ME 4K03 Assignment 2

1. a) see diagram

b)

n+1	θ_{n+1}	d_{n+1}	a_{n+1}	α_{n+1}
1	90°	d_1	0	90°
2	θ_2	0	0	-90°
3	180°	d_3	0	0°

d_1, θ_2, d_3 are joint variables

c) see diagram

d) $A_1 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} = {}^0T_1$

$A_2 = \begin{bmatrix} c\theta_2 & 0 & -s\theta_2 & 0 \\ s\theta_2 & 0 & c\theta_2 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = {}^1T_2$

$A_3 = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix} = {}^2T_3$

$${}^0T_3 = A_1 A_2 A_3 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c\theta_2 & 0 & -s\theta_2 & 0 \\ s\theta_2 & 0 & c\theta_2 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -1 & 0 & 0 \\ c\theta_2 & 0 & -s\theta_2 & 0 \\ s\theta_2 & 0 & c\theta_2 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -c\theta_2 & 0 & -s\theta_2 & -s\theta_2 d_3 \\ -s\theta_2 & 0 & c\theta_2 & c\theta_2 d_3 + d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. a) see diagram

b)

$n+1$	θ_{n+1}	d_{n+1}	a_{n+1}	α_{n+1}
1	θ_1	0	a_1	$0°$
2	θ_2	0	a_2	$0°$
3	θ_3	0	a_3	$0°$

where $\theta_1, \theta_2, \theta_3$ are joint variables; a_1, a_2, a_3 are fixed parameters

c) see diagram

d) $$A_1 = \begin{bmatrix} C\theta_1 & -S\theta_1 & 0 & a_1 C\theta_1 \\ S\theta_1 & C\theta_1 & 0 & a_1 S\theta_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad A_2 = \begin{bmatrix} C\theta_2 & -S\theta_2 & 0 & a_2 C\theta_2 \\ S\theta_2 & C\theta_2 & 0 & a_2 S\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} C\theta_3 & -S\theta_3 & 0 & a_3 C\theta_3 \\ S\theta_3 & C\theta_3 & 0 & a_3 S\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_1 A_2 = \begin{bmatrix} C\theta_{12} & -S\theta_{12} & 0 & a_2 C\theta_{12} + a_1 C\theta_1 \\ S\theta_{12} & C\theta_{12} & 0 & a_2 S\theta_{12} + a_1 S\theta_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} C\theta_3 & -S\theta_3 & 0 & a_3 C\theta_3 \\ S\theta_3 & C\theta_3 & 0 & a_3 S\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_1 A_2 A_3 = \begin{bmatrix} C\theta_{123} & -S\theta_{123} & 0 & a_3 C\theta_{123} + a_2 C\theta_{12} + a_1 C\theta_1 \\ S\theta_{123} & C\theta_{123} & 0 & a_3 S\theta_{123} + a_2 S\theta_{12} + a_1 S\theta_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Hilroy

z = thumb
x = index
y = middle

ME 4K03/6K03

Assignment #2

Due: 11:59pm 18th Oct, 2021

$$^{n}T_{n+1} = A_{n+1} = Rot(z,\theta_{n+1}) * Trans(0,0,d_{n+1}) * Trans(a_{n+1},0,0) * Rot(X,\alpha_{n+1})$$

