ME604: Introduction to Robotics

Spring 2025

Quiz 3

- **Duration: 50 minutes**
- **Write legibly and show all your work.**
- **You may refer to up to 1 A4 sized sheet of handwritten material during the exam.**

i. Write velocities of center of masses vci. See Q2 sol outline.
ii. Ang. vel of links are same (q1dot about z0). Hence, only Izc1 and Iz2 (axis passing thru CoM). KE = 1/2(mi vci^2 + Izci omega^2)
iii. Write the expression for Kinetic and Potential energy and use the Lagrangian formulation.

1. [10 marks] Consider the two-link RP manipulator in Fig 1a. Derive the differential equations governing the dynamics of the robot. You should clearly identify the axes about which moment of inertia is being computed, the manipulator's inertia matrix, as well as the vector of gravity terms.

   Assume acceleration due to gravity to be in the -y_0 direction. You need not provide expressions for the moment of inertia.

2. [10 marks] Consider the 6 DOF manipulator shown in Fig 1b. Assume that the location of the center of the spherical wrist (C) is to be located at (c_x, c_y, c_z). Solve the relevant inverse kinematics problem to determine joint variables θ_1, θ_2 and d_3 to achieve the same. How many solutions are there?

   You may assume θ_1 to be 0 and solve only for θ_2 and d_3 for 50% credit. Assume the co-ordinates of C to be defined in the appropriate plane in such a case.

Note that joint 4 doesn't affect position of C. Rest is similar to polar manipulator discussed in class. See Differential Kinematics slides. That's also an alternate sol for 2d in Quiz 2.
q1 = atan2(cx,cy) d3 = sqrt(cx^2 + cy^2 + cz^2) q2 = atan2(sqrt(cx^2 + cy^2), cz)

I have assumed origins of frames 0 and 1 to be same here, if not cz gets replaced by cz - constant.

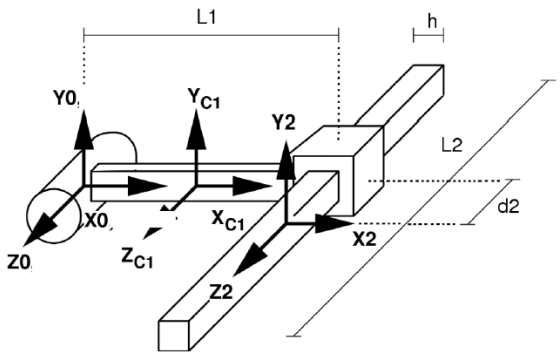

Figure 1(a)

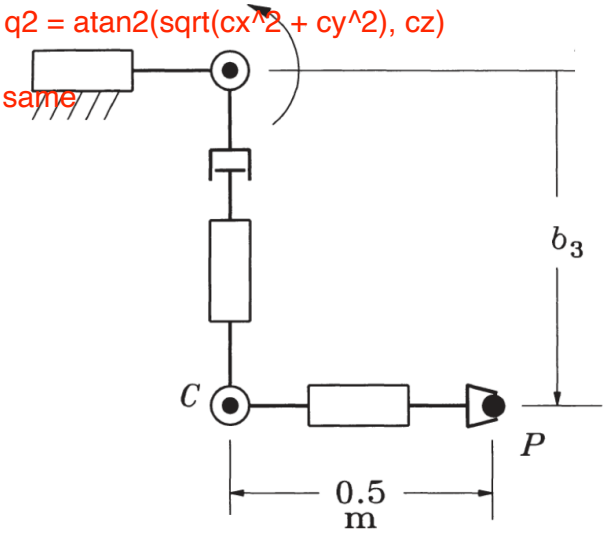

Figure1(b)