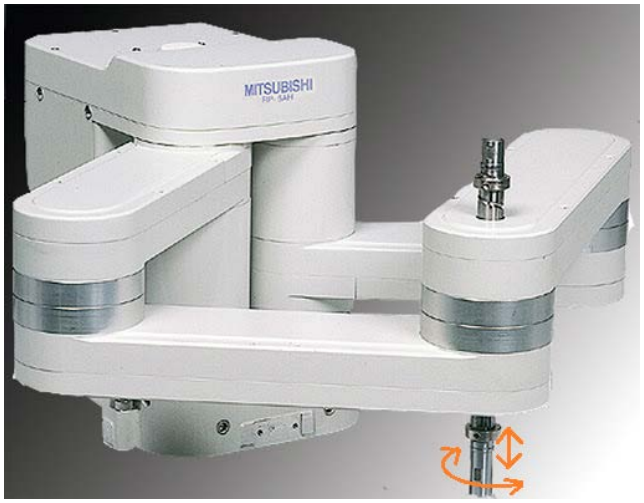
Assignment #1 – Kinematics – 10 points of your final grade.

Your first assignment follows. You may complete this assignment by hand (pen and paper) if you wish.

Scan your work and submit it via the course website by 11.4.2021, 23:59 (China Standard Time).

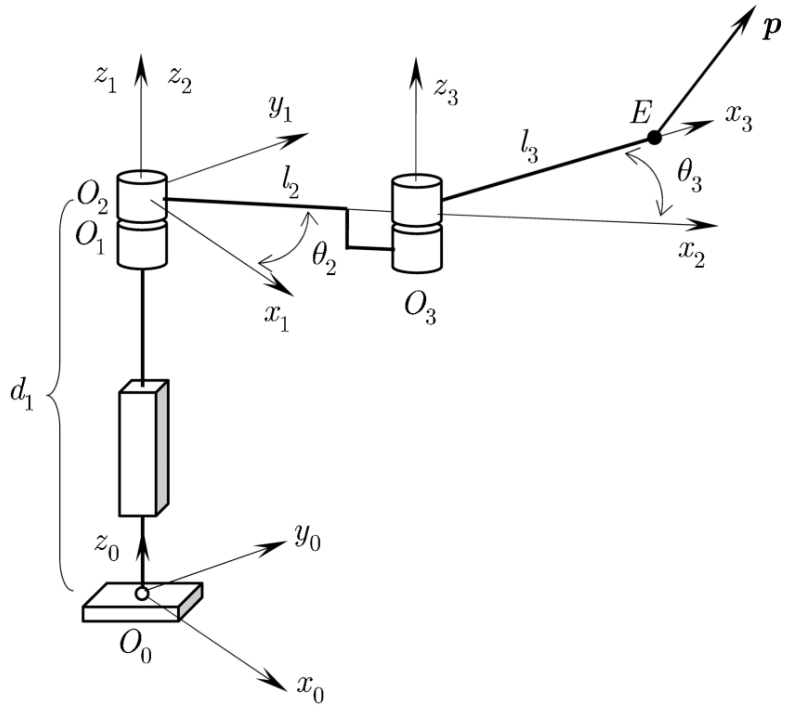
There are four problems that total 10 points of your final grade. A fifth, optional problem is also included. This problem will not be allotted any points, but it will help you with your next assignment.

1. Determine the number of Degrees of Freedom (DOF, Mobility index) of the following robot (1 point)



Note: The end effector is capable of vertical translation, and rotation (drawn).

2. Determine the position of the point P relative to the following robot's base. (3 points)



Parameters:

