Assumption University (ABAC)
Classwork 1

Name....Todsavad T.....**ID**.....6114215.....**Date:**.15/07/21.....

1. **Obtain** A^{-1} **show your working steps.**

if $A = \begin{bmatrix} 1 & 2 & 3 \\ 1 & 3 & 2 \\ 1 & 4 & 3 \end{bmatrix}$

Ans:

$$\det A = \begin{bmatrix} 1 & 2 & 3 \\ 1 & 3 & 2 \\ 1 & 4 & 3 \end{bmatrix} \begin{matrix} 1 & 2 \\ 1 & 3 \\ 1 & 4 \end{matrix} = 2$$

$-9 \quad -8 \quad -6$

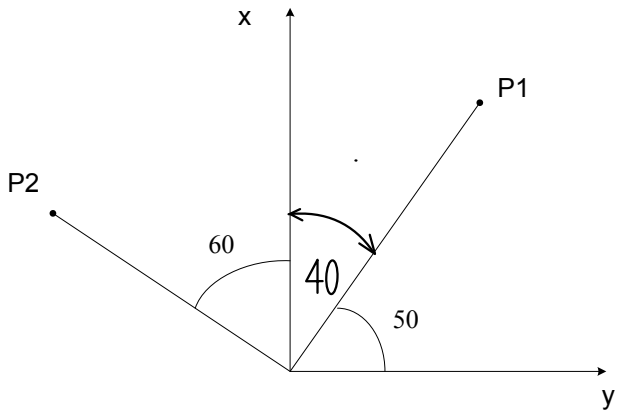
$9 \quad 4 \quad 12$

$$= \frac{1}{\det A} \begin{bmatrix} +\begin{bmatrix} 3 & 2 \\ 4 & 3 \end{bmatrix} & -\begin{bmatrix} 2 & 3 \\ 4 & 3 \end{bmatrix} & +\begin{bmatrix} 2 & 3 \\ 3 & 2 \end{bmatrix} \\ -\begin{bmatrix} 1 & 2 \\ 1 & 3 \end{bmatrix} & +\begin{bmatrix} 1 & 3 \\ 1 & 3 \end{bmatrix} & -\begin{bmatrix} 1 & 3 \\ 1 & 2 \end{bmatrix} \\ +\begin{bmatrix} 1 & 3 \\ 1 & 4 \end{bmatrix} & -\begin{bmatrix} 1 & 2 \\ 1 & 4 \end{bmatrix} & +\begin{bmatrix} 1 & 2 \\ 1 & 3 \end{bmatrix} \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 1 & 6 & -5 \\ -1 & 0 & 1 \\ 1 & -2 & 1 \end{bmatrix}$$

Assumption University (ABAC)
Classwork 2

Name...Todsavad....T.....**ID**.....6114215.....**Date: 22/6/21**

1. **Obtain P1 and P2 location if L = 2. X is starting axis,**



Ans:

$$p_0 = \begin{bmatrix} 2 & 0 & 0 \end{bmatrix}^T = \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix}$$

$$R_1^0 = \begin{bmatrix} \cos(40^\circ) & -\sin(40^\circ) & 0 \\ \sin(40^\circ) & \cos(40^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$p^1 = R_1^0 p_0$$

$$= \begin{bmatrix} \cos(40^\circ) & -\sin(40^\circ) & 0 \\ \sin(40^\circ) & \cos(40^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 1.5321 \\ 1.2856 \\ 0 \end{bmatrix}$$

$$R_2^0 = \begin{bmatrix} \cos(-60^\circ) & -\sin(-60^\circ) & 0 \\ \sin(-60^\circ) & \cos(-60^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$p_2 = R_2^0 p_0$$

$$= \begin{bmatrix} \cos(-60^\circ) & -\sin(-60^\circ) & 0 \\ \sin(-60^\circ) & \cos(-60^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 1 \\ -1.7321 \\ 0 \end{bmatrix}$$

$$R_2^1 = \begin{bmatrix} \cos(-100^\circ) & -\sin(-100^\circ) & 0 \\ \sin(-100^\circ) & \cos(-100^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$p_2 = R_2^1 p_1$$

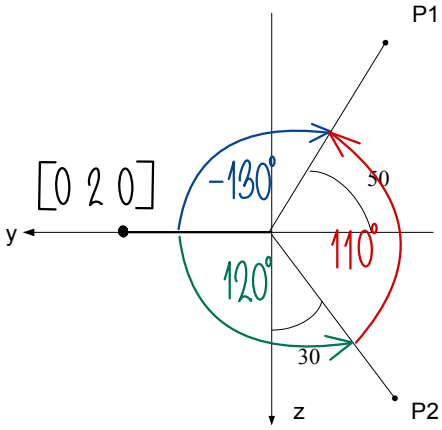
$$= \begin{bmatrix} \cos(-100^\circ) & -\sin(-100^\circ) & 0 \\ \sin(-100^\circ) & \cos(-100^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1.5321 \\ 1.2856 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 1 \\ -1.7321 \\ 0 \end{bmatrix}$$

