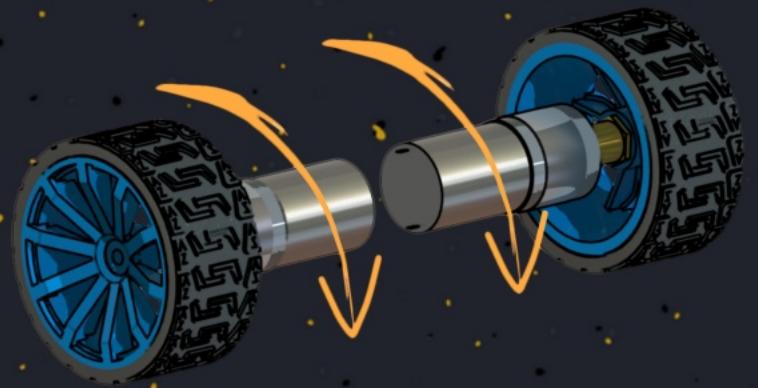
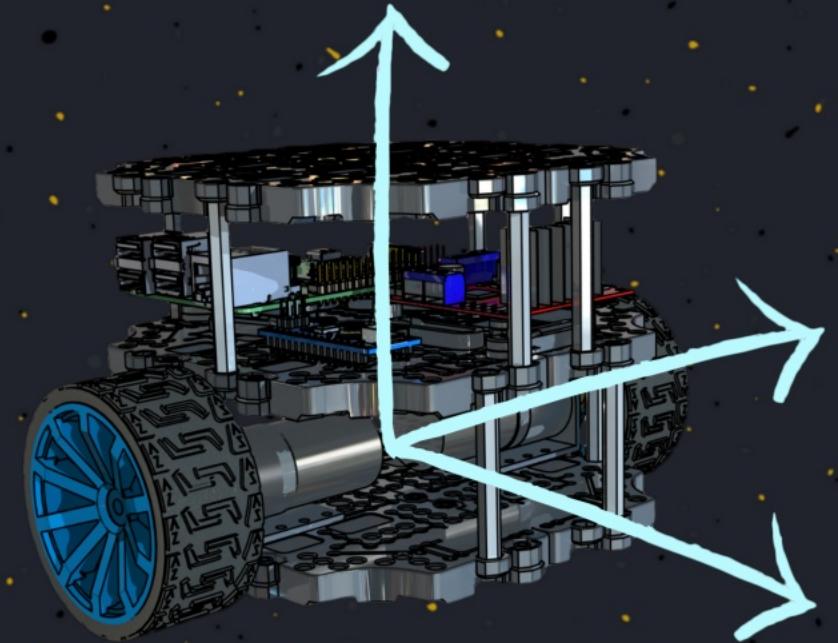
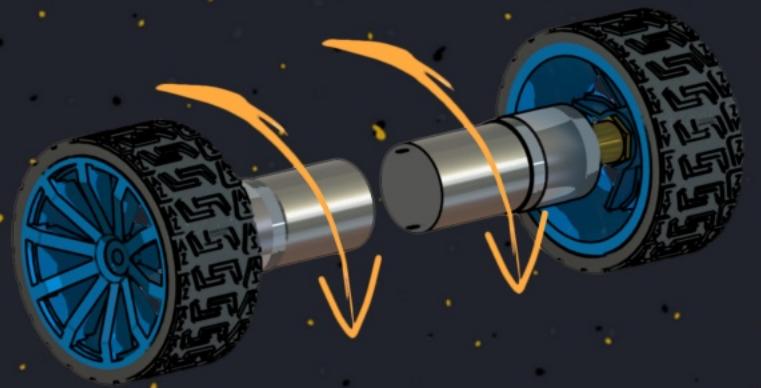


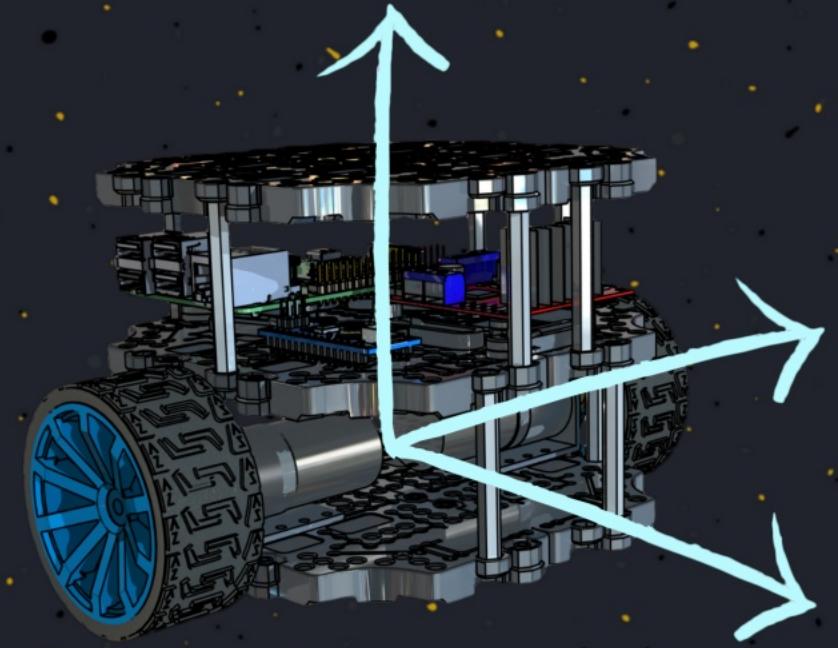
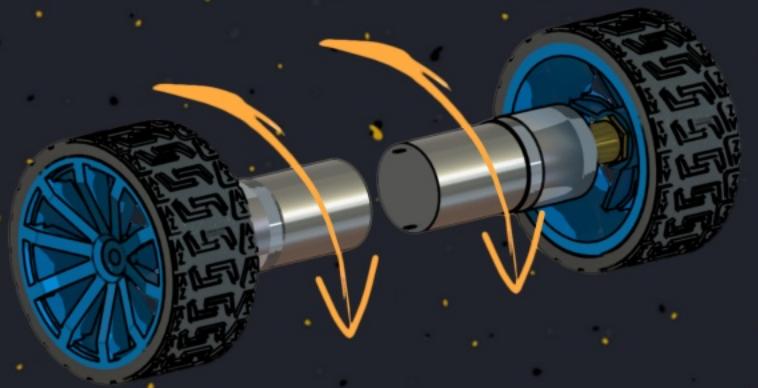
Kinematics



Kinematics



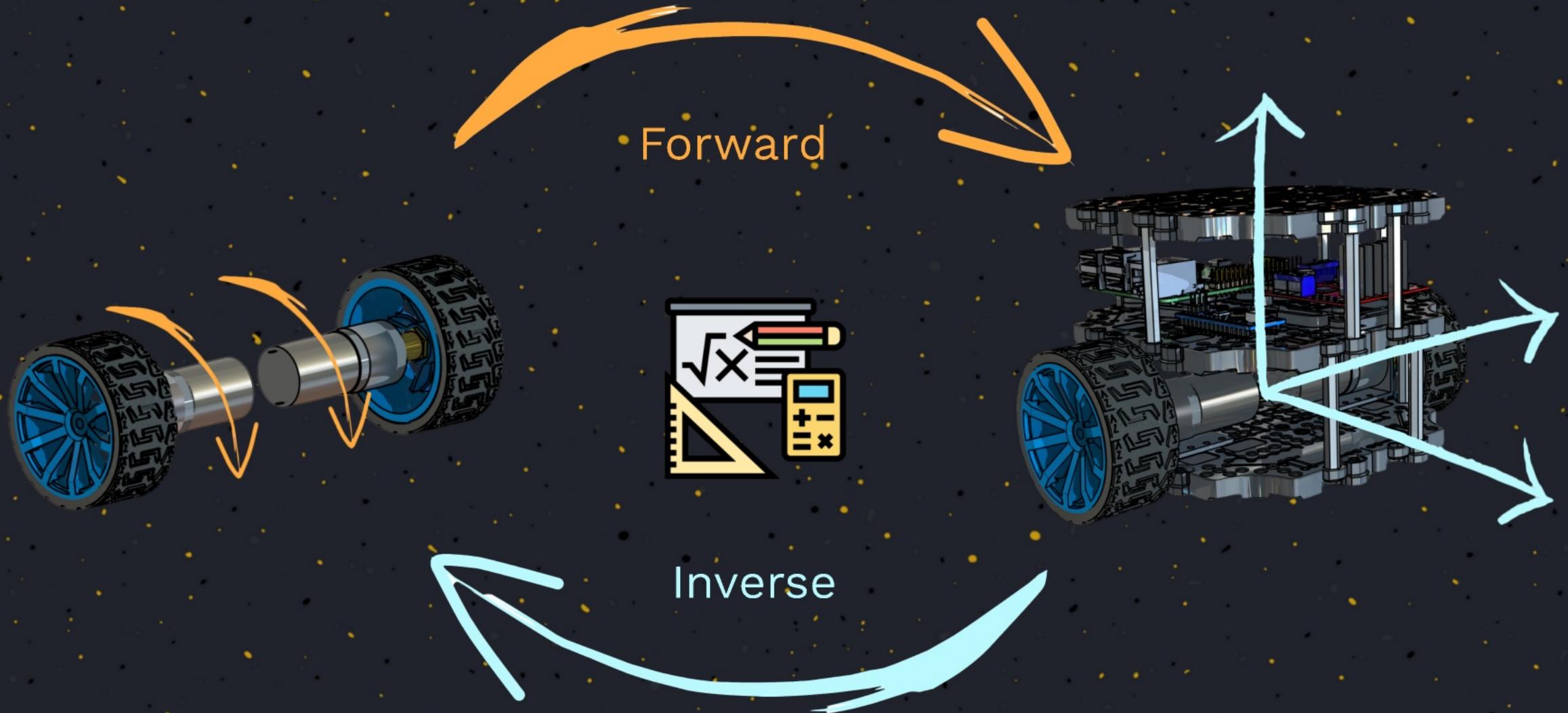
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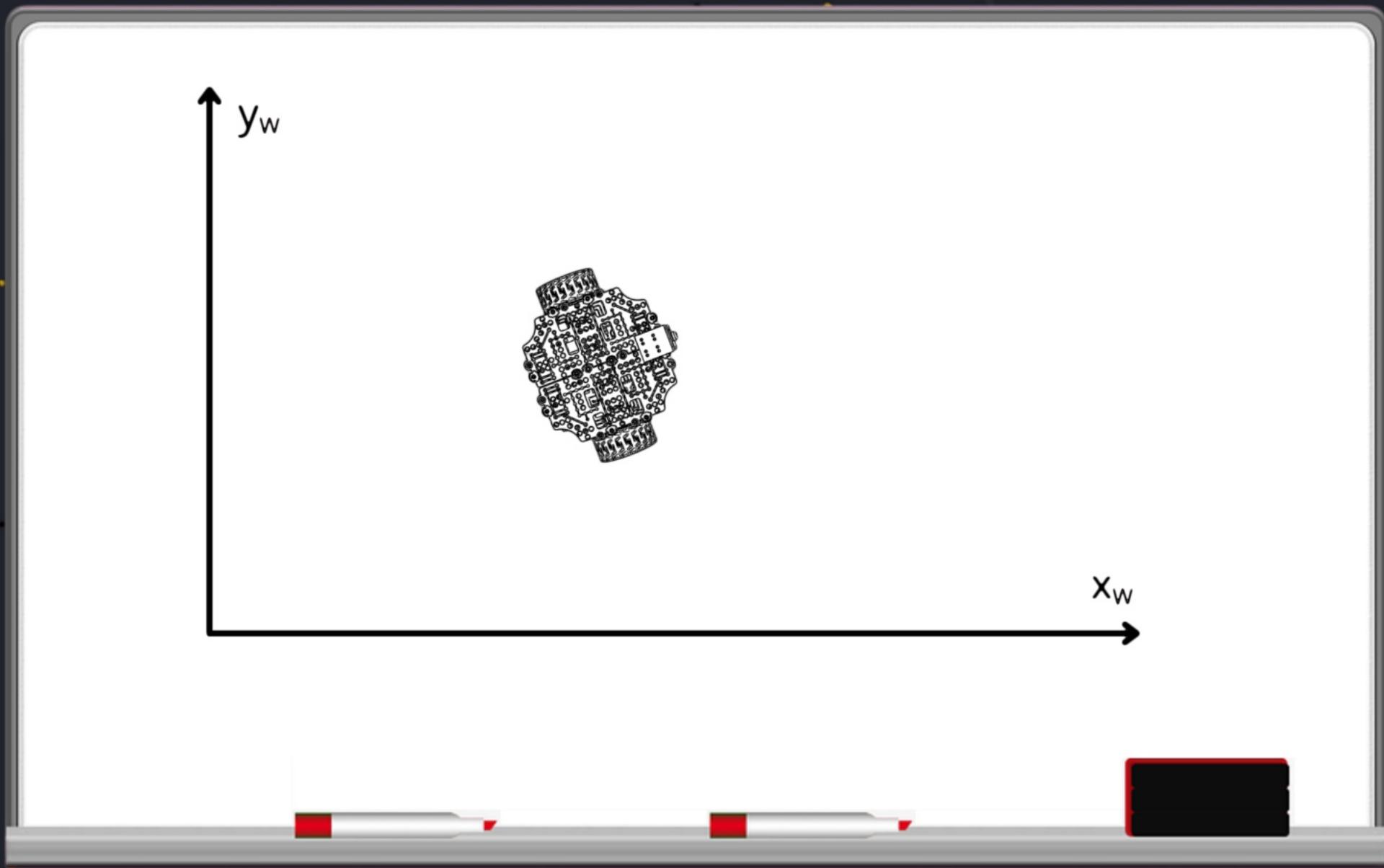