$d_1 = 300$ mm , $\theta_2 = 20°$, $\theta_3 = 30°$

$l_2 = 100$ mm , $l_3 = 80$ mm

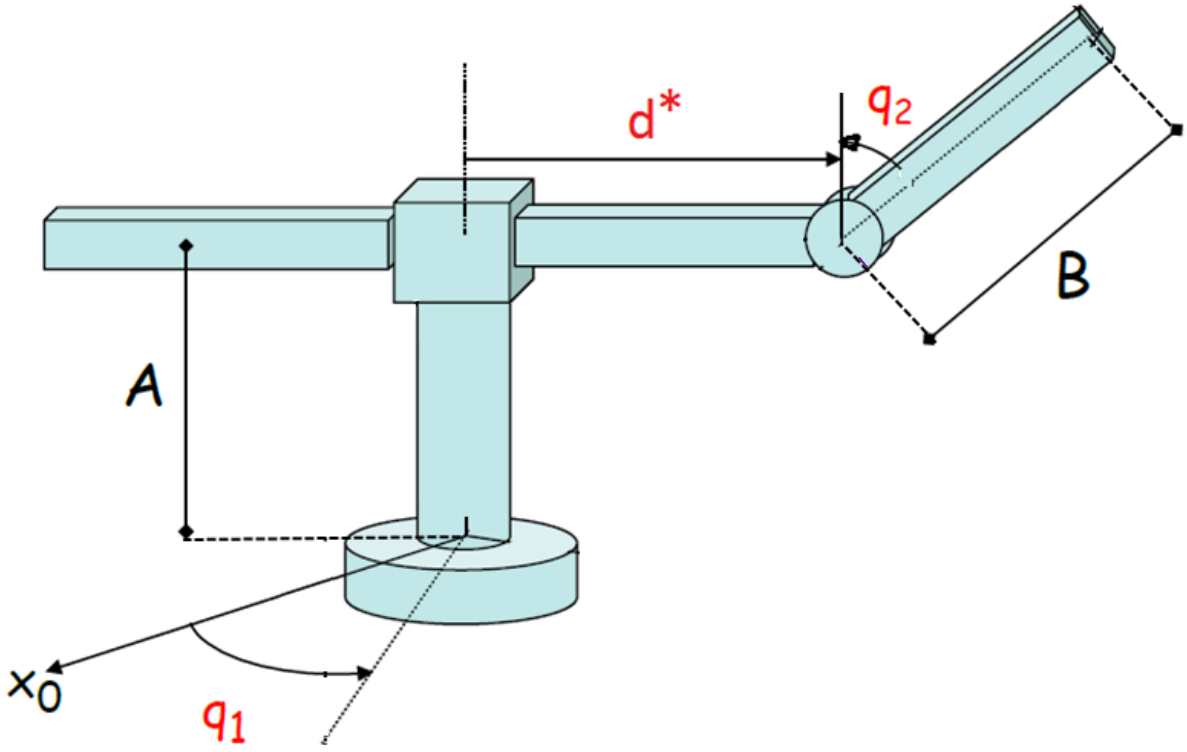
$\overline{P-E} = (-10, 40, 38)$. This is the vector going from point E to point P in the **world frame**.

3.1. Draw the reference frames for this robot according to the DH convention. The x axis of the world frame is given (drawn “into the page”). (1 point)

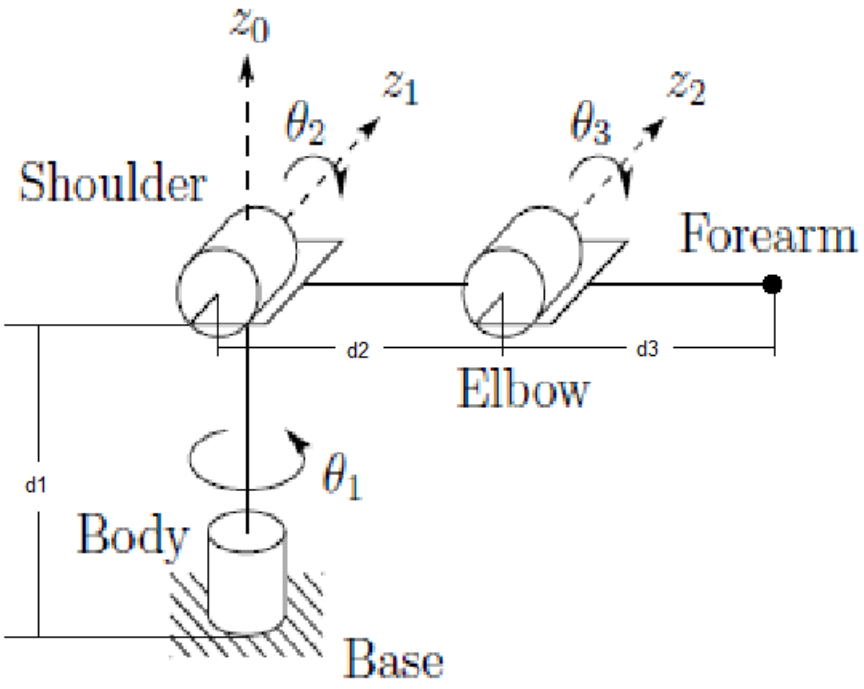
3.2. Complete the DH parameter table (1 point)

