ECE 470/ ME 445: Introduction to Robotics- Homework 01

Question 1.

Figure 1 shows an aerial robot, a ground robot and a robot arm. ***(5 Points)***

a) How many independent variables would be required to fully describe the position and pose of the

   I. aerial robot in free 3D space?

   II. mobile ground robot, if the wheels are constrained to be always in contact with the ground?

b) If the robot arm has six joints, what is the dimension of the configuration space?

Explain your answer and state any assumption made in all the above questions.

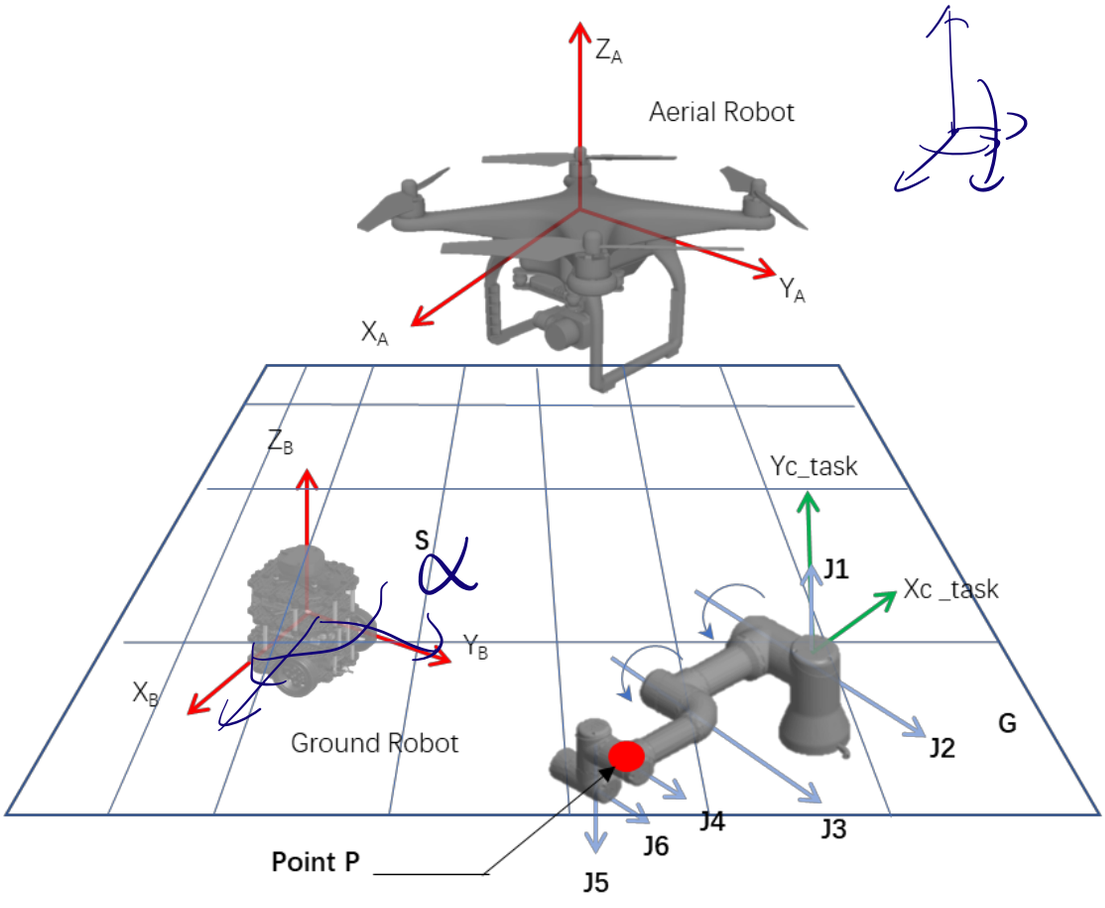


Figure 1

Q1

Part a) How many independent variables would be required to fully describe the position and pose of the:

I. **Aerial robot in free 3D space?**
An aerial robot (the four-rotor drone) in 3D space has **6** degrees of freedom:

- 3 for positioning (x, y, and z coordinates)
- 3 for orientation (roll, pitch, and yaw angles)

This is because the drone can move forward/backward, left/right, up/down, and can rotate around its longitudinal axis (roll), lateral axis (pitch), and vertical axis (yaw).

II. **Mobile ground robot, if the wheels are constrained to be always in contact with the ground?**
A ground robot, if it's a standard vehicle with non-steerable wheels, has **3** degrees of freedom:

- 2 for positioning (x and y coordinates on the ground plane)
- 1 for orientation (yaw angle)

We assume that the ground robot cannot move vertically and it cannot roll or pitch significantly.

Part b) If the robot arm has six joints, what is the dimension of the configuration space?

The dimension of the configuration space is 6.

The configuration space dimension is equal to the number of independent joints for a robot arm, as each independent joint represents one DOF. Each joint angle represents one independent variable in the configuration space.

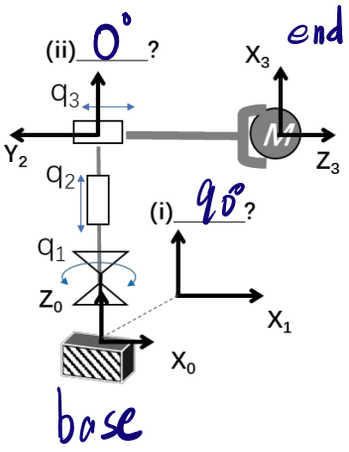
Here, we assumed that:

- each joint provides one DOF
- there are no kinematic constraints that couple the movements of the joints.

Question 2.

The schematic of a robot with a revolute joint and two prismatic joints is shown in Figure 2.

a) Fill in the missing information of the axes and D-H parameters from (i)-(viii) ***(8 Points)***



	Link Twist α_{i-1}	Link Length a_{i-1}	Joint Angle θ_i	Link offset d_i
${}^0_1T$	0	0	q_1	0
${}^1_2T$	0	0	(iii) 0° ?	(iv) q_2 ?
${}^2_3T$	(vi) q_1 ?	(vii) q_2 ?	90°	(viii) q_3 ?

Figure 2

b) Obtain the position of the center of *m*, ${}^0_3P$ in terms of q_1, q_2, and q_3. ***(3 Points)***

c) If the desired position of the center of *m*, ${}^0_3P = \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \\ 1 \end{pmatrix}$, what should be the joint coordinates of the robot manipulator? ***(4 Points)***

(b): ${}^0_3P = \begin{bmatrix} q_1 \\ q_2 \\ q_3 \end{bmatrix}$

(c): $q_1 = \frac{\sqrt{2}}{2}$ $q_2 = \frac{\sqrt{2}}{2}$, $q_3 = 1$