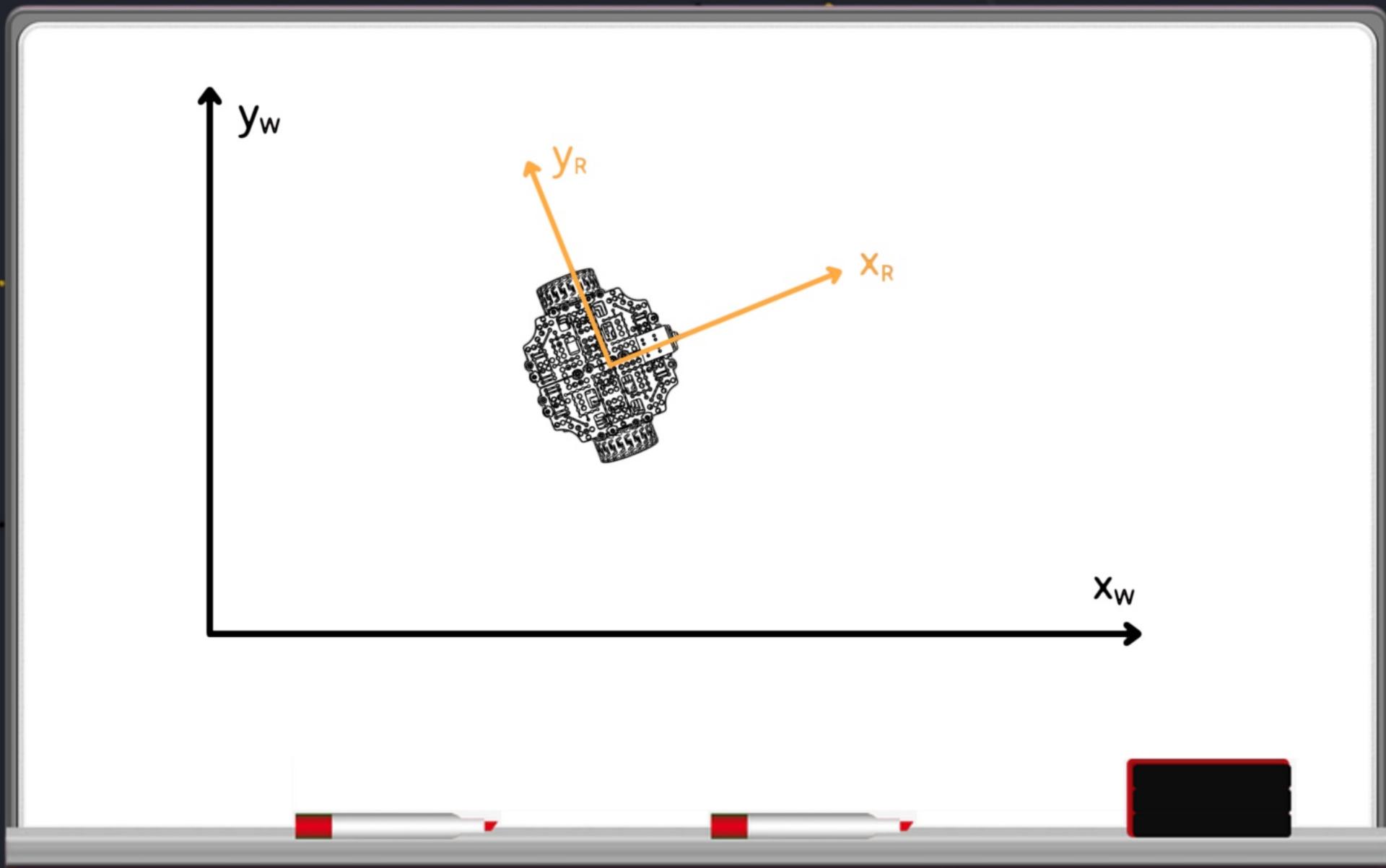
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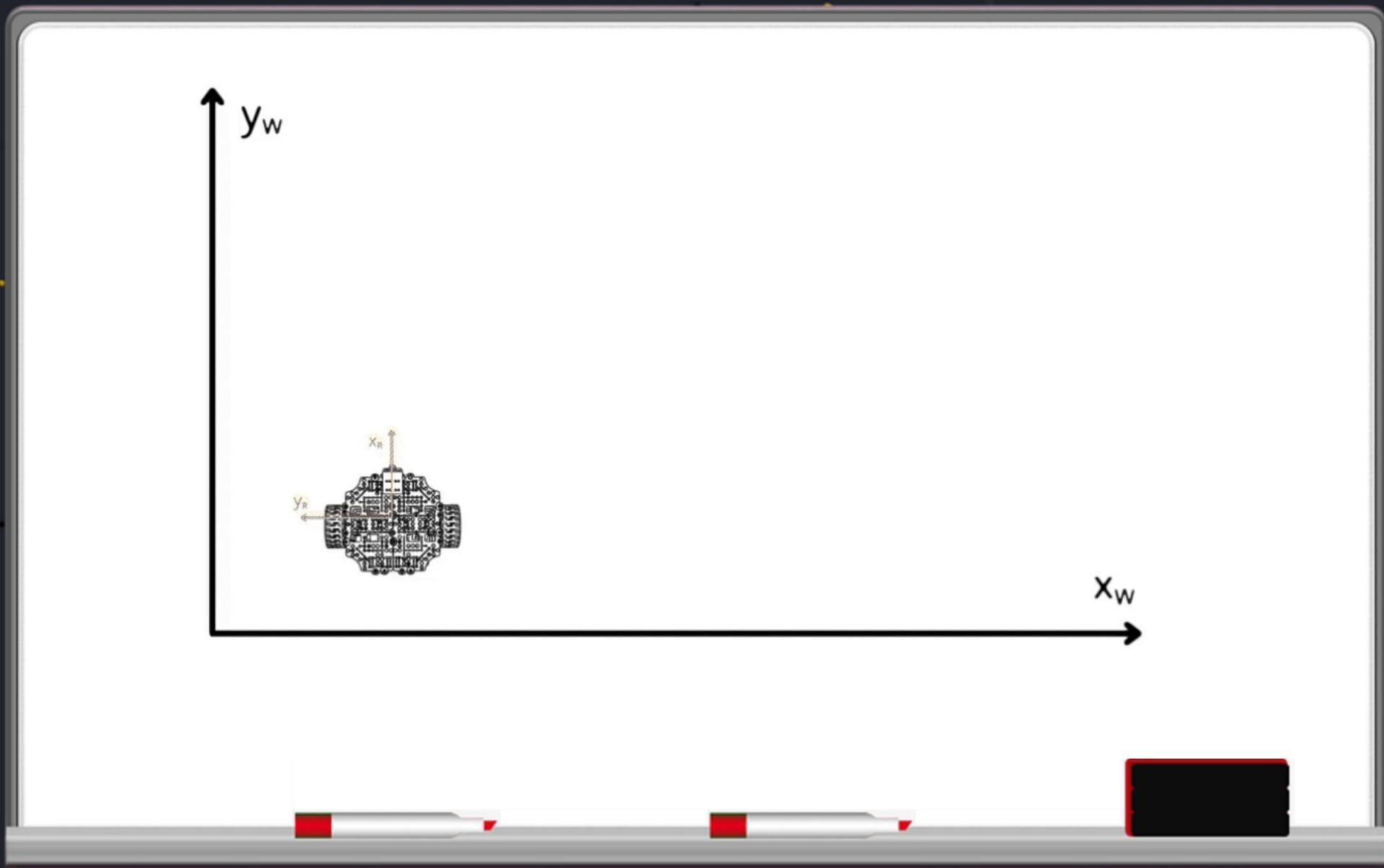
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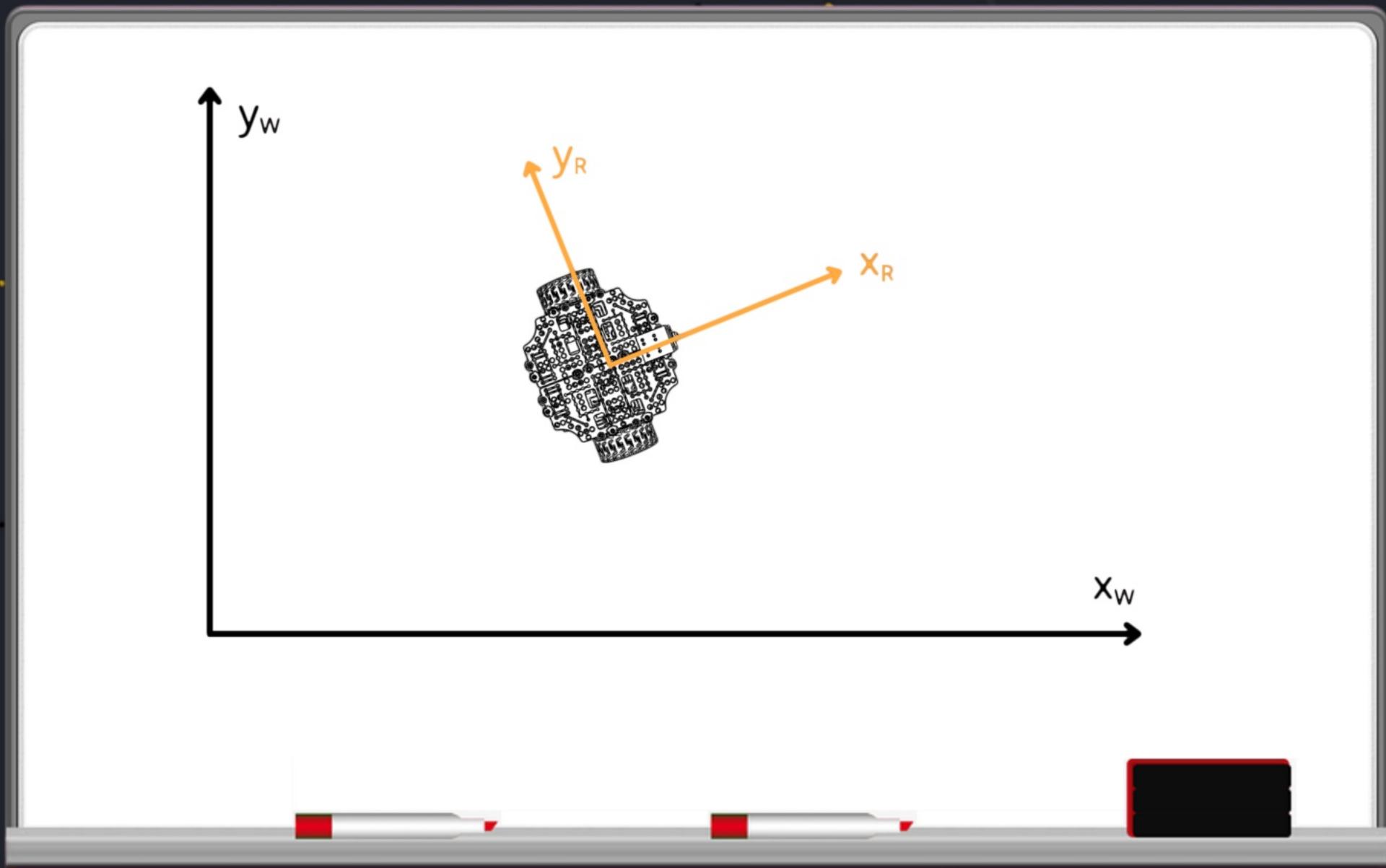


