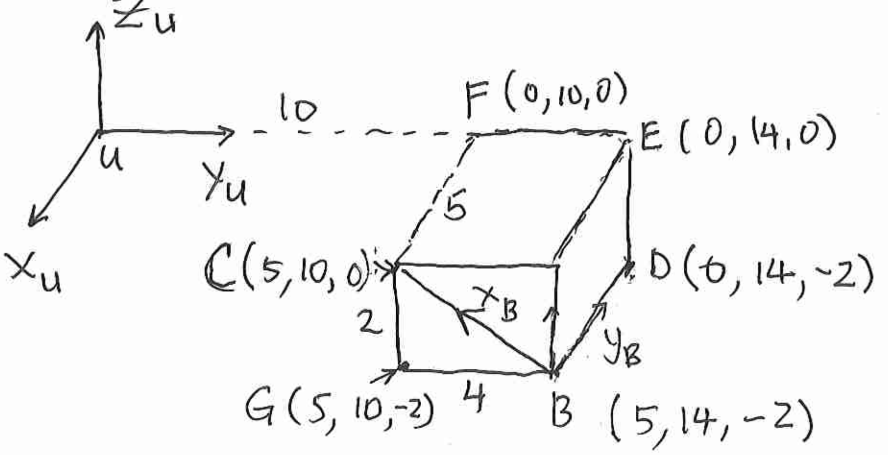
ME4245. Quiz 1.1 (Chapters 1 & 2) 1 hour 1/9/2014

1.



- All coords shown are Expressed in Frame U.
- Frame B is attached to Block,

a) Define the position & orientation of Frame B in U.

b) Determine the position of U in Frame B

c) The Block undergoes the ff motion in sequence:

1> Rot (Z_u, 60°)

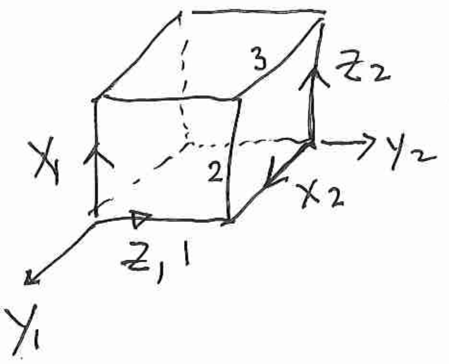
2> Translation along $\overrightarrow{BC}$ by 5

3> Rot (X_u, 90°)

i) Determine the coords of E in U after these 3 motions.

ii) Determine the orientation of $\overrightarrow{EF}$ after the 3 motions

2. Two consecutive Frames (1 + 2) are defined accdg to the DH convention, as shown:



Determine θ_2

r_2

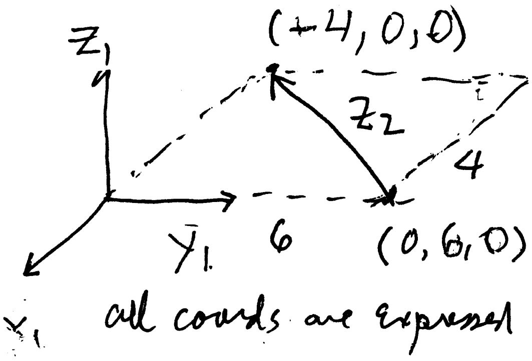
d_2

α_2

3. Frame 1 is attached to Link 1.

Link 2 has the Z axis as shown

Compute the frame assignment for Link 2, & determine $\theta_2, r_2, d_2, \alpha_2$.

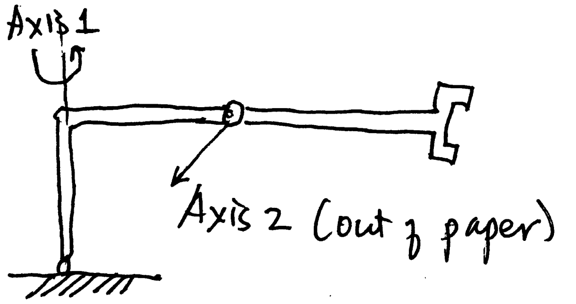


all coords are expressed in Frame 1

4. A robot with 2 rotational Joints are shown.

a) Assign Frames acc'dy to DH convention

b) Draw the 2 links separately and showing the frame attached to each link.



Joint axes:

#1: vertical, in plane of paper

#2: out of paper & normal to plane of paper.

