

Bonus Assignment 1

CSE461

Introduction to Robotics

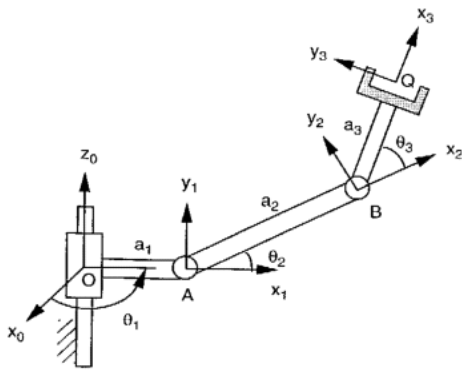
Topic: Inverse kinematics

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Sec: 4 (RAD)



Question:

The given manipulator has 3 Degrees of freedom, And all of the joints are revolute joints.

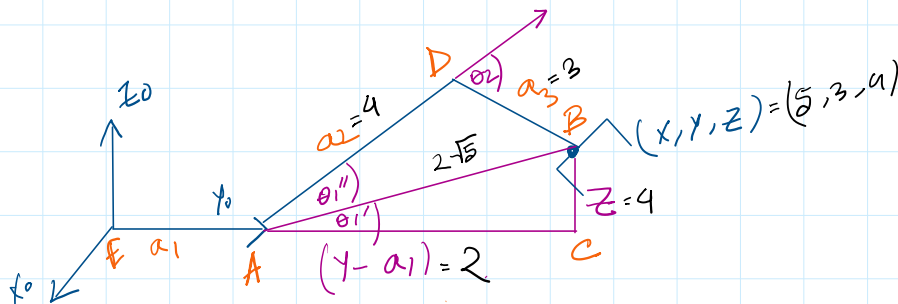
[$a_1 = 1 \text{ cm}$, $a_2 = 4 \text{ cm}$, $a_3 = 3 \text{ cm}$]

Now, you are required to grab an object by moving the end effector of the given manipulator to the location of the object. If the position of the object is $(X, Y, Z) = (5, 3, 4)$, what is the amount of rotation needed at each joint?

Here , $a_1 = 1 \text{ cm}$, $a_2 = 4 \text{ cm}$, $a_3 = 3 \text{ cm}$

$(X, Y, Z) = (5, 3, 4)$

Now, redrawing the figure:



① Using Pythagoras, $AB^2 = AC^2 + BC^2$
 $\Rightarrow AB = \sqrt{(y - a_1)^2 + z^2}$
 $= \sqrt{2^2 + 4^2}$
 $= 2\sqrt{5}$

$AC = y - a_1$
 $= 3 - 1 = 2$
 $BC = 4$

② Now i) $\tan \theta_1' = \frac{BC}{AC} = \frac{4}{2} = 2$

$\theta_1' = \tan^{-1}(2) = 63.43^\circ$

ii) $\cos \theta'' = \frac{AB^2 + AD^2 - BD^2}{2 \cdot AB \cdot AD}$

$$= \frac{(2\sqrt{5})^2 + (4)^2 - (3)^2}{2 \times 2\sqrt{5} \times 4}$$

$$= 0.754$$

$$\therefore \theta_1'' = \cos^{-1}(0.754)$$

$$= 41.003^\circ$$

$$\therefore \theta_1 = \theta_1' + \theta_1'' = 63.43^\circ + 41.003^\circ$$

$$= 104.43^\circ$$

$$\therefore \theta_1 = 104.43^\circ$$

$$\textcircled{3} \cos D = \frac{AD^2 + BD^2 - AB^2}{2 \cdot AD \cdot BD}$$

$$= \frac{4^2 + 3^2 - (2\sqrt{5})^2}{2 \cdot 4 \cdot 3}$$

$$= 0.2083$$

$$\therefore D = \cos^{-1}(0.2083)$$

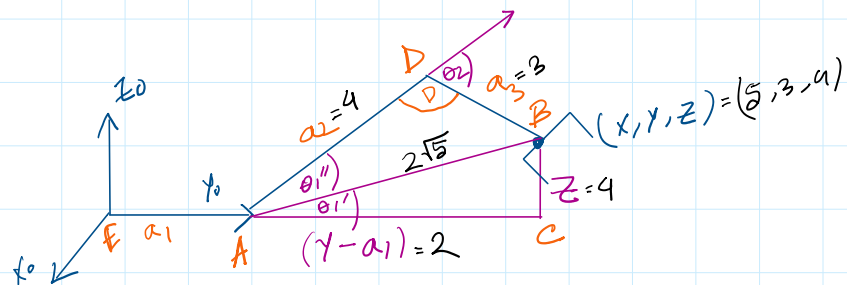
$$= 77.97^\circ$$

$$\therefore \theta_2 = 180^\circ - D$$

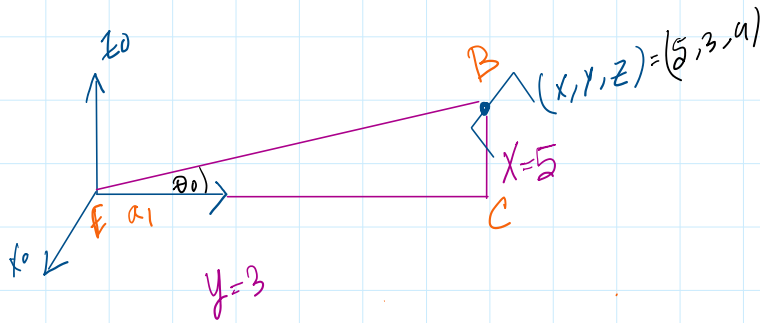
$$= 180^\circ - 77.97^\circ$$

$$= 102.02^\circ$$

$$\therefore \theta_2 = 102.02^\circ$$



④ Now, X axis lays of the inward - outward from screen space



$$\begin{aligned} 1) \text{ Here, } \tan \theta_0 &= \frac{BC}{EC} \\ &= \frac{5}{3} \end{aligned}$$

$$\begin{aligned} \therefore \theta_0 &= \tan^{-1} \left(\frac{5}{3} \right) \\ &= 59.03^\circ \end{aligned}$$

$$\therefore \theta_0 = 59.03^\circ$$

Amount of rotation needed at each joint:

$$\begin{aligned} \theta_0 &= 59.03^\circ \\ \theta_1 &= 104.43^\circ \\ \theta_2 &= 102.02^\circ \end{aligned}$$