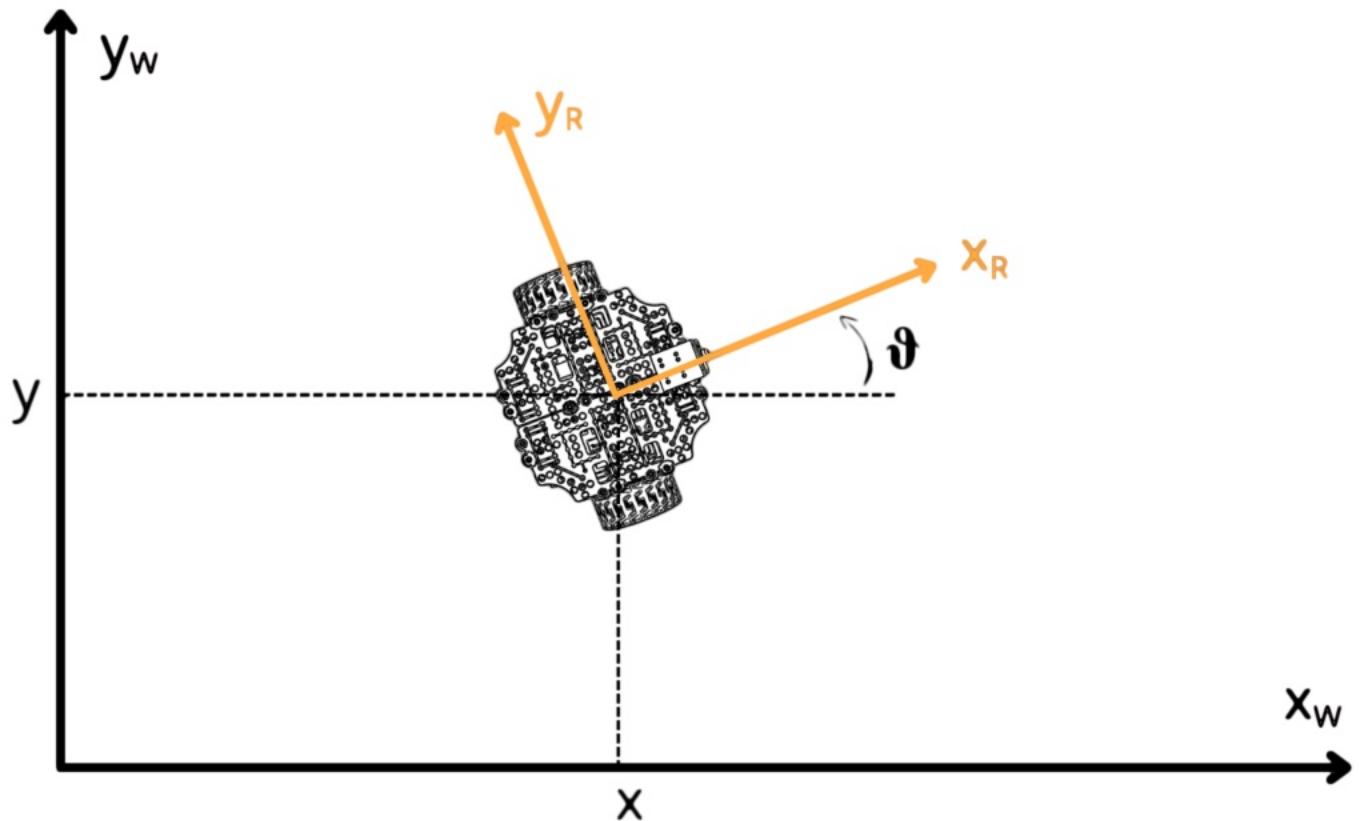


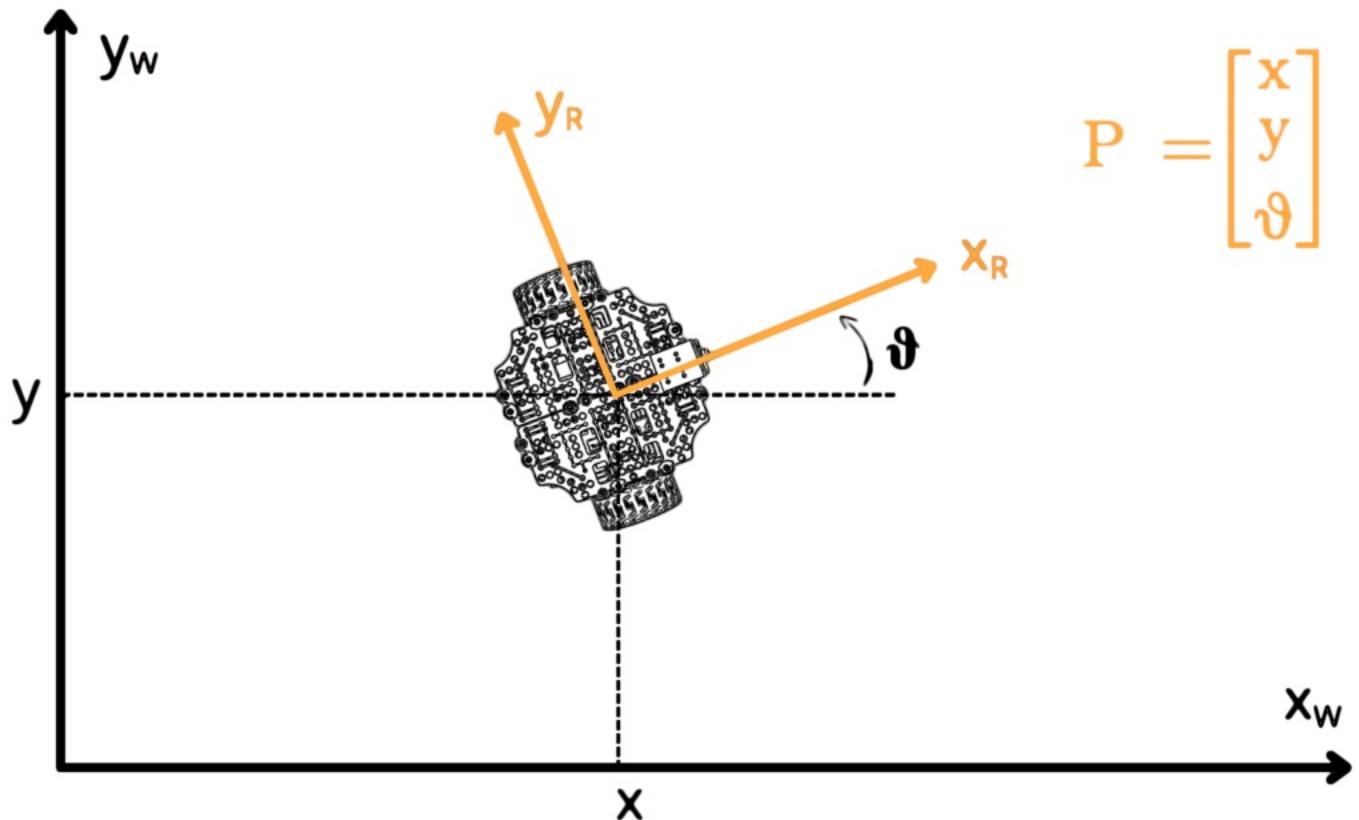




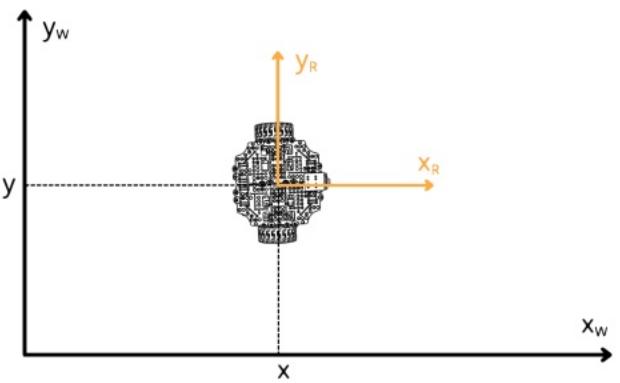




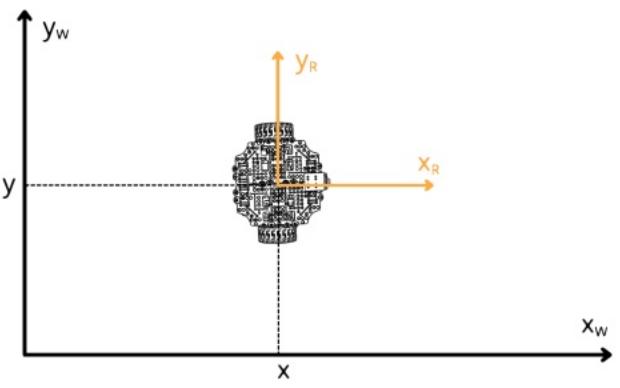




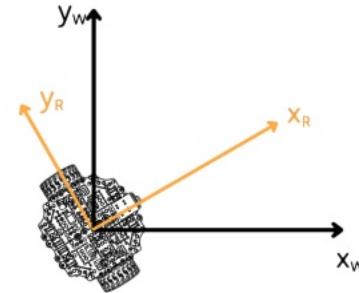




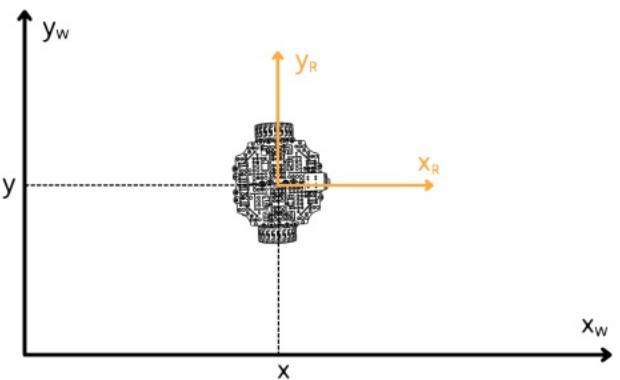
Translation



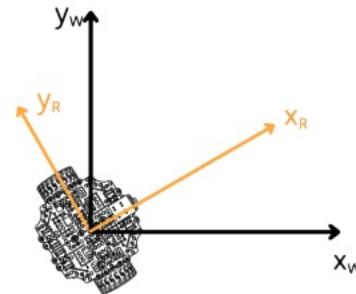
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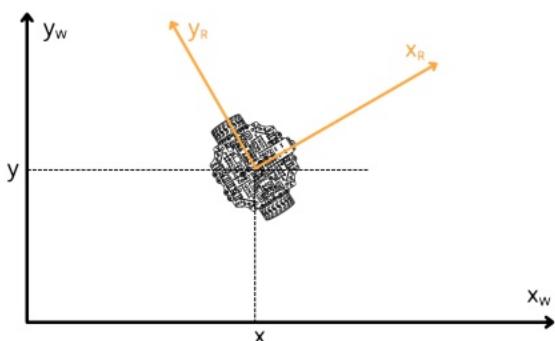
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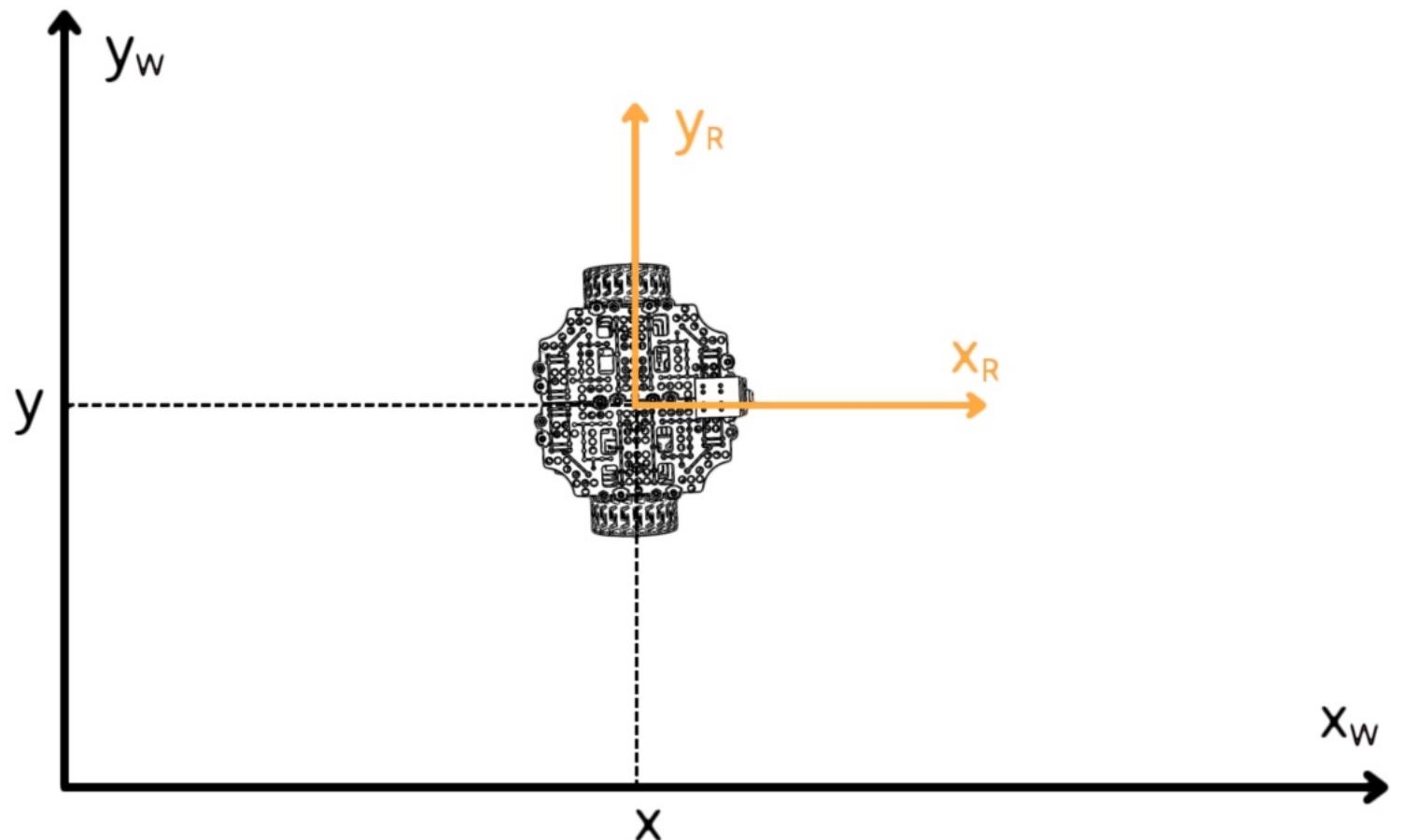
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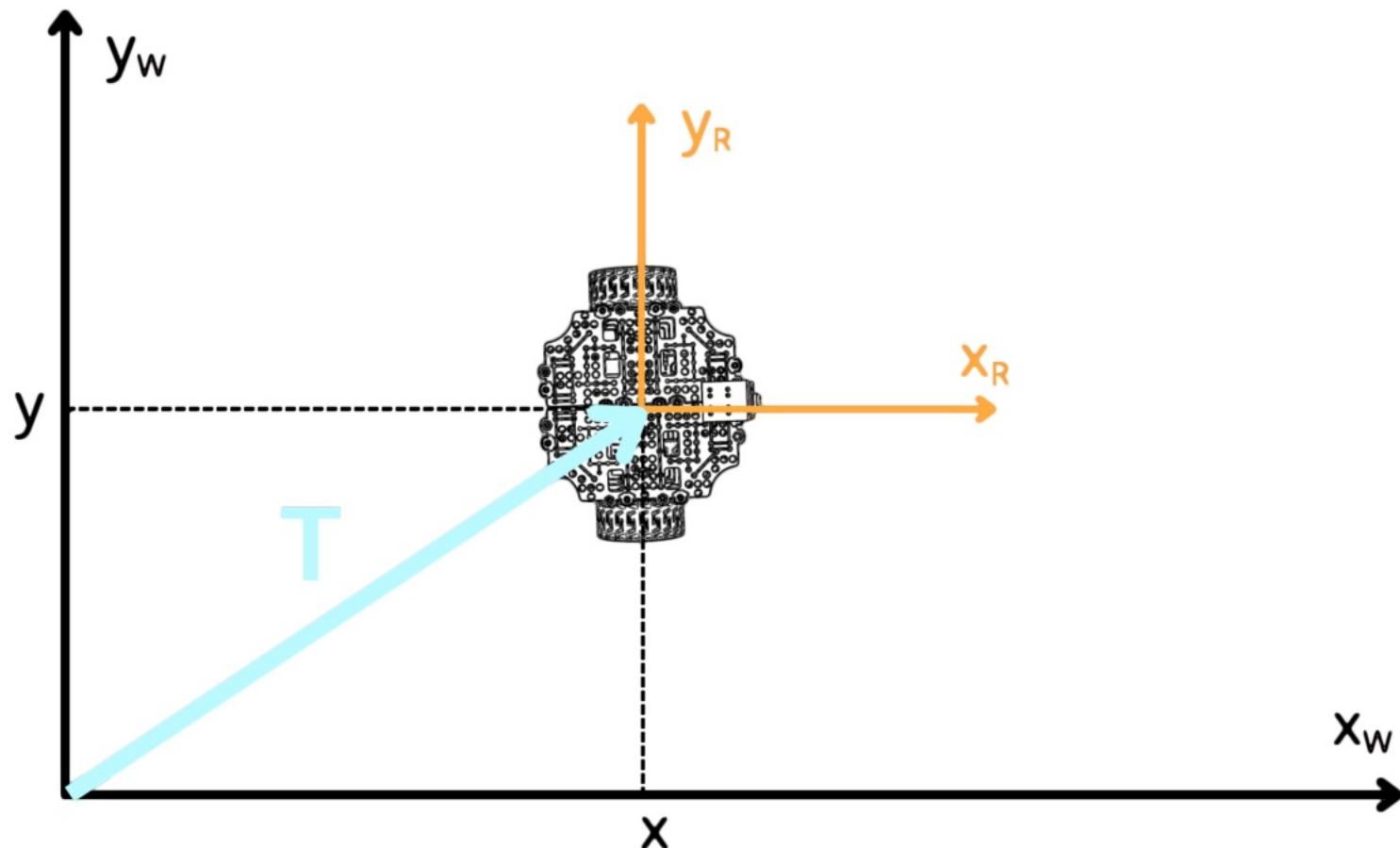


