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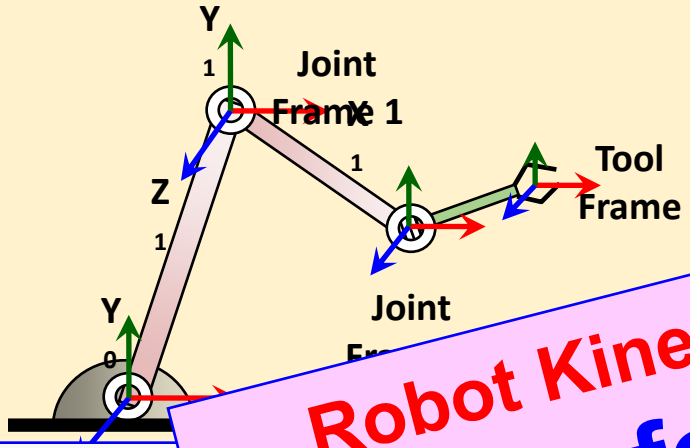
FY - Department of Engineering, Sciences and Humanities



Robot Kinematics – 2.3

Transformation

(Translation)

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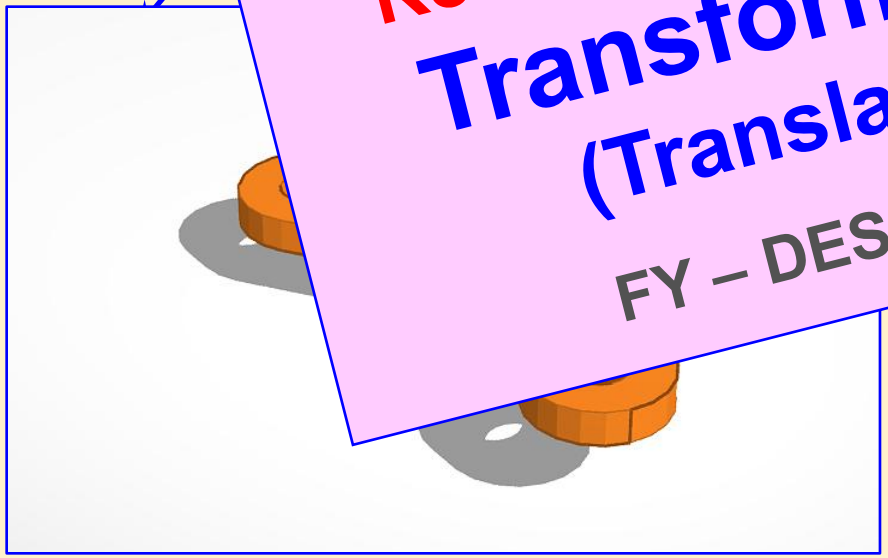
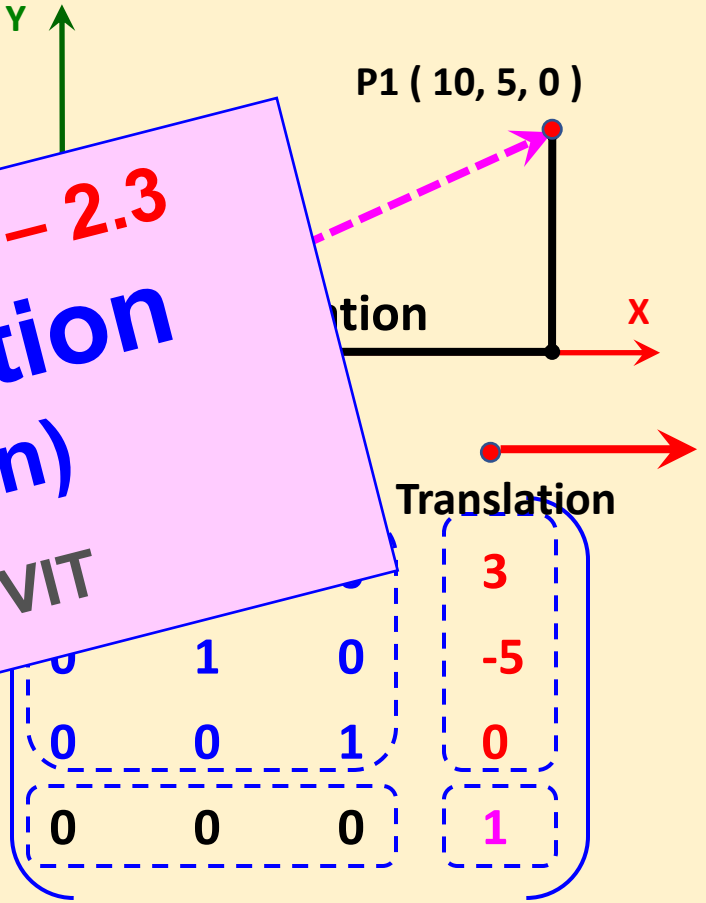