3.3. Compute the position of the end effector using the homogenous transformations derived from the previous answers, given the parameters: (1 point)

$A = 200\ mm, \quad B = 100\ mm, \quad q_1 = 20°, \quad d^* = 75\ mm, \quad q_2 = 35°$



4. Find the inverse kinematics solution for the following robot. (3 points)



I.e., solve the following:

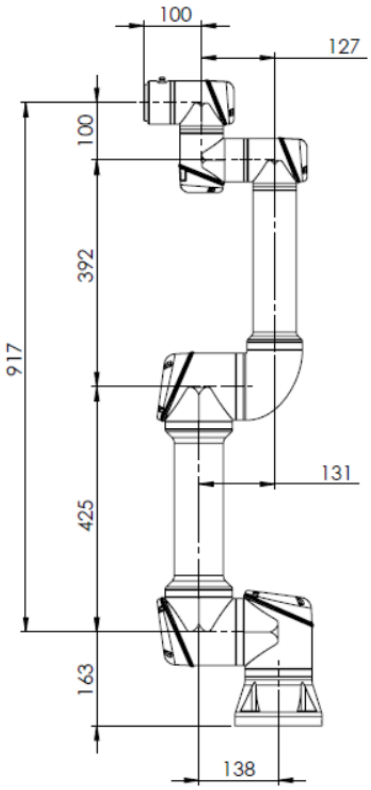
$$\theta_1\left({}^0P_x, {}^0P_y, {}^0P_z\right) = ?$$

$$\theta_2\left({}^0P_x, {}^0P_y, {}^0P_z\right) = ?$$

$$\theta_3\left({}^0P_x, {}^0P_y, {}^0P_z\right) = ?$$

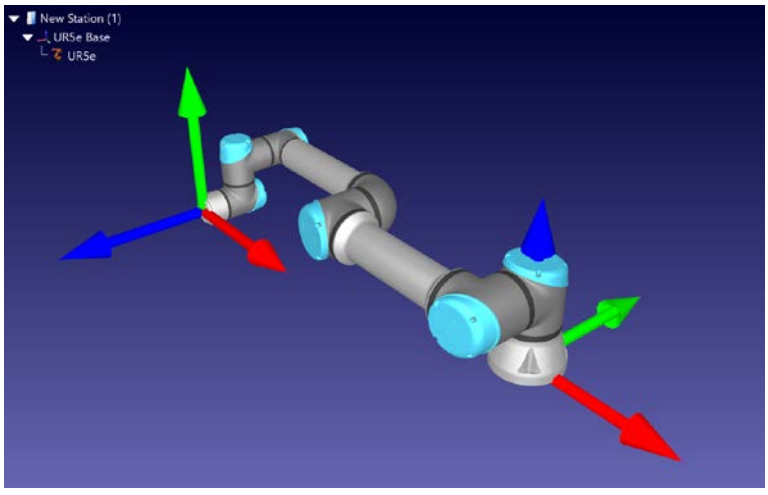
Given that the point P is the end effector (the dot at the distal point of the robot arm). The parameters d1, d2 and d3 are known.

5. OPTIONAL – Find the homogenous transformations for the joints and end-effector of the Universal Robotics UR5e robotic arm. This type of arm will be used in the second assignment, and finding the transformations will help complete the assignment. This problem is not awarded points, but will be checked if submitted. The arm dimensions are as follows.



All dimension is in mm

The arm's zero-position (the pose when all of the angles equal 0) is as such:



Good luck!