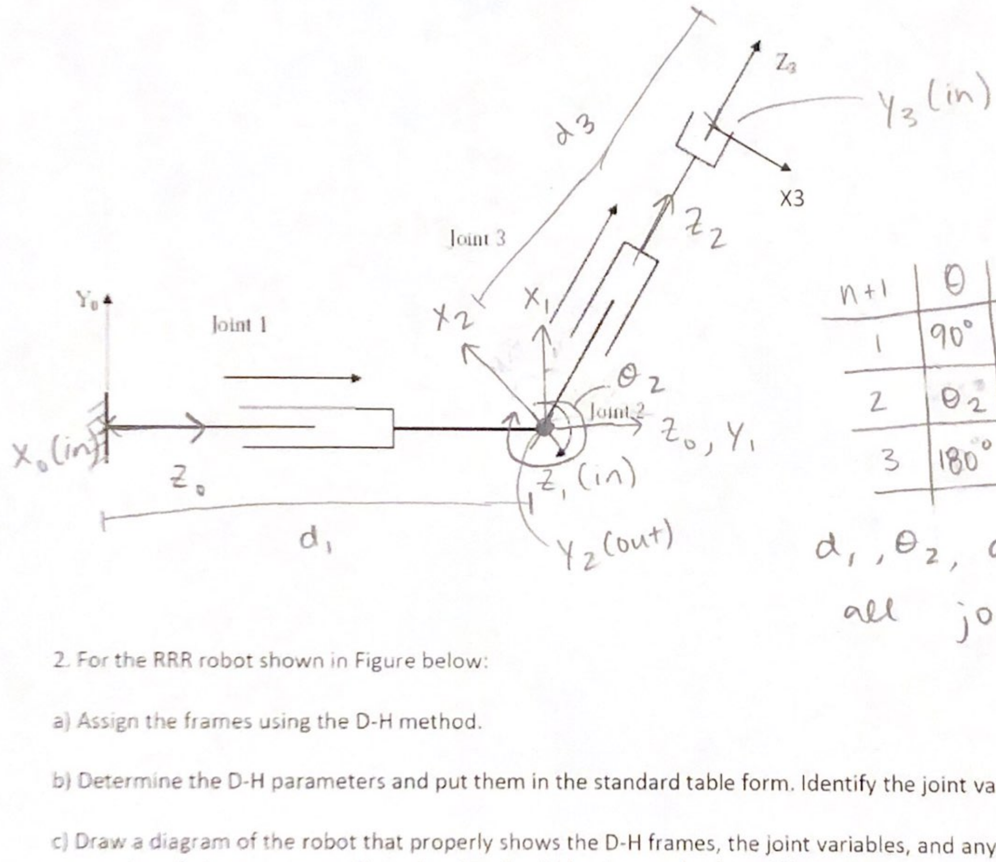
1. For the PRP planar robot shown in Figure below.

a) Using the predefined Y0 and Z3 axes, assign the frames using the D-H method.

b) Determine the D-H parameters and put them in the standard table form. Identify the joint variables.

c) Draw a diagram of the robot that properly shows the D-H frames, the joint variables, and any d or a parameters that are non-zero. Your drawing should be clear and at least 75 mm X 75 mm in size.

d) Calculate the A matrices and $^{0}T_{3}$.



n+1	θ	d	a	α
1	90°	d_1	0	90°
2	θ_2	0	0	-90°
3	180°	d_3	0	0°

d_1, θ_2, and d_3 are all joint variables

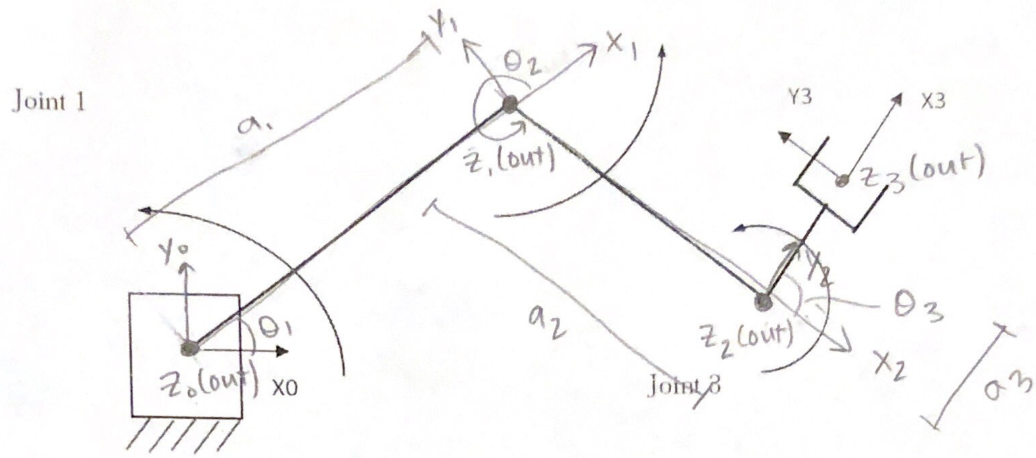
2. For the RRR robot shown in Figure below:

a) Assign the frames using the D-H method.

b) Determine the D-H parameters and put them in the standard table form. Identify the joint variables.

c) Draw a diagram of the robot that properly shows the D-H frames, the joint variables, and any *d* or *a* parameters that are non-zero. Your drawing should be clear and at least 75 mm X 75 mm in size.

d) Calculate the A matrices and $^{0}T_{3}$.



$n+1$	θ	d	a	α
1	θ_1	0	a_1	0
2	θ_2	0	a_2	0
3	θ_3	0	a_3	0

where θ_1, θ_2, θ_3 are joint variables,
a_1, a_2, a_3 are fixed parameters