Rotational and Translational motion (Linear)

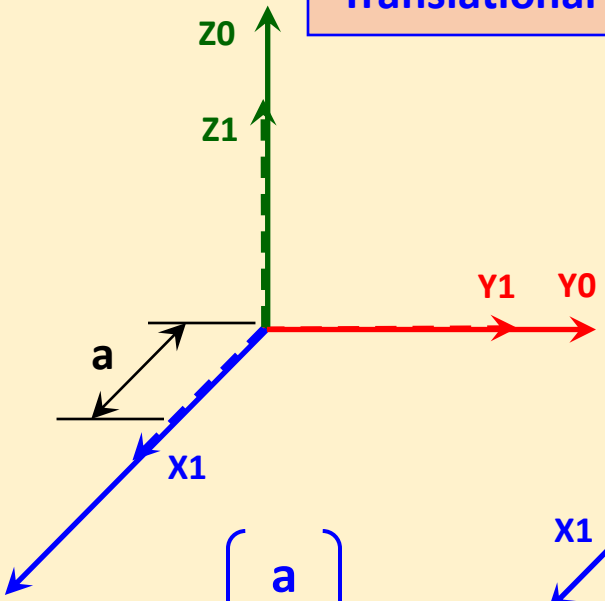
We have seen how rotation matrices are formed.

Actually there is always a translational (linear) motion along with a rotational motion.

The calculation becomes little more complicated.

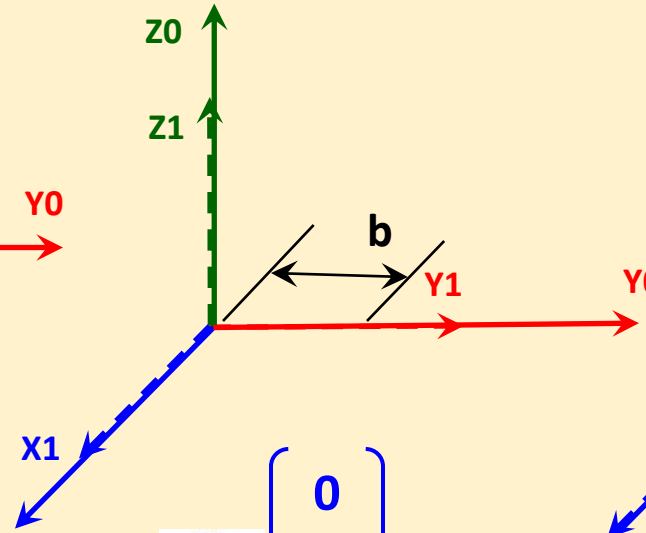
Let us see how is this done !

Translational motion (Linear) and the Displacement Vector (Matrix)



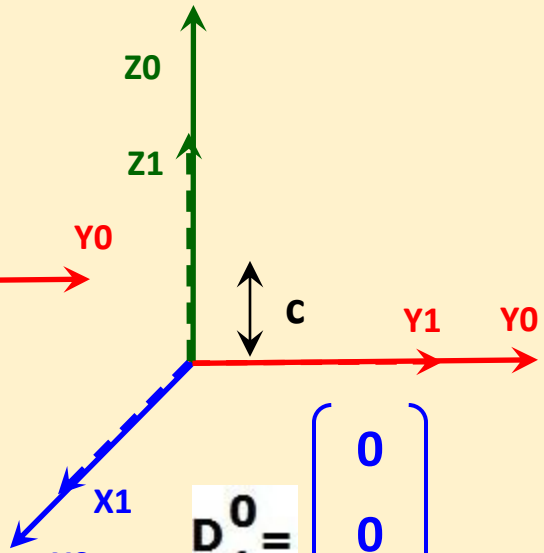
$$D_1^0 = \begin{pmatrix} a \\ 0 \\ 0 \end{pmatrix}$$

