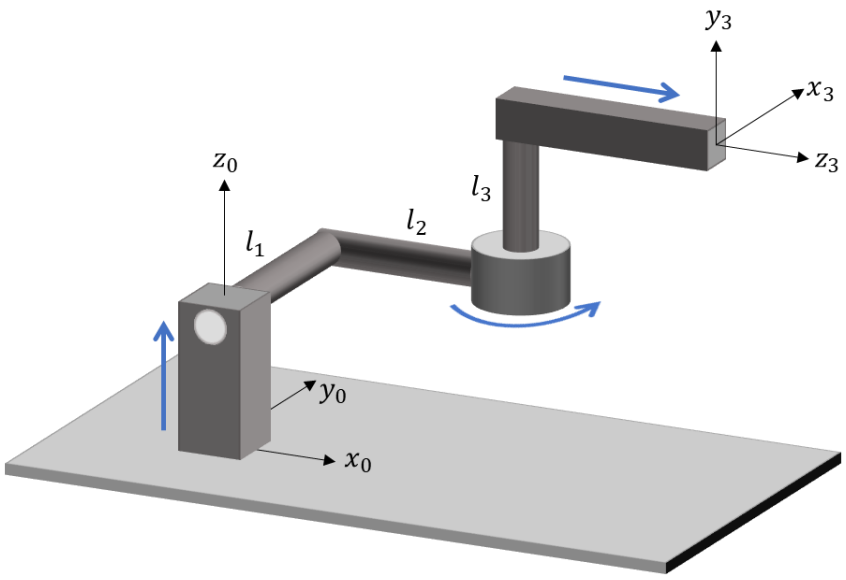
Homework Exercise 3

Submission is in pairs only.

Submission deadline: 20/5/2021, 23:59

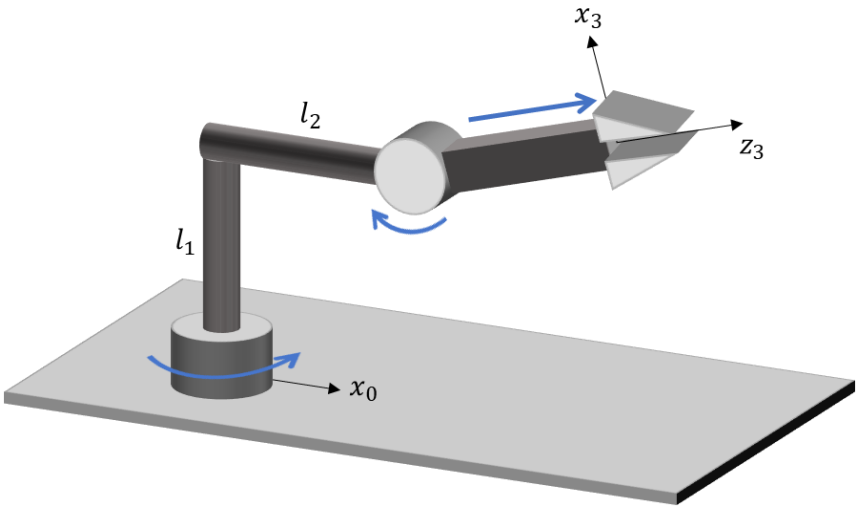
Question 1

Find the inverse kinematics function of the arm below:



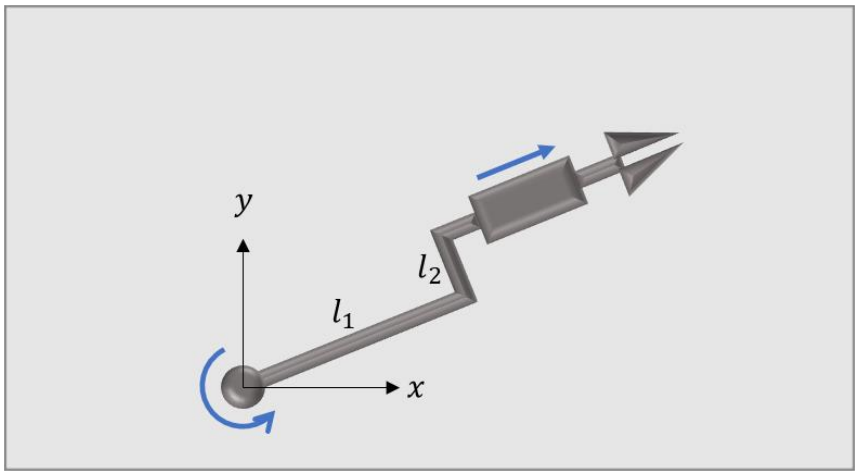
Question 2

1. Compute the geometric Jacobian of the arm below.
2. Find the configurations with reduced manipulability and the directions of reduced manipulability. Explain the geometric meaning.
3. The manipulator is now gripping a mass M and we wish to maintain static equilibrium. Is there a configuration of the robot in which no motor force is required in the prismatic joint? Is there a configuration of the robot in which no motor torque is required in any of the revolute joints?



Question 3

In this question you will plan a trajectory in the task space and then convert it to the joint space.



The end-effector of the planar revolute-prismatic arm below is required to move from a starting point (x_0, y_0) to a destination point (x_f, y_f) along a straight line in the task space and during time T. The velocity and acceleration of the end-effector at its starting point and destination need to be zero.

1. Find the end-effector's trajectory $x(t), y(t)$. Use simple polynomials for both x and y.
2. Find the end-effector's linear velocity and acceleration.
3. Convert the trajectory to the joint space.
4. Assume now $l_1 = 4, l_2 = 3$. The starting point is $(x_0, y_0) = (6,1)$ and the destination point is $(x_f, y_f) = (-6,1)$. The prismatic joint is allowed only positive values. Explain why the planned trajectory formula cannot be used in this case. Suggest a way to overcome the problem, while still using the calculated linear trajectory formula.

Question 4

In class we derived the analytical Jacobian from the geometric Jacobian for ZYZ angles. Derive it for the XYX angle representation (rotations with respect to current frame).