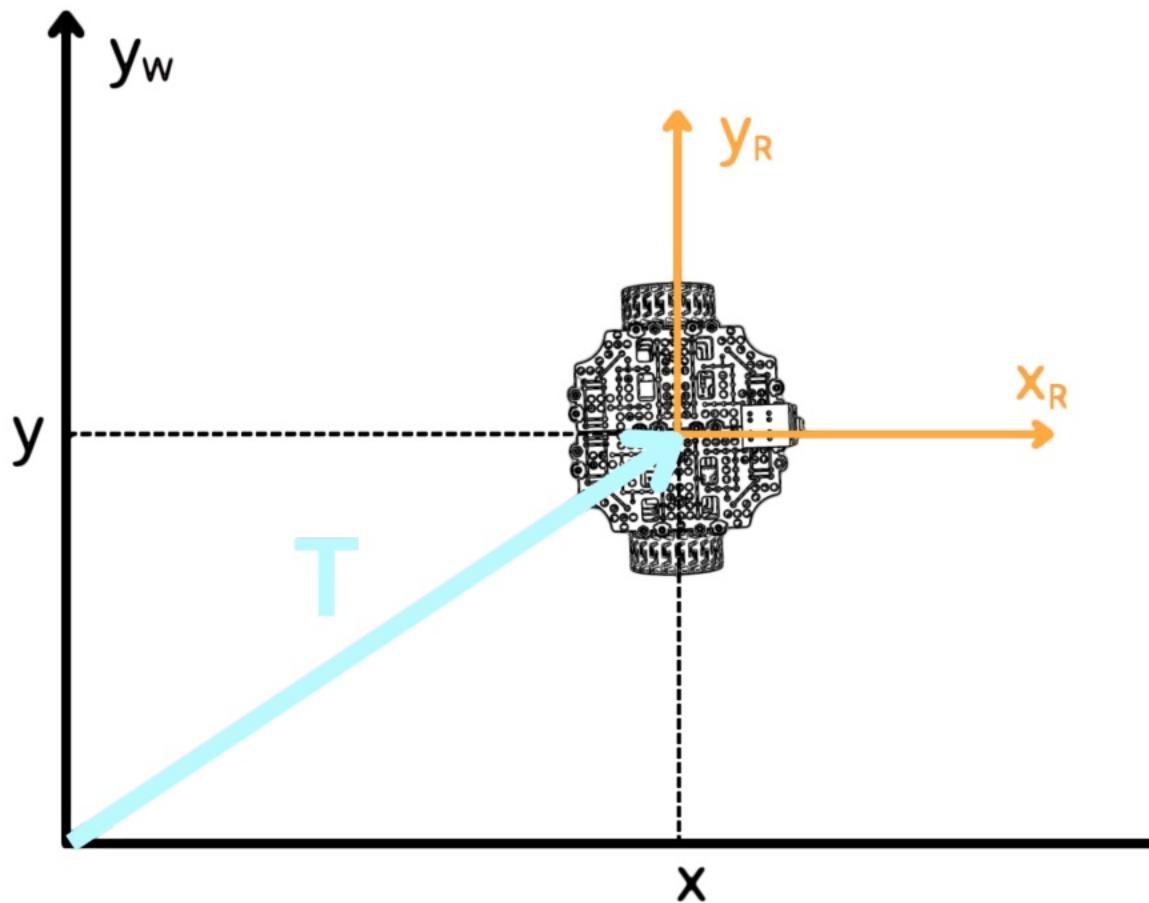
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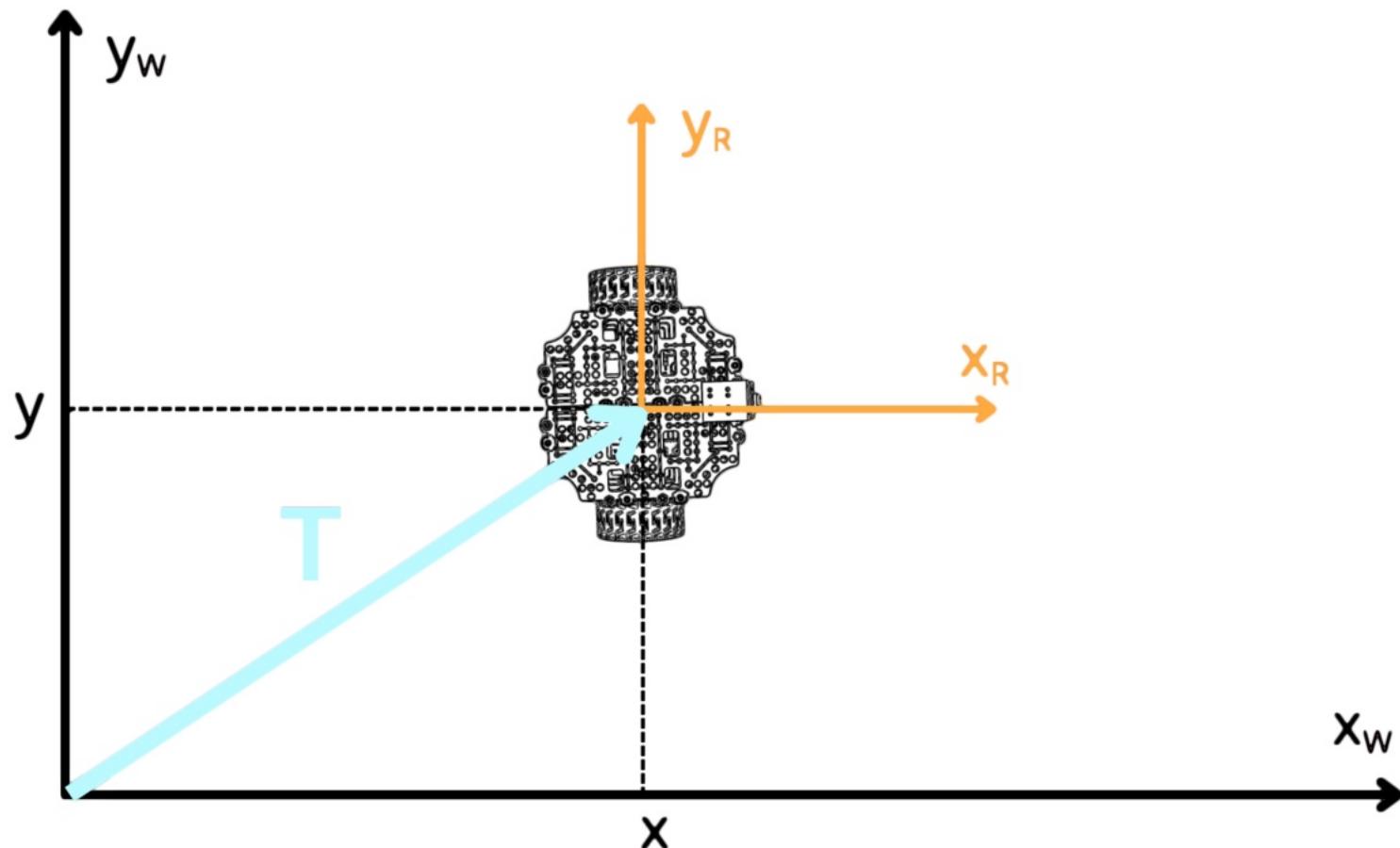
Roto-Translation