Frame 1 is translated in the direction of **X axis.**



$$D_1^0 = \begin{pmatrix} 0 \\ b \\ 0 \end{pmatrix}$$

Frame 1 is translated in the direction of **Y axis.**



$$D_1^0 = \begin{pmatrix} 0 \\ 0 \\ c \end{pmatrix}$$

Frame 1 is translated in the direction of **Z axis.**

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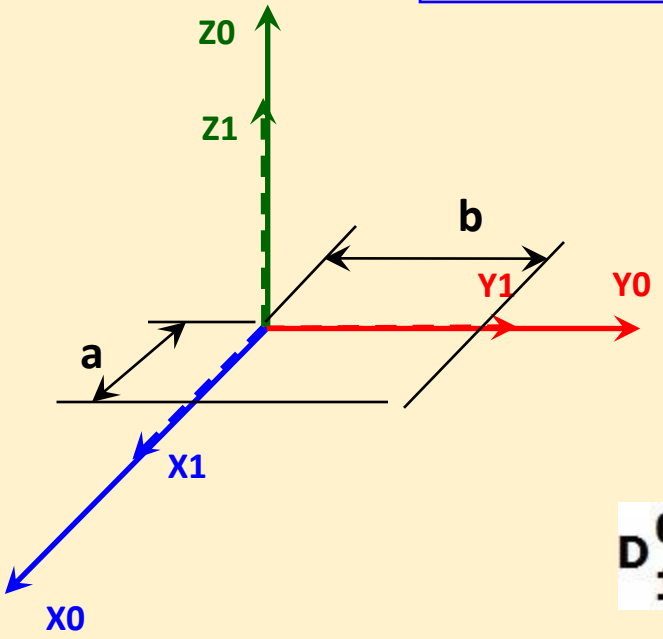
Translational motion in two directions



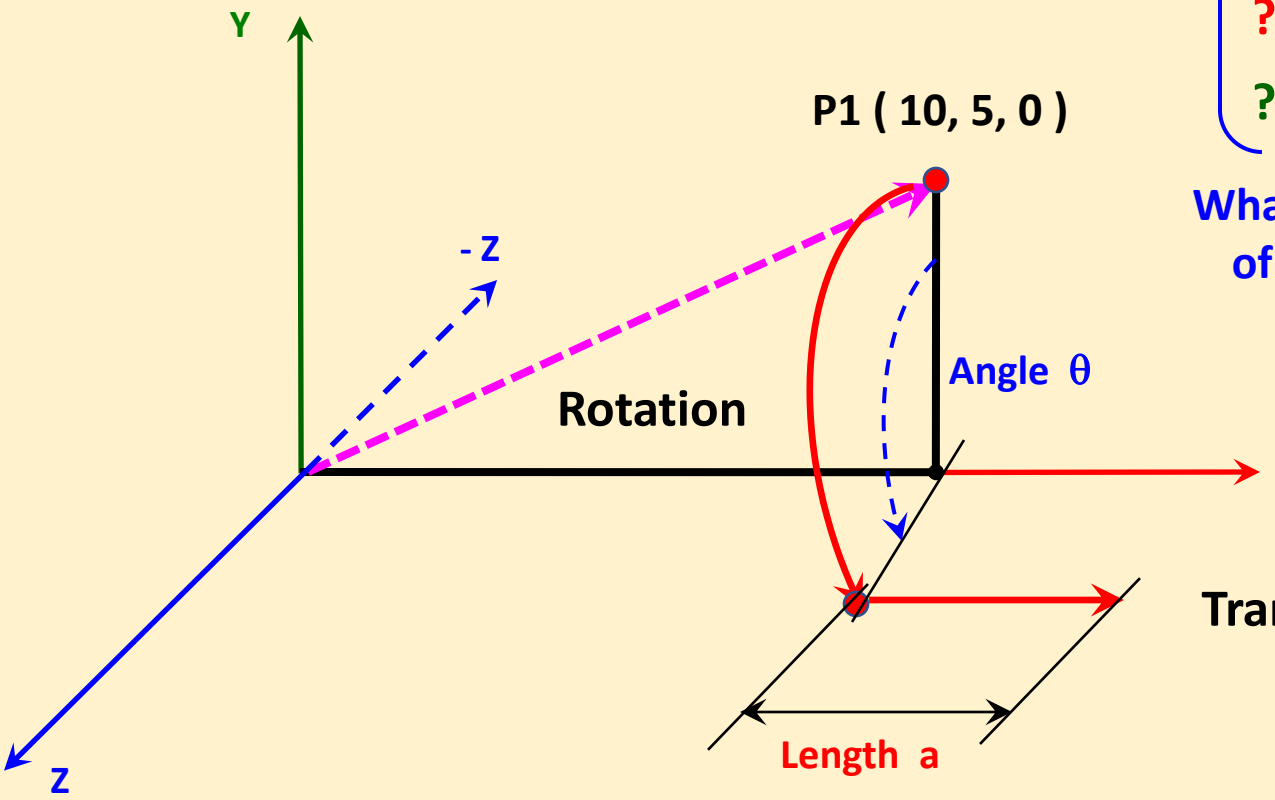
$$D_1^0 = \begin{pmatrix} a \\ b \\ 0 \end{pmatrix}$$

What type of Matrix will you get, if the translational motion is done along all 3 directions ?

