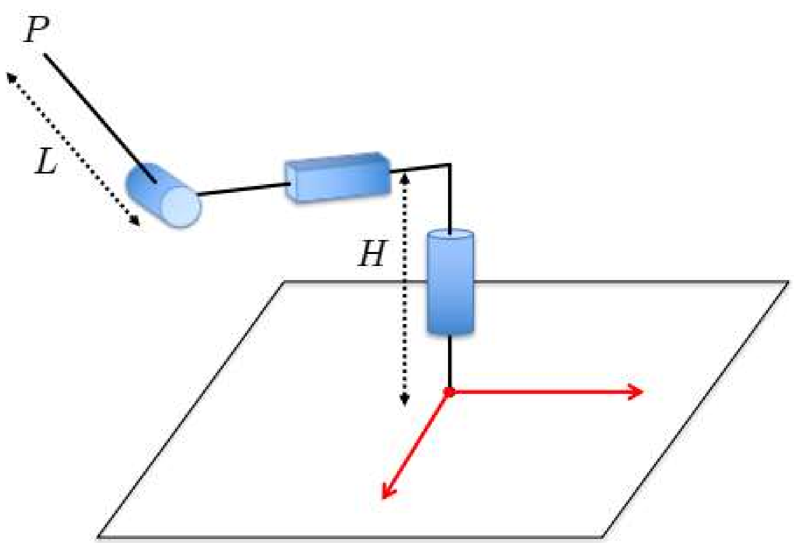
Q8. Discuss the use and advantages of closed loop mechanism over open loop. [1]

Q9. Discuss the steps required to obtain the matrix ${}^{i-1}T_i$ [1]

Q10. What is a knot point? [1]

Q10. Determine the inverse of ${}^{i-1}T_i$ matrix [2]

Q11. Assign Frames to the following Arm using DH convention. Identify the type of joints and DOF. [2]



Q12. Derive the expression for $\tau = J^T F$ [2]

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Two Hour PART B 25 Marks

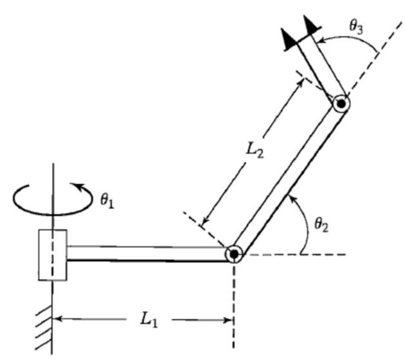
Q1. Consider the rotation matrix

$$R = \frac{1}{3}\begin{pmatrix} -2 & 2 & -1 \\ 2 & 1 & -2 \\ -1 & -2 & -2 \end{pmatrix}$$

Find the axis-angle (k,θ) that provide the desired orientation. [2]

Q2. Write a MATLAB program to calculate the inverse homogenous transformation ${}^{A}T_{B}^{-1} = {}^{B}T_{A}$ using symbolic formula. [2]

Q3. (a) For the arm shown in the Figure (3-DOF arm) determine the kinematic model [2+3]
(b) Determine the inverse kinematic model of the given arm [3]
(c) A payload (W) is acting at the end-effector then determine the torque acting at the joints to be in static equilibrium. [3]
(d) Assume link mass is at the CG, determine M11, M12 and M13 coefficients for the M matrix. [4]
(e) Determine gravity coefficients G1 and G2. [2]



Q4. (a) In a system the inertial load, J_L, varies between 4 and 5 Kg-m^2. The rotor inertia is Jm = 0.01Kg-m^2, and the gear ratio is $\eta = 10$. The system possesses unmodeled resonances at 8.0, 12.0, and 20.0 rad/sec. Design a controller and determine the values of Kp and Kv such that the system is never underdamped and never excites resonances, but is as stiff as possible. [3]
(b) A single-link robot with a rotary joint is motionless at $\theta = -5^0$. It is desired to move the joint in a smooth manner to $\theta = 80^0$ in 4 seconds and stop smoothly. Compute the corresponding parameters of a linear trajectory with parabolic blends. [2]

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