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1. a) $^{u}P_B = \begin{pmatrix} 5 \\ 14 \\ -2 \end{pmatrix}$

b) $^{u}R_B = (^{u}x_B \; ^{u}y_B \; ^{u}z_B)$ where $^{u}x_B = \begin{pmatrix} 5-5 \\ 10-14 \\ 0--2 \end{pmatrix} \cdot \frac{1}{\sqrt{()}} = \begin{pmatrix} 0 \\ -4 \\ 2 \end{pmatrix} \frac{1}{\sqrt{16+4}}$

$^{u}y_B = \begin{pmatrix} -1 \\ 0 \\ 0 \end{pmatrix}$ $\quad ^{u}z_B = {}^{u}x_B \times {}^{u}y_B$

$^{u}T_{B_0} = \begin{pmatrix} ^{u}R_B & ^{u}P_B \\ 000 & 1 \end{pmatrix}$ B before motion, coords of u in B = $^{B_0}P_u = {}^{u}T_{B_0}^{-1} \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}$ //

c) $^{u}T_{B_1} = Rot(z, 60°)\, ^{u}T_{B_0}$, $Rot(z,60°) = \begin{pmatrix} \cos 60° & -\sin 60° & 0 & 0 \\ \sin 60° & \cos 60° & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

$^{u}T_{B_2} = {}^{u}T_{B_1}\, Trans(5,0,0)$, $Trans(5,0,0) = \begin{pmatrix} 1 & 0 & 0 & 5 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

$^{u}T_{B_3} = Rot(x, 90°)\, ^{u}T_{B_2}$, $Rot(x,90°) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 90° & -\sin 90° & 0 \\ 0 & \sin 90° & \cos 90° & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

$^{B}P_E = {}^{B_3}P_{E_3} = {}^{B_0}P_{E_0} = {}^{B_0}T_{E_0} \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}$

$^{u}P_{E_0} = \begin{pmatrix} 0 \\ 14 \\ 0 \\ 1 \end{pmatrix} \rightsquigarrow {}^{B_0}P_{E_0} = {}^{B_0}T_u \, ^{u}P_{E_0} = {}^{u}T_{B_0}^{-1} \, ^{u}P_{E_0}$

i) $^{u}P_{E_3} = {}^{u}T_{B_3} \, ^{B_3}P_{E_3}$ //

ii) $^{u}(\vec{EF})_0 = \begin{pmatrix} 0 \\ -1 \\ 9 \\ 0 \end{pmatrix} \rightsquigarrow {}^{B_0}(EF)_0 = {}^{B_0}T_u \, ^{u}(EF)_0 = {}^{u}T_{B_0}^{-1} \, ^{u}(\vec{EF})_0$

$^{u}(\vec{EF})_3 = {}^{u}T_{B_3} \, ^{B_3}(EF)_3$, $\quad ^{B_3}(EF)_3 = {}^{B_0}(EF)_0$ bec. same rigid body

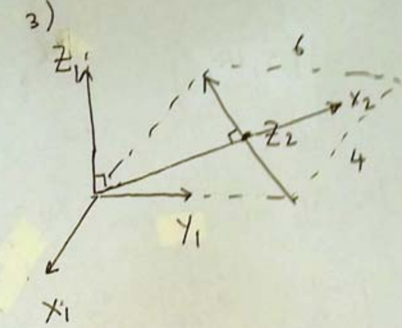
2. $\theta_1 = 90^\circ$

$r_1 = 1$

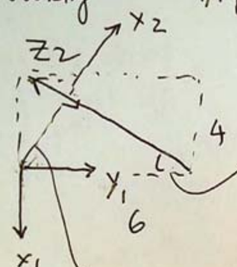
$d_1 = -3$

$\alpha_1 = 90^\circ$

3)



Looking at the X_1Y_1 plane



$\beta = \text{ATAN2}(4/6) = 33.7^\circ$

$6 \sin 33.7^\circ = 3.33$

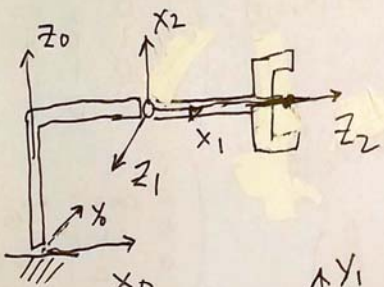
$\theta_2 = 90^\circ + (90 - 33.7^\circ) =$ 146.3°

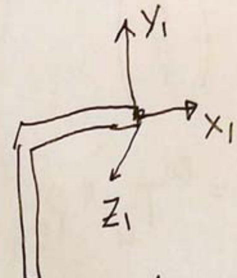
$r_2 = 0$

$d_2 = 3.33$

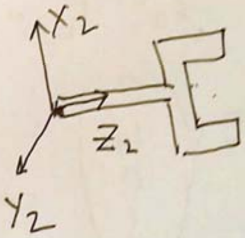
$\alpha_2 = -90^\circ$

4.

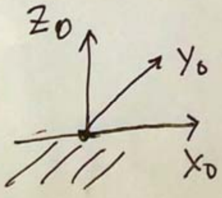




Link 1



Link 2



Link ϕ

(Base / ground)

Fixed