$$D_1^0 = \begin{pmatrix} a \\ b \\ c \end{pmatrix}_{3 \times 1}$$

Frame 1 is translated in the direction of **X axis** and then in **Y axis.**

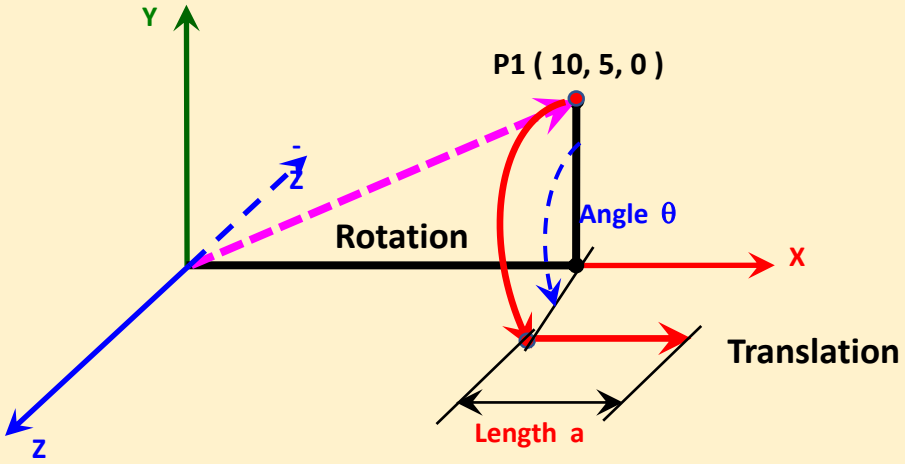
Rotation of a point around an axis and Translation -



$$\begin{pmatrix} ? & ? & ? \\ ? & ? & ? \\ ? & ? & ? \end{pmatrix}$$

What will be dimension of the Matrix now ?

Rotation of a point around an axis and Translation -



?	?	?
?	?	?
?	?	?

Will 3x3 be enough ?

Rotation Matrix

Translation Matrix

?	?	?	?
?	?	?	?
?	?	?	?
?	?	?	?

4 X 4

Scaling Factor

Rotation and Translation together -

Rotation Matrix

Translation Matrix

$$\begin{pmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Scaling Factor – which represents stretching or shrinking

For e.g.

Find what type of movement this robot is doing ?

$$\begin{pmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -5 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

This 4x4 matrix is called as Homogeneous Transformation Matrix –

Rotation and Translation together -

Find what type of movements this robot is doing ?

From DH 1 = $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

To DH 2 = $\begin{pmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

To DH 3 = $\begin{pmatrix} 0.866 & -0.5 & 0 & 0 \\ 0.5 & 0.866 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

To DH 4 = $\begin{pmatrix} 0.707 & 0.707 & 0 & 3 \\ 0.707 & 0.707 & -0.6427 & 0 \\ 0 & 0.6427 & 0.766 & -2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Rotation and Translation together -

Find what type of movements this robot is doing ?

From DH 1 =
$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

To DH 2 =
$$\begin{pmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

To DH 3 =
$$\begin{pmatrix} 0.866 & -0.5 & 0 & 0 \\ 0.5 & 0.866 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

To DH 4 =
$$\begin{pmatrix} 1 & 0 & 0 & 3 \\ 0 & 0.766 & -0.6427 & 0 \\ 0 & 0.6427 & 0.766 & -2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

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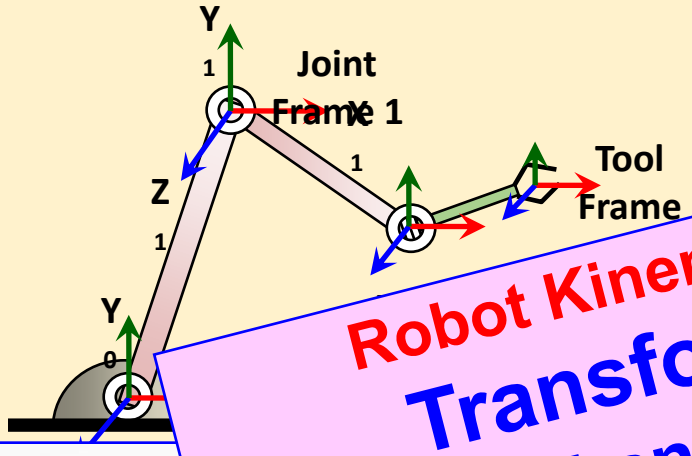

Robot Kinematics – 4.3

Transformation (Translation)

Thanks !

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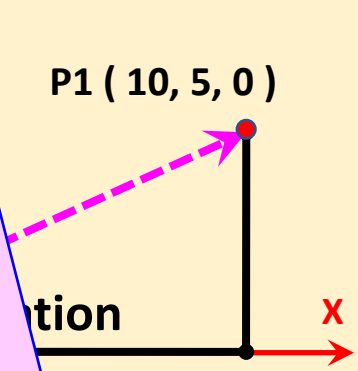

Translation

$$\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & -5 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$