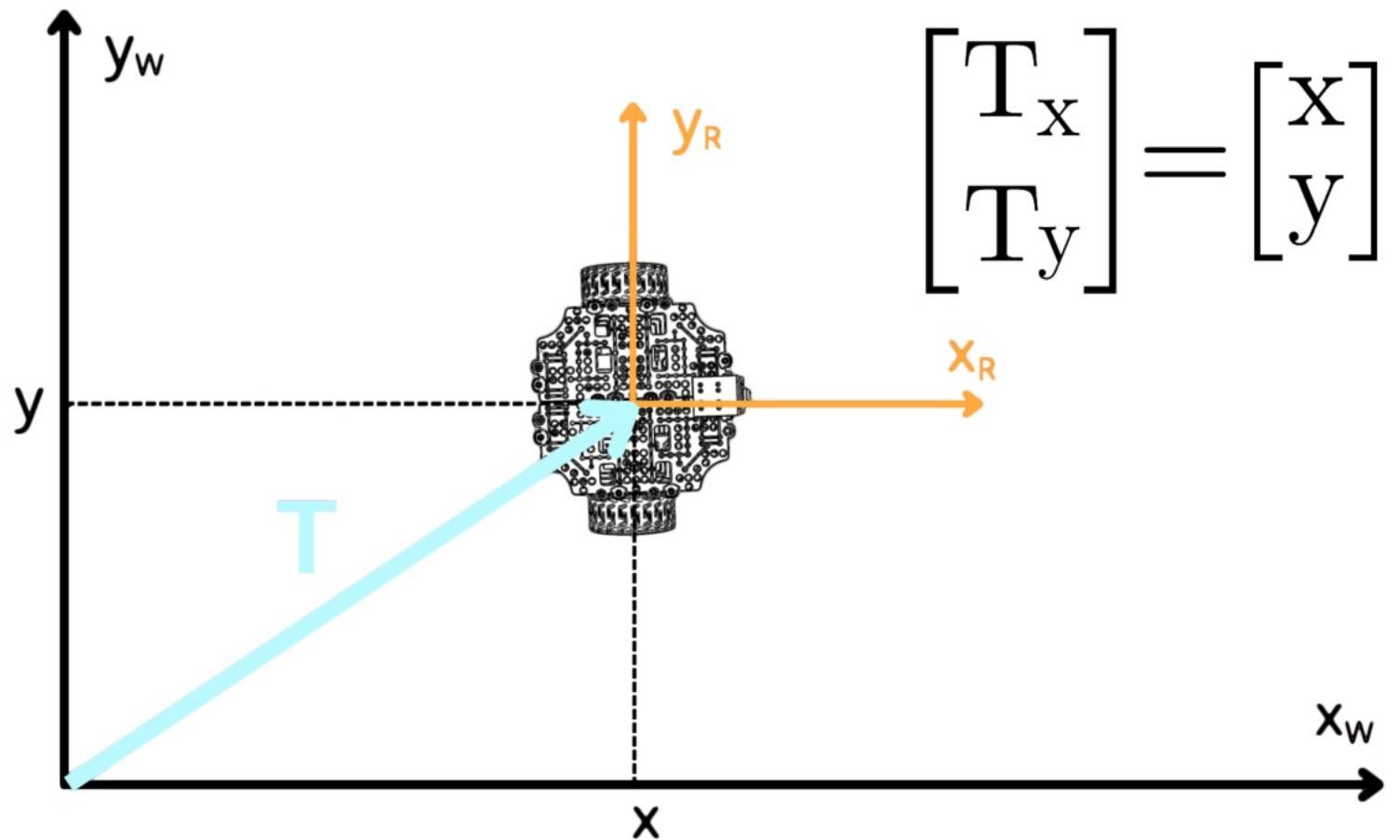


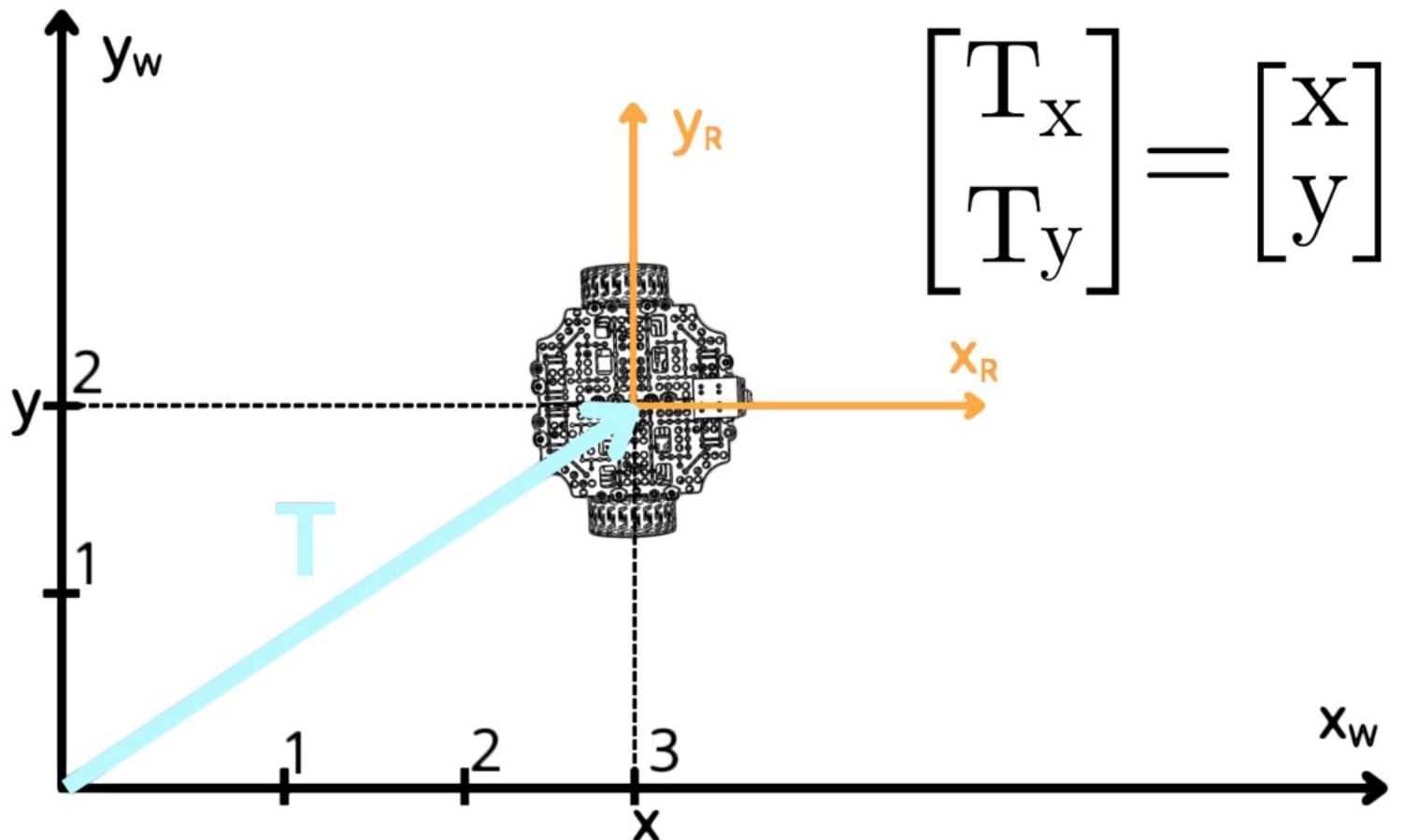


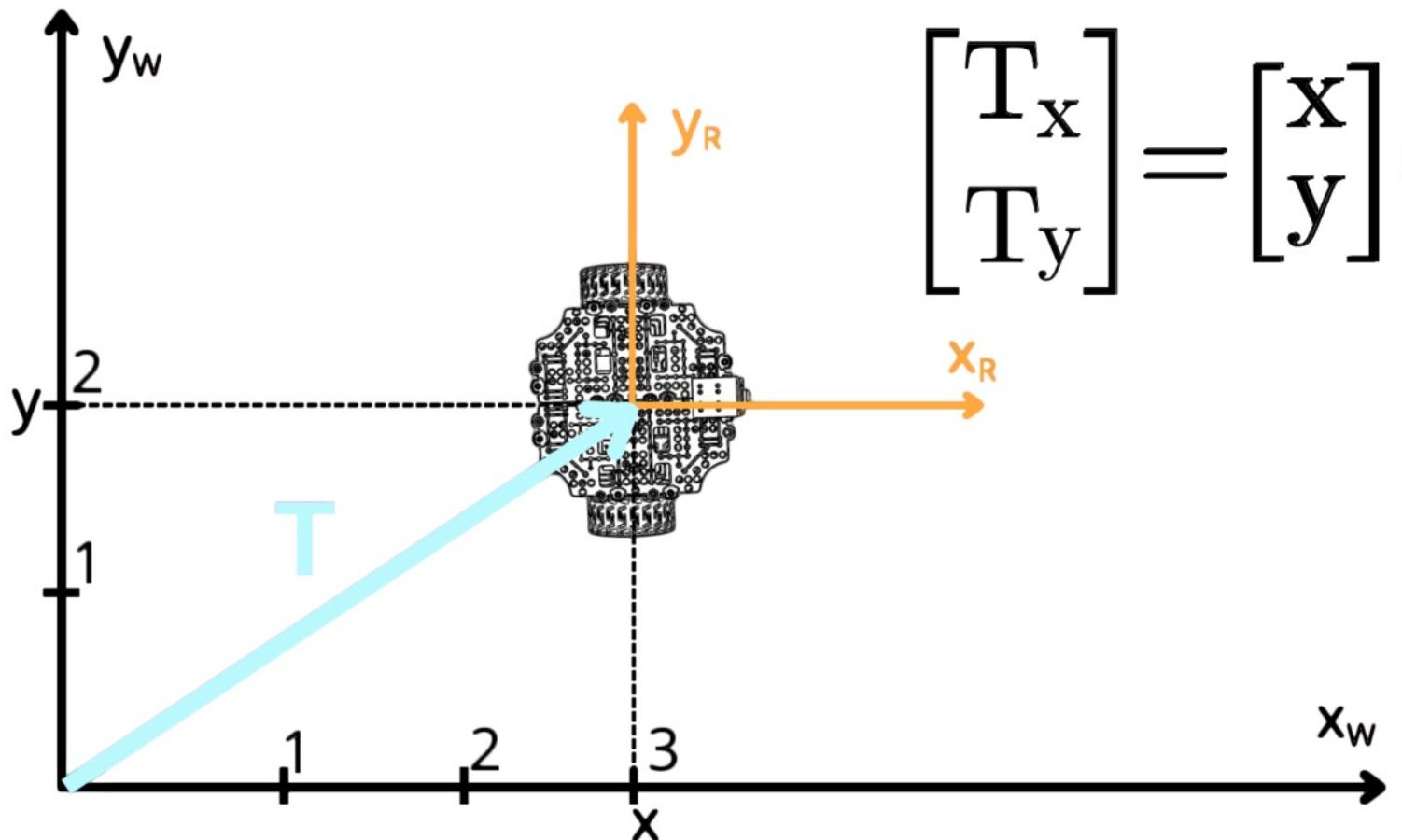


$$\begin{cases} T_x = x \\ T_y = y \end{cases}$$

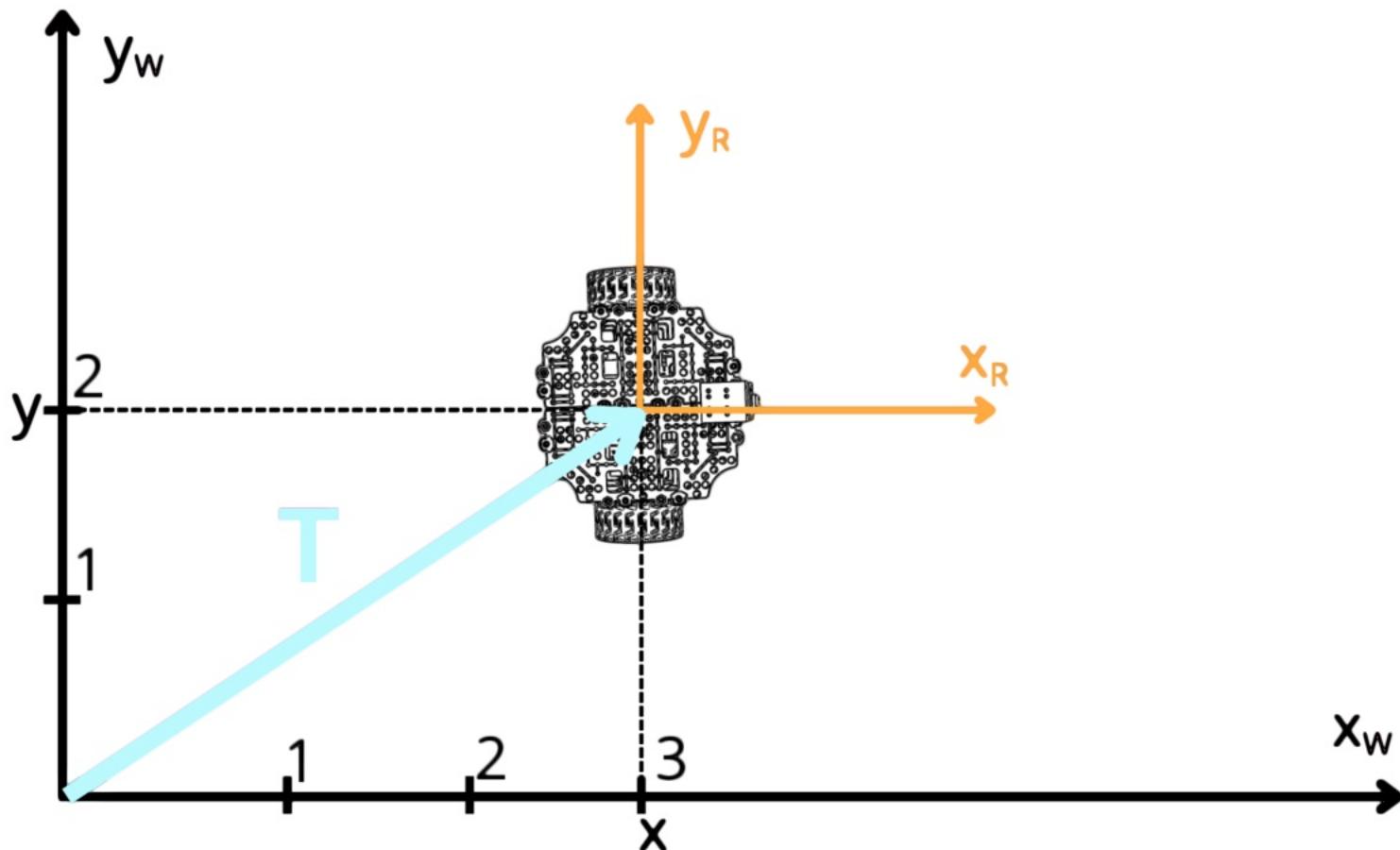


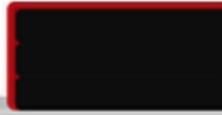
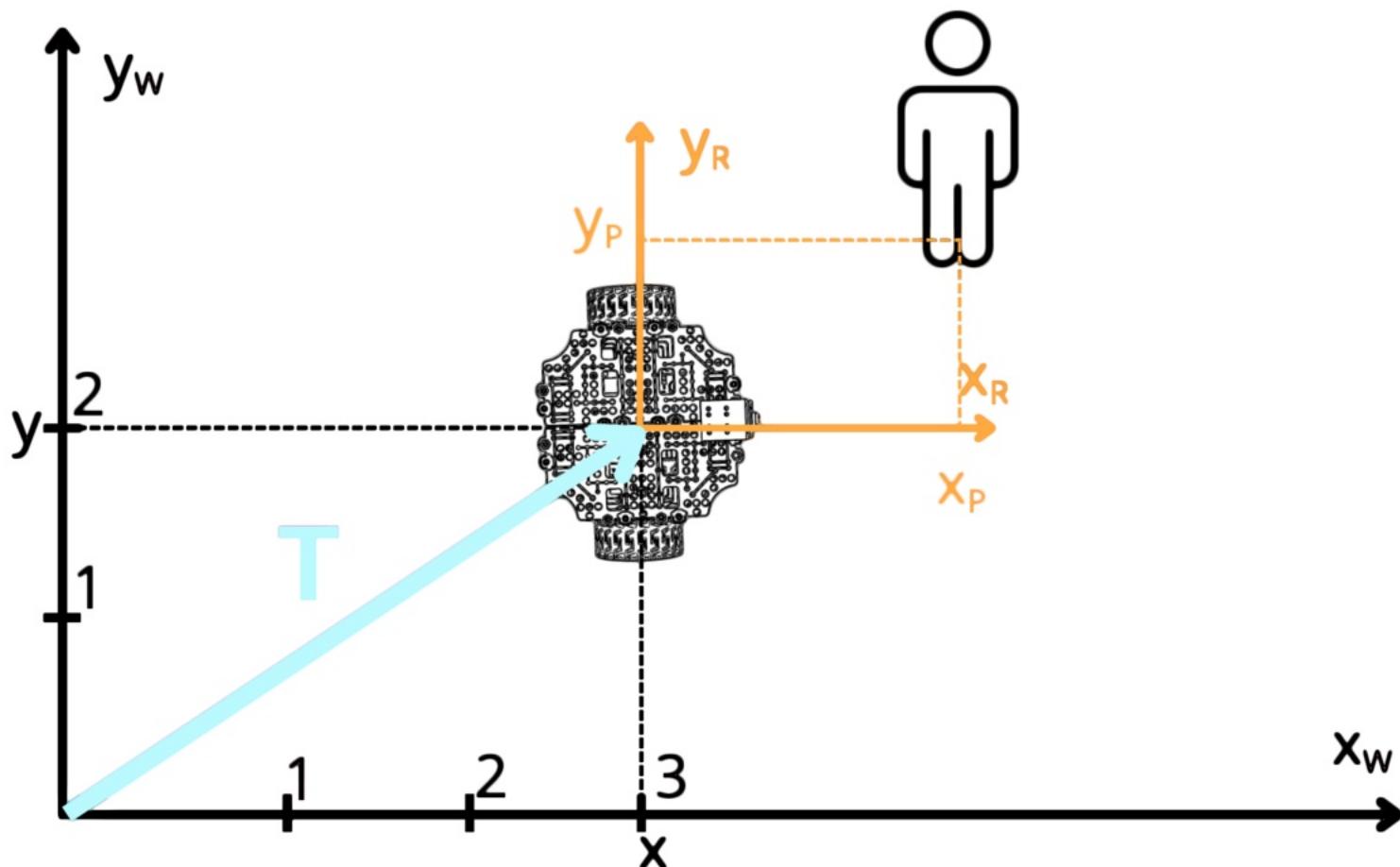


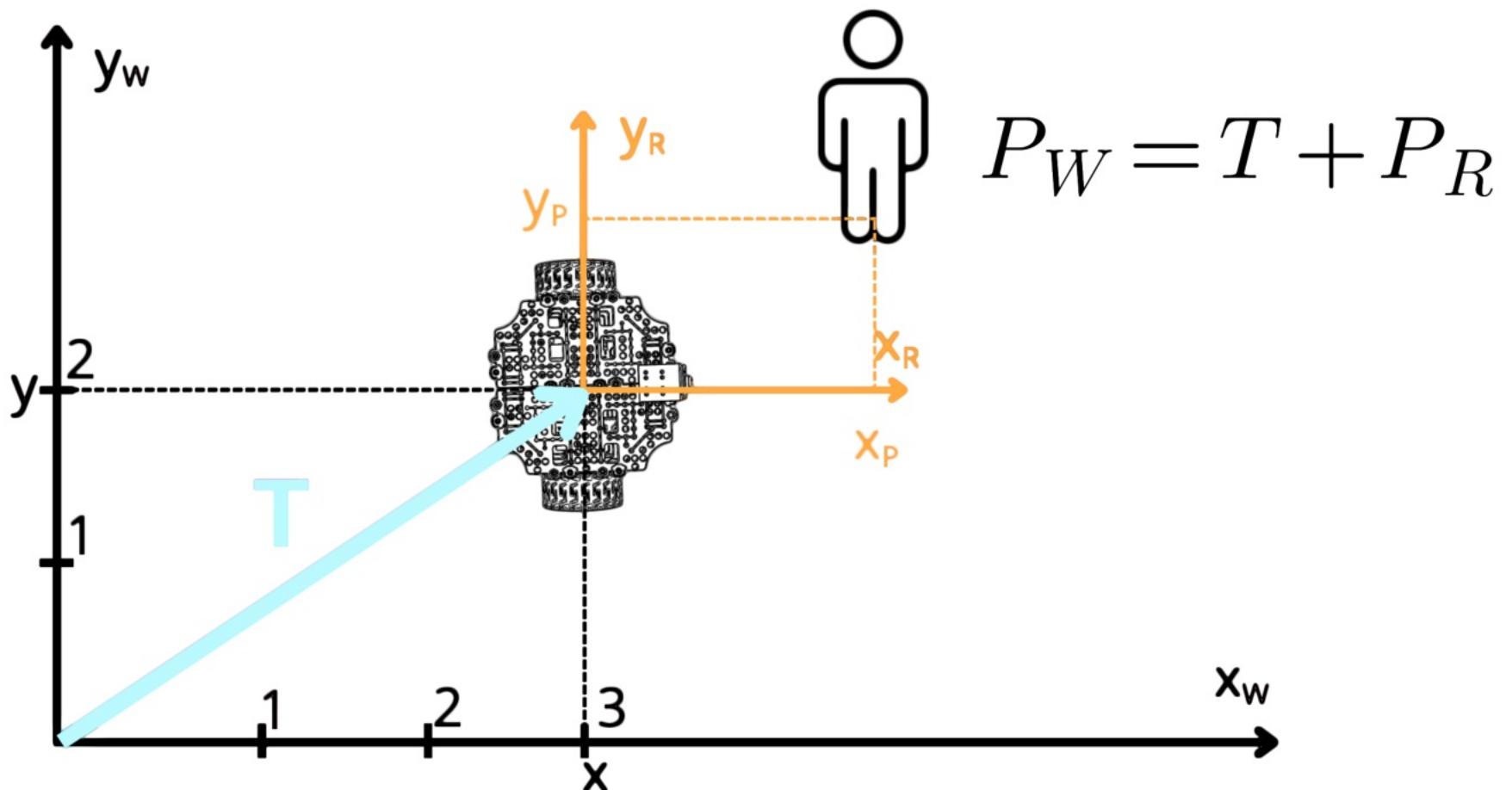


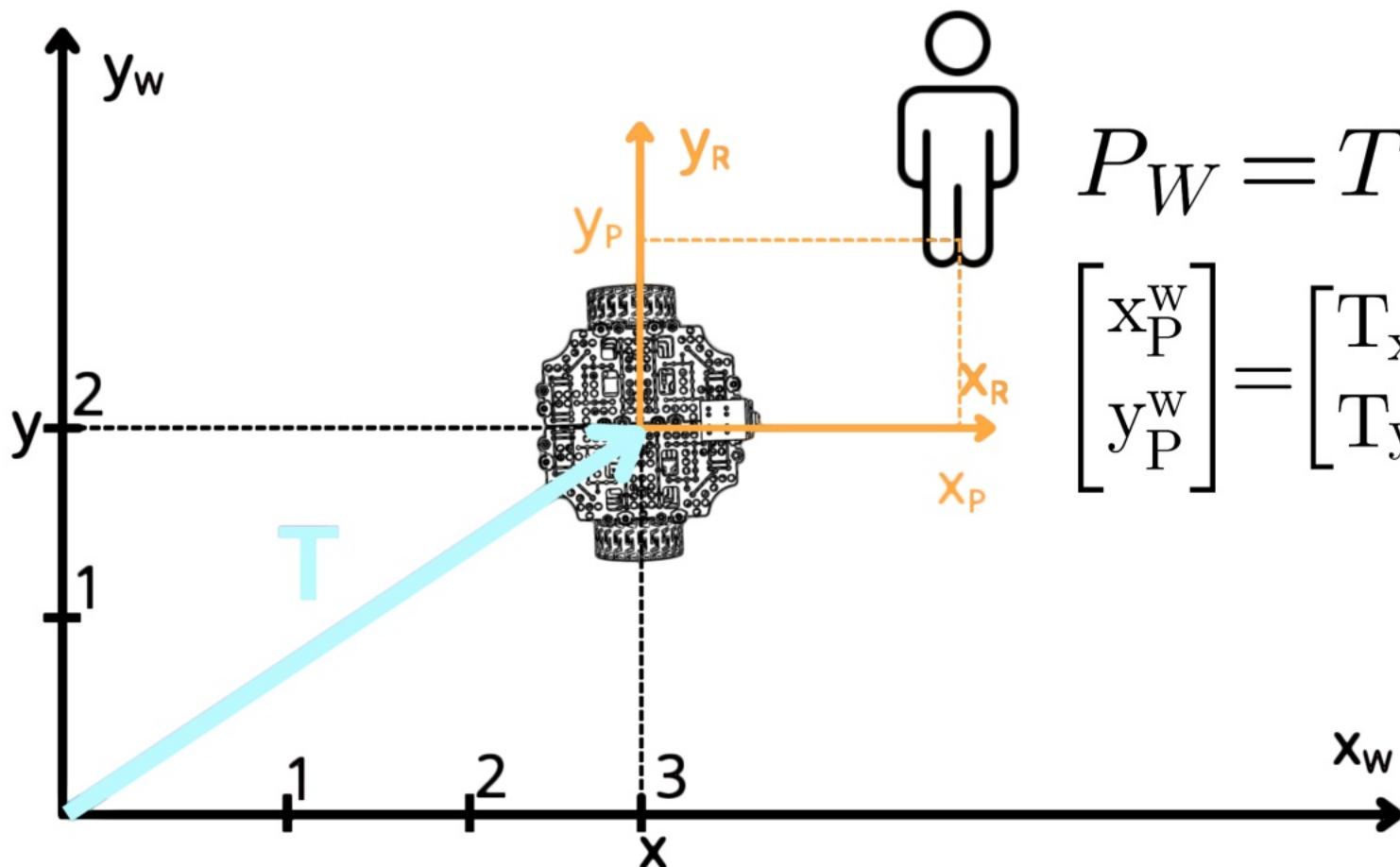


$$\begin{bmatrix} T_x \\ T_y \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \end{bmatrix}$$



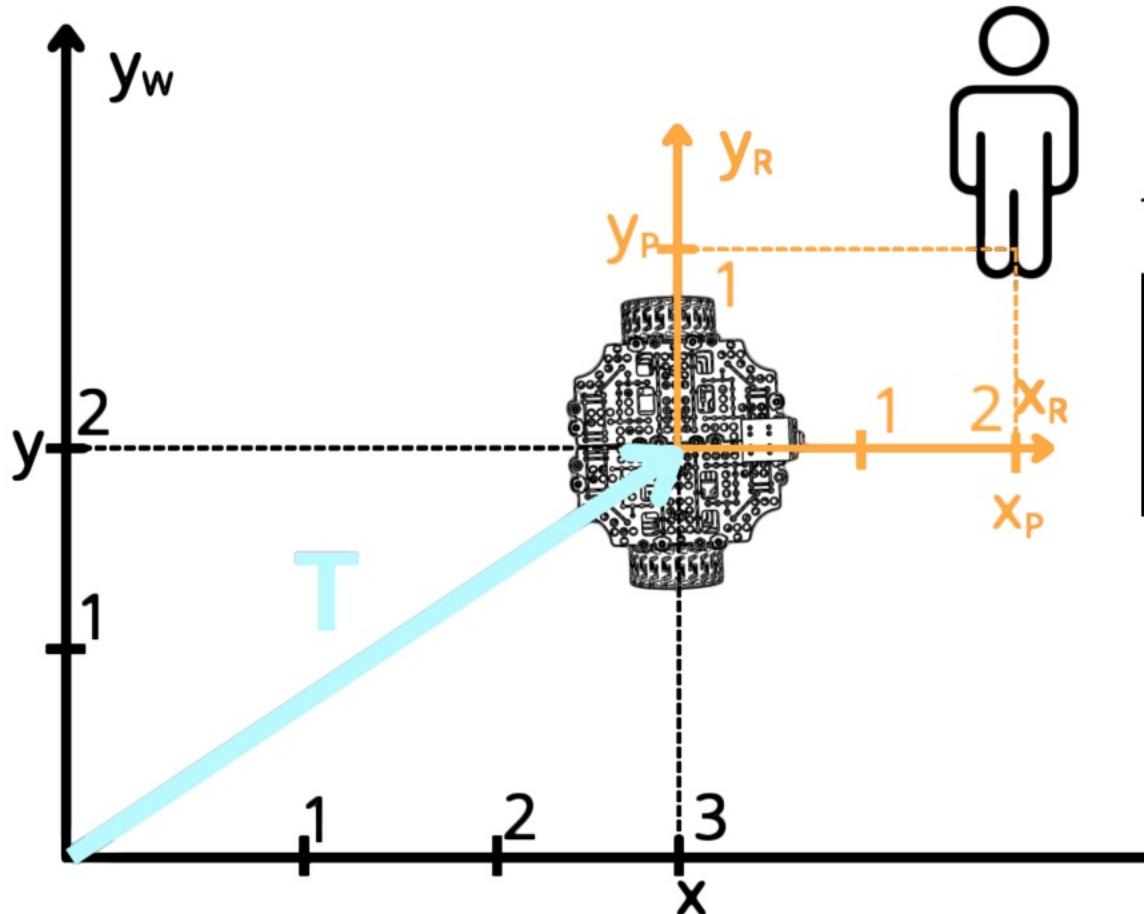






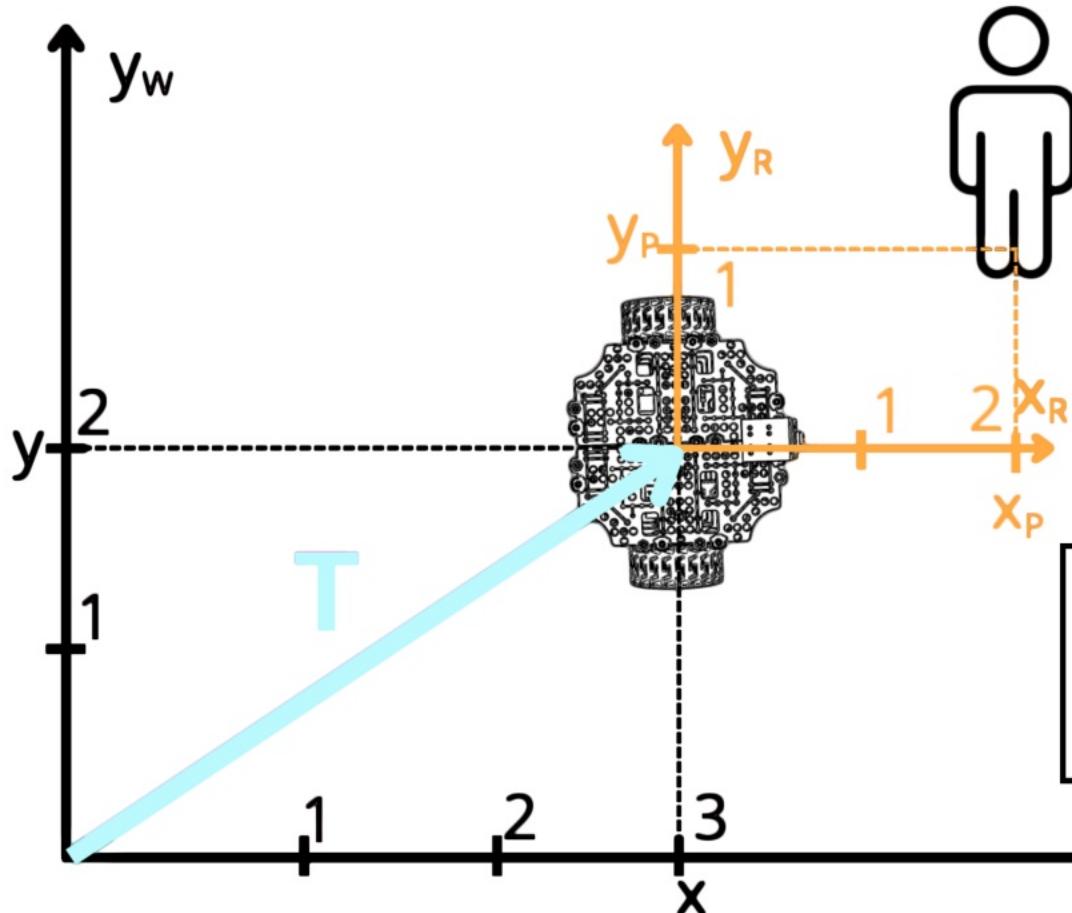
$$P_W = T + P_R$$

$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$



$$P_W = T + P_R$$

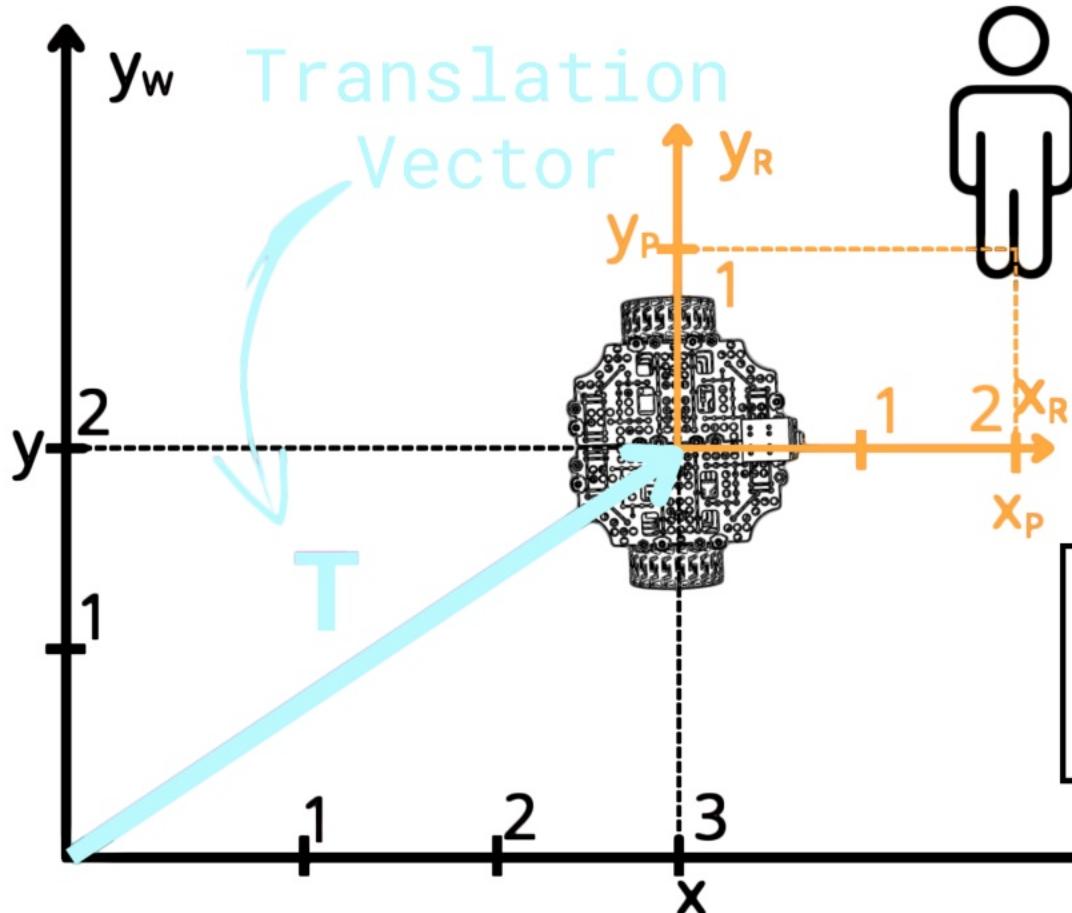
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$



$$P_W = T + P_R$$

$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

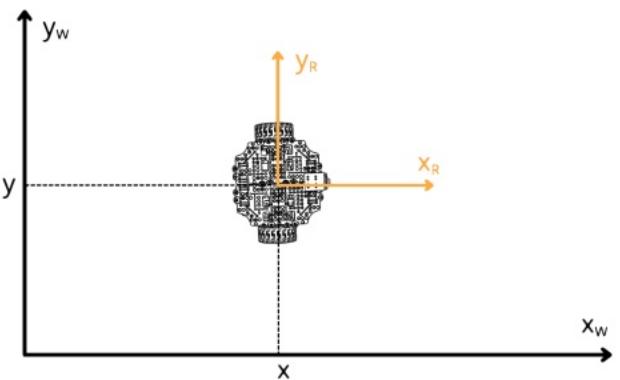
$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 5 \\ 3 \end{bmatrix}$$



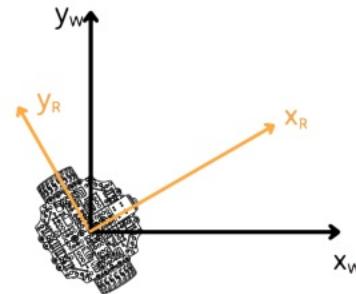
$$P_W = T + P_R$$

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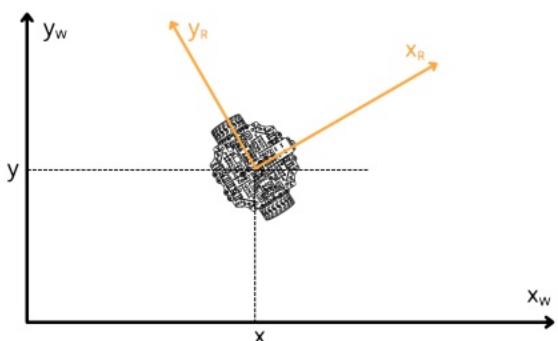
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 5 \\ 3 \end{bmatrix}$$



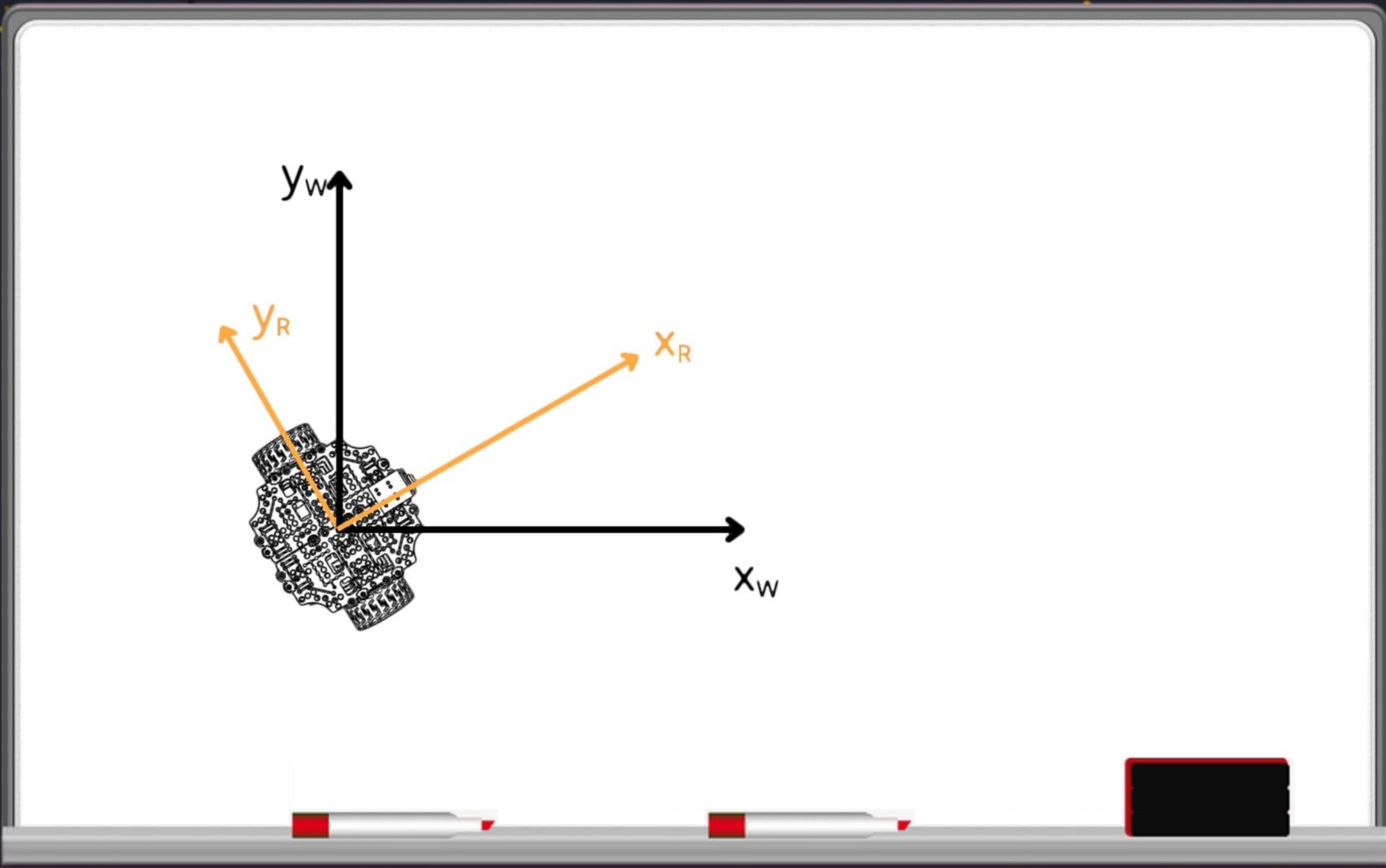
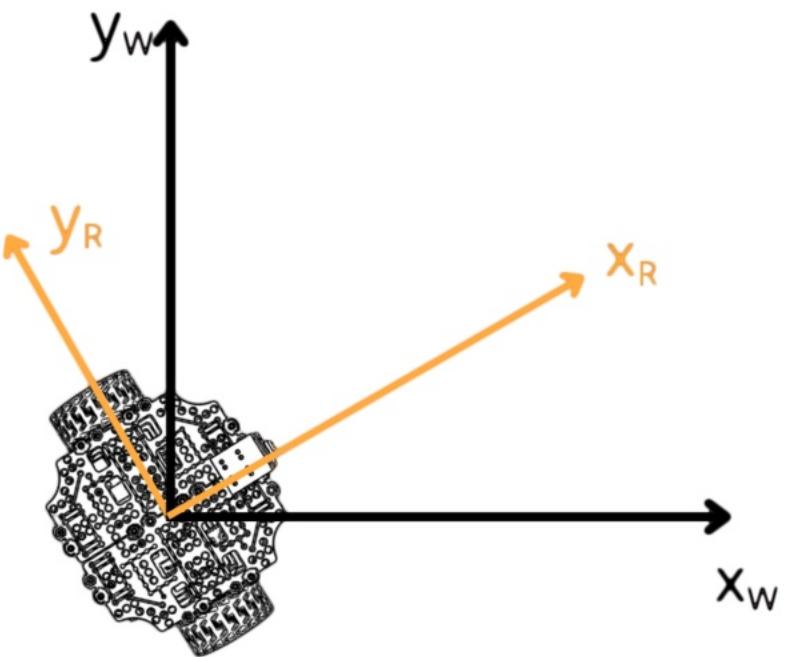
Translation

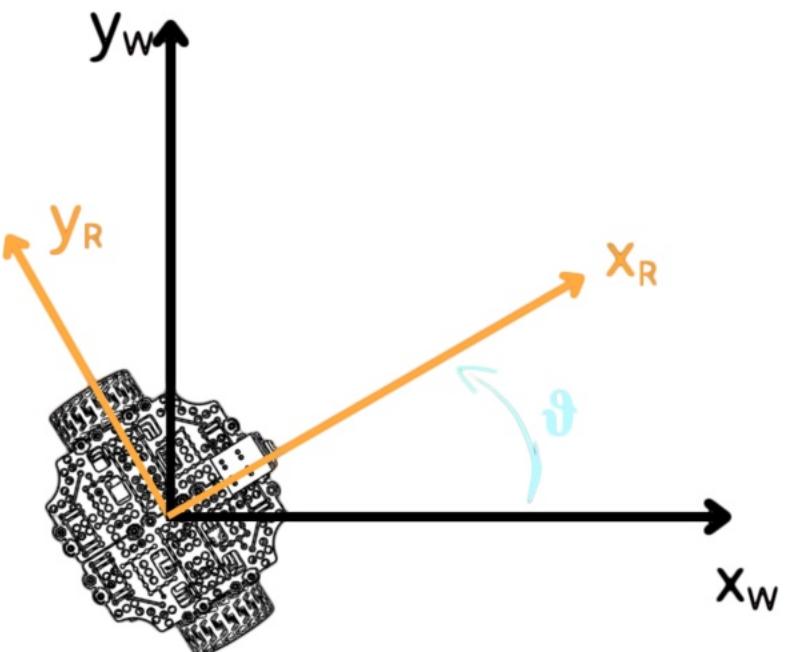


Rotation

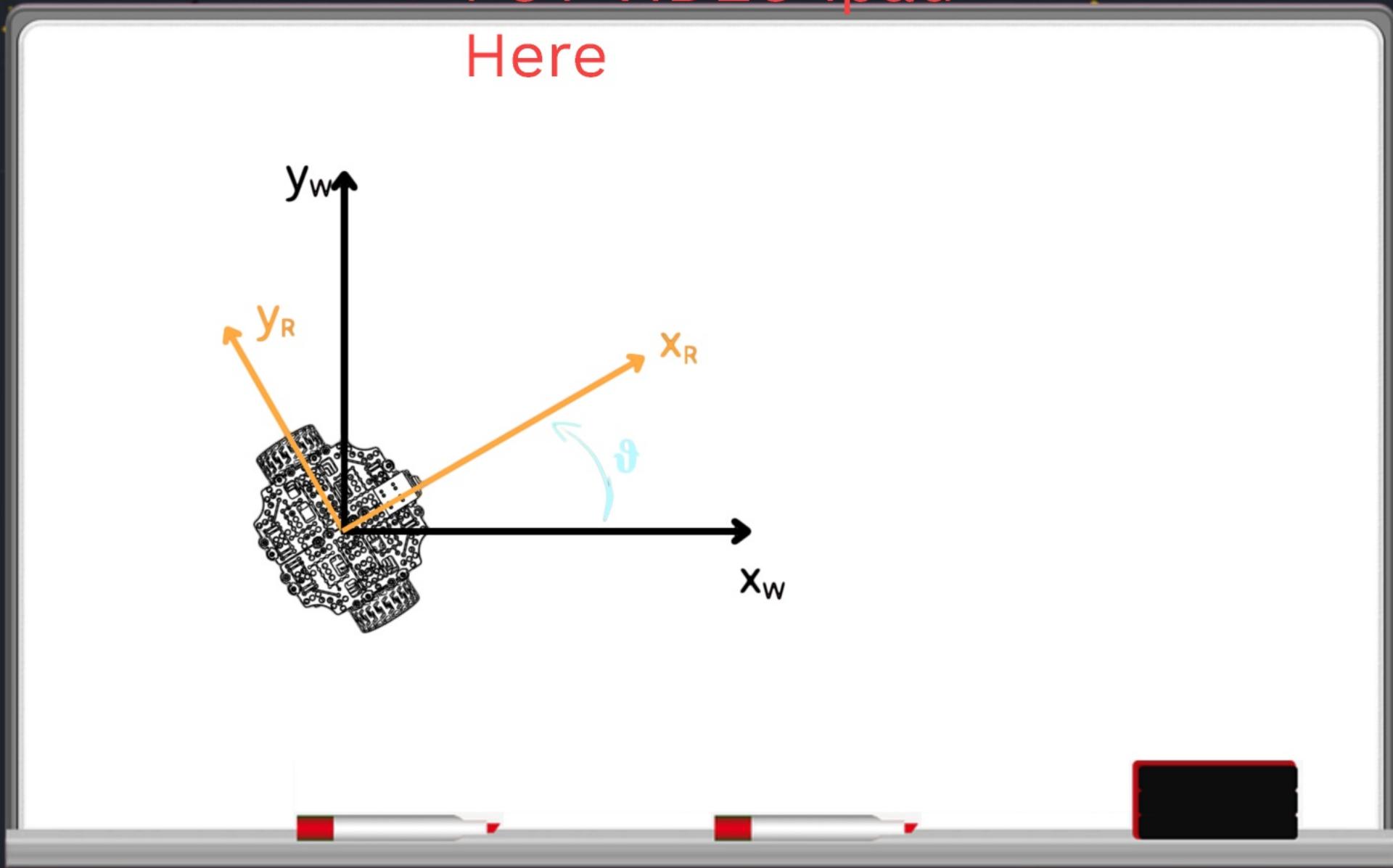
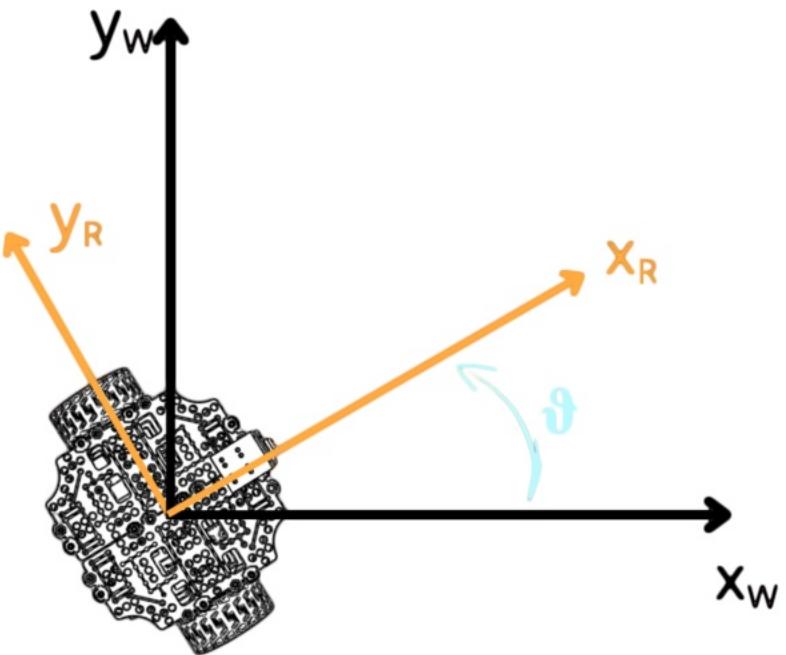


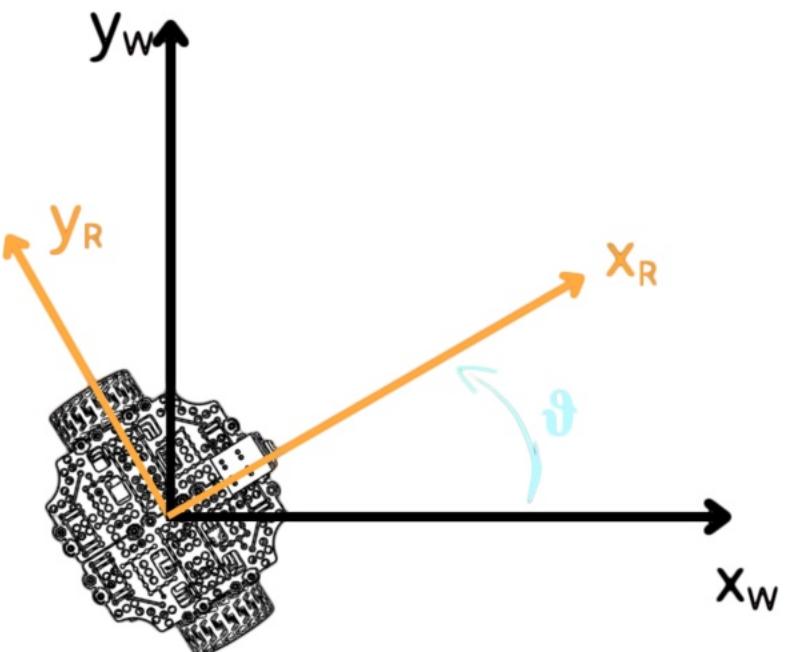
Roto-Translation

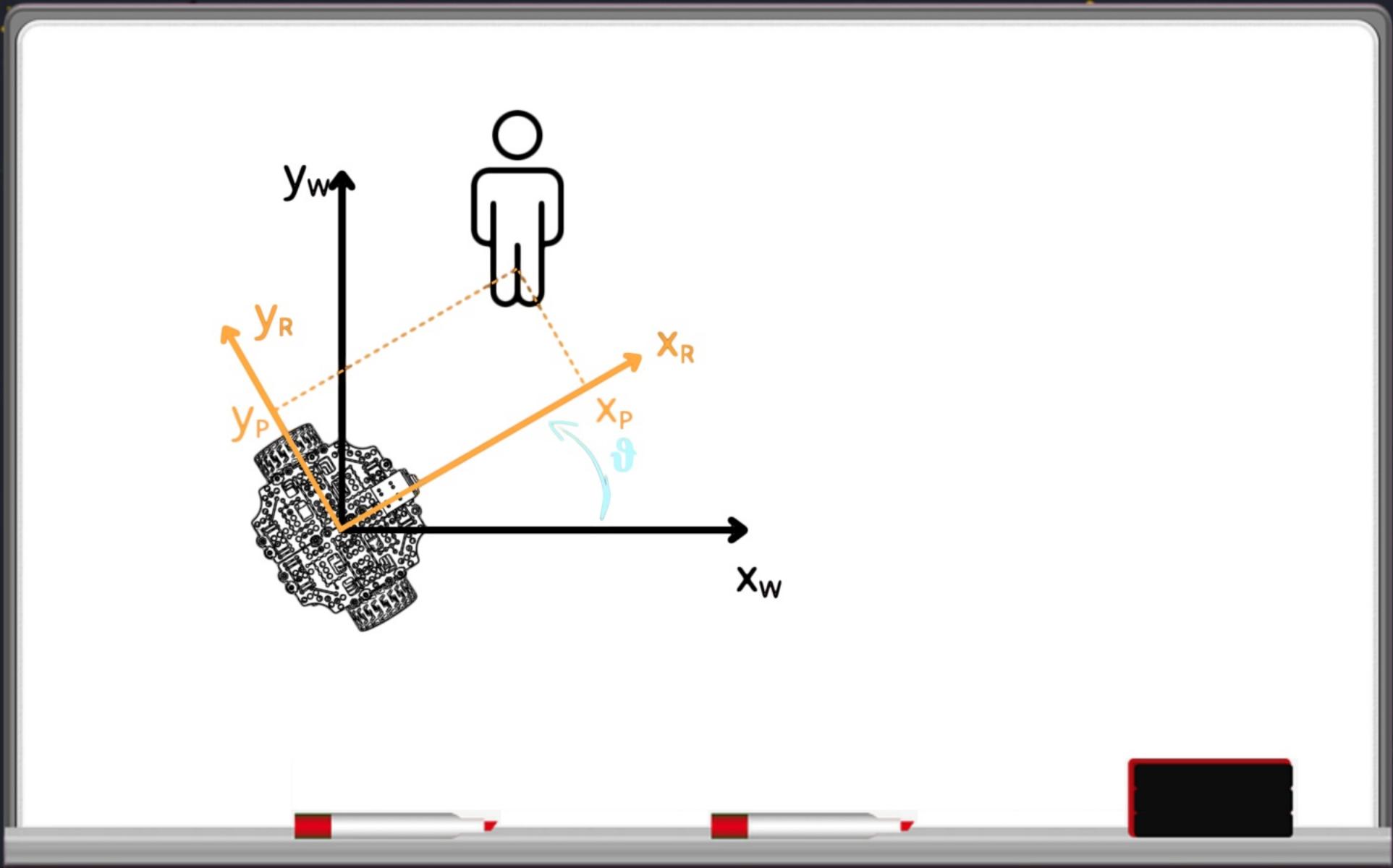
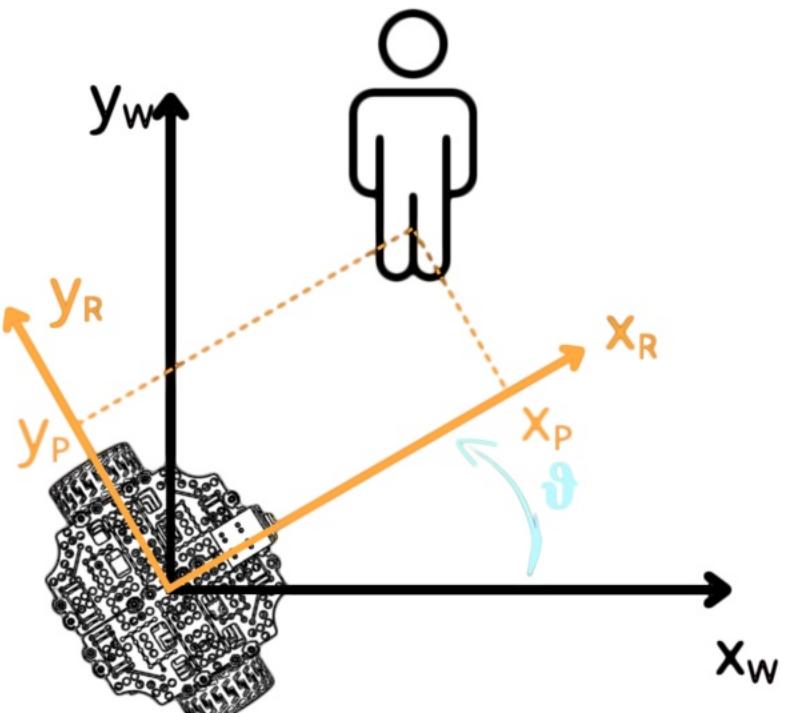


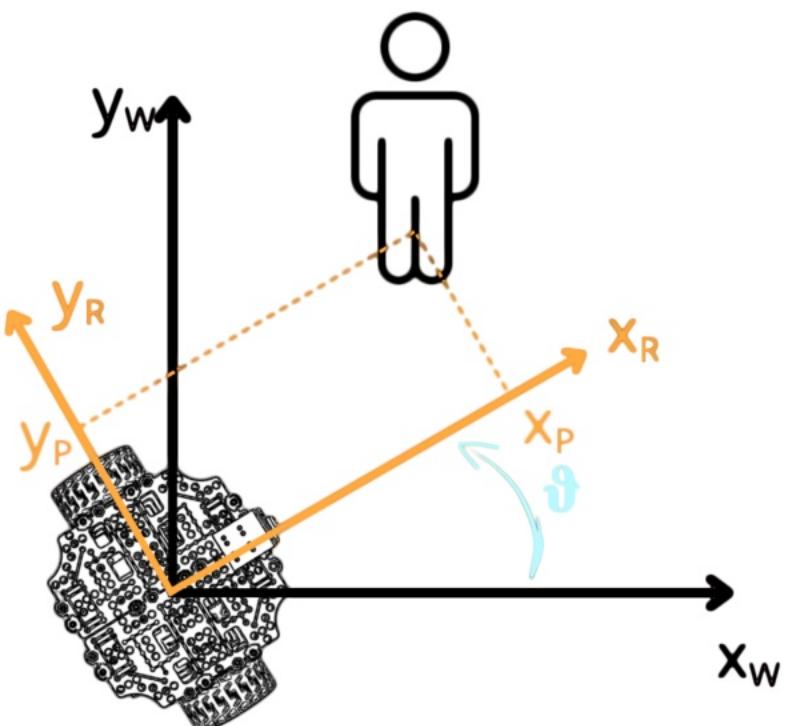


PUT VIDEO ipad
Here