Assumption University (ABAC)
Classwork 3

Name..Todsarad.....T.....**ID**....6114215..... **Date: 24 June 2021**

1. **Obtain P1 and P2 locations (applying rotating matrix method, and show those steps), given L = 2. Y is starting axis of robot arm, and X is rotating axis.**



Ans:

$$p_0 = \begin{bmatrix} 0 & 2 & 0 \end{bmatrix}^T = \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$R_1^0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-130^\circ) & -\sin(-130^\circ) \\ 0 & \sin(-130^\circ) & \cos(-130^\circ) \end{bmatrix}$$

$$p^1 = R_1^0 p_0$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-130^\circ) & -\sin(-130^\circ) \\ 0 & \sin(-130^\circ) & \cos(-130^\circ) \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -1.286 \\ -1.532 \end{bmatrix}$$

$$R_2^0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(120^\circ) & -\sin(120^\circ) \\ 0 & \sin(120^\circ) & \cos(120^\circ) \end{bmatrix}$$

$$p_2 = R_2^0 p_0$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(120^\circ) & -\sin(120^\circ) \\ 0 & \sin(120^\circ) & \cos(120^\circ) \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -1 \\ 1.732 \end{bmatrix}$$

$$R_2^1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(110^\circ) & -\sin(110^\circ) \\ 0 & \sin(110^\circ) & \cos(110^\circ) \end{bmatrix}$$

$$p_2 = R_2^1 p_1$$

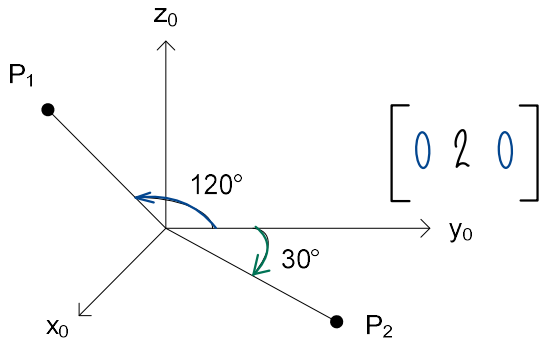
$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(110^\circ) & -\sin(110^\circ) \\ 0 & \sin(110^\circ) & \cos(110^\circ) \end{bmatrix} \begin{bmatrix} 0 \\ -1.286 \\ -1.532 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -1 \\ 1.732 \end{bmatrix}$$

Assumption University (ABAC)
Classwork 4

Name...Todsavad T.....**ID**.....6114215..... **Date: 29 June 2021**

1. **Obtain P1 and P2 locations (applying rotating matrix method, and show those steps), given L = 2. Y is starting axis of robot arm, and X is rotating axis.**



$$\begin{bmatrix} 0 & 2 & 0 \end{bmatrix}$$

$$p_0 = \begin{bmatrix} 0 & 2 & 0 \end{bmatrix}^T = \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$R_1^0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(120°) & -\sin(120°) \\ 0 & \sin(120°) & \cos(120°) \end{bmatrix}$$

$$p^1 = R_1^0 p_0$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(120°) & -\sin(120°) \\ 0 & \sin(120°) & \cos(120°) \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -1 \\ 1.732 \end{bmatrix}$$

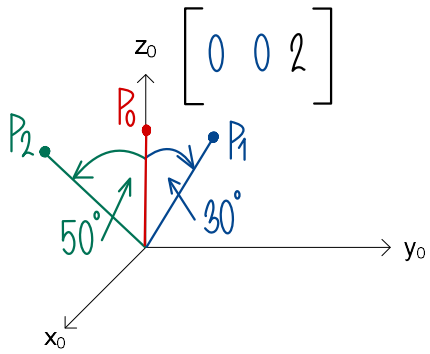
$$R_2^0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-30°) & -\sin(-30°) \\ 0 & \sin(-30°) & \cos(-30°) \end{bmatrix}$$

$$p_2 = R_2^0 p_0$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-30°) & -\sin(-30°) \\ 0 & \sin(-30°) & \cos(-30°) \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 1.732 \\ -1 \end{bmatrix}$$

2. P1 is 30° CW from the starting axis and P2 is 50° CCW from starting axis. Given L = 2 and Z is starting axis of robot arm, and X is rotating axis. Draw and locate P1 and P2 on the diagram.



$$P_0 = \begin{bmatrix} 0 & 0 & 2 \end{bmatrix}^T = \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

$$R_1^0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-30^\circ) & -\sin(-30^\circ) \\ 0 & \sin(-30^\circ) & \cos(-30^\circ) \end{bmatrix}$$

$$P^1 = R_1^0 P_0$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-30^\circ) & -\sin(-30^\circ) \\ 0 & \sin(-30^\circ) & \cos(-30^\circ) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 1 \\ 1.732 \end{bmatrix}$$

$$R_2^0 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(50^\circ) & -\sin(50^\circ) \\ 0 & \sin(50^\circ) & \cos(50^\circ) \end{bmatrix}$$

$$P_2 = R_2^0 P_0$$

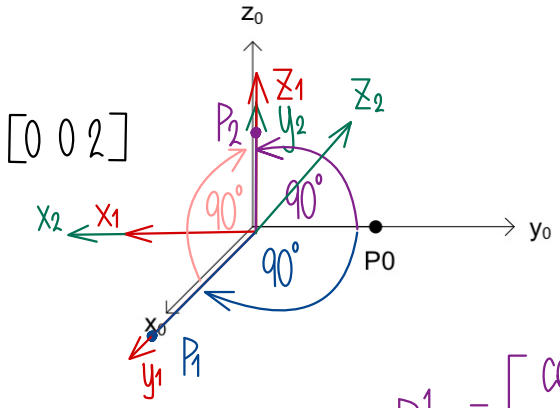
$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(50^\circ) & -\sin(50^\circ) \\ 0 & \sin(50^\circ) & \cos(50^\circ) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ -1.532 \\ 1.286 \end{bmatrix}$$

3. **Given L = 2 and P0 is on the initial position on the robot arm.**
   a. **P1 is rotate of 90° CW on the Z-axis.**
   b. **From Frame 1, P2 is rotate of 90° CCW on the current X-axis.**

   Draw the Frame 1 and Frame 2 on the given axis and locate the P2 on the diagram.

   Find P2 locations from transformation matrix (please show working steps).



$$p_0 = \begin{bmatrix} 0 & 2 & 0 \end{bmatrix}^T = \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$R_1^0 = \begin{bmatrix} \cos(-90^\circ) & -\sin(-90^\circ) & 0 \\ \sin(-90^\circ) & \cos(-90^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad z\text{-axis}$$

$$p_1 = R_1^0 p_0$$

$$= \begin{bmatrix} \cos(-90^\circ) & -\sin(-90^\circ) & 0 \\ \sin(-90^\circ) & \cos(-90^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix}$$

$$R_2^1 = \begin{bmatrix} \cos(90^\circ) & 0 & -\sin(90^\circ) \\ 0 & 1 & 0 \\ \sin(90^\circ) & 0 & \cos(90^\circ) \end{bmatrix} \quad y\text{-axis}$$

$$p_2 = R_2^1 p_1$$

ref of p_1

$$= \begin{bmatrix} \cos(90^\circ) & 0 & -\sin(90^\circ) \\ 0 & 1 & 0 \\ \sin(90^\circ) & 0 & \cos(90^\circ) \end{bmatrix} \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

ref of p_0 Aj

$$p_2 = \left[R_1^0 \times R_2^1\right] p_0$$

$$= \begin{bmatrix} \cos(-90^\circ) & -\sin(-90^\circ) & 0 \\ \sin(-90^\circ) & \cos(-90^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(90^\circ) & -\sin(90^\circ) \\ 0 & \sin(90^\circ) & \cos(90^\circ) \end{bmatrix} \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}$$

1. Don't change question reference frame.
2. Draw all the frames on the same frame
3. Pls use different colour

Assumption University (ABAC)
Classwork 5

Name..Todsavad T.....**ID**.....6114215.....**Date: 6/7/21**

Perform the below transformations, where Frame 0 (original frame) is shown. Given $p^0 = [1,0,0]$.

a. Rotate -90 degree CURRENT y-axis.
b. Translate -3 unit CURRENT z-axis.
c. Rotate 90 degree CURRENT x-axis.

$$R_1^0 = \begin{bmatrix} \cos(-90^\circ) & 0 & -\sin(-90^\circ) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-90^\circ) & 0 & \cos(-90^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

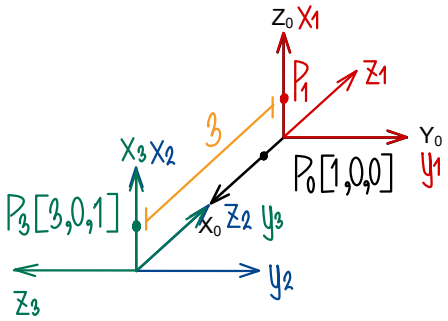
i. Find transformation matrix for the following steps, show T_{03} with working steps.
ii. Calculate the value of p^3 wrt frame 0.
iii. Draw the following frames and point out p^3 on the diagram.

iii)

$R_1^0 = Rot(y, -90^\circ)$

$D_2^1 = D(z, -3)$

$R_3^2 = Rot(x, 90^\circ)$



$$P_1^0 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} \qquad D_2^1 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R_3^2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(90^\circ) & -\sin(90^\circ) & 0 \\ 0 & \sin(90^\circ) & \cos(90^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

i) $T_3^0 = R_1^0 D_2^1 R_3^2$

$$= \begin{bmatrix} \cos(-90^\circ) & 0 & -\sin(-90^\circ) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-90^\circ) & 0 & \cos(-90^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(90^\circ) & -\sin(90^\circ) & 0 \\ 0 & \sin(90^\circ) & \cos(90^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -1 & 0 & 3 \\ 0 & 0 & -1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

ii) $P_3 = T_3^0 P^0$

$$= \begin{bmatrix} 0 & -1 & 0 & 3 \\ 0 & 0 & -1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 3 \\ 0 \\ 1 \\ 1 \end{bmatrix}$$

Assumption University (ABAC)
Classwork 6

Name...Todsavad T.....**ID**.....6114215.....**Date: 8/7/21**

Perform the below transformations, where Frame 0 (original frame) is shown. Given $p^0 = [1,0,0]$.

a. Rotate -90 degree FIXED y-axis.
b. Translate -3 unit FIXED z-axis.
c. Rotate 90 degree FIXED x-axis.

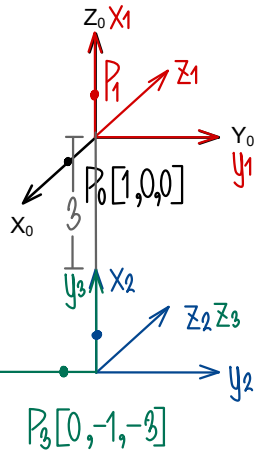
i. Find transformation matrix for the following steps, show T_{03} with working steps.
ii. Calculate the value of p^3 wrt frame 0.
iii. Draw the following frames and point out p^3 on the diagram.

iii)

$T_1^0 = Rot(y, -90°)$

$T_2^1 = D(z, -3)$

$T_3^2 = Rot(x, 90°)$



-3

i) $T_3^0 = T_2^1[T_3^2 T_1^0]$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(90°) & -\sin(90°) & 0 \\ 0 & \sin(90°) & \cos(90°) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos(-90°) & 0 & -\sin(-90°) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-90°) & 0 & \cos(-90°) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

ii) $P_3 = T_3^0 P^0$

$$= \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ -1 \\ -3 \\ 1 \end{bmatrix}$$

Assumption University (ABAC)
Classwork 7

Name...Todsavad.....T.....**ID**.....6114215.....**Date: 13/7/21**

Perform the below transformations, where Frame 0 (original frame) is shown. Given $p^0 = [1,0,0]$.

a. Rotate -90 degree FIXED y-axis.
b. Translate -3 unit FIXED z-axis.
c. Rotate 90 degree FIXED x-axis.
d. Translate 3 unit FIXED y-axis.

i. Find transformation matrix for the following steps, show T_{04} with working steps.
ii. Calculate the value of p^4 wrt frame 0.
iii. Draw the following frames and point out p^4 on the diagram.

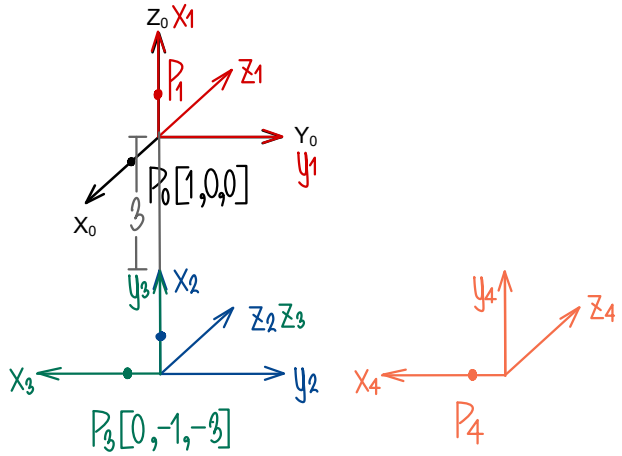
iii)

$T_1^0 = Rot(y, -90°)$

$T_2^1 = D(z, -3)$

$T_3^2 = Rot(x, 90°)$

$T_4^3 = D(y, 3)$



i) $T_3^0 = T_4^3 T_2^1 [T_3^2 T_1^0]$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(90°) & -\sin(90°) & 0 \\ 0 & \sin(90°) & \cos(90°) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos(-90°) & 0 & -\sin(-90°) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-90°) & 0 & \cos(-90°) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

ii) $P_4 = T_4^0 P^0$

$$= \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 2 \\ -3 \\ 1 \end{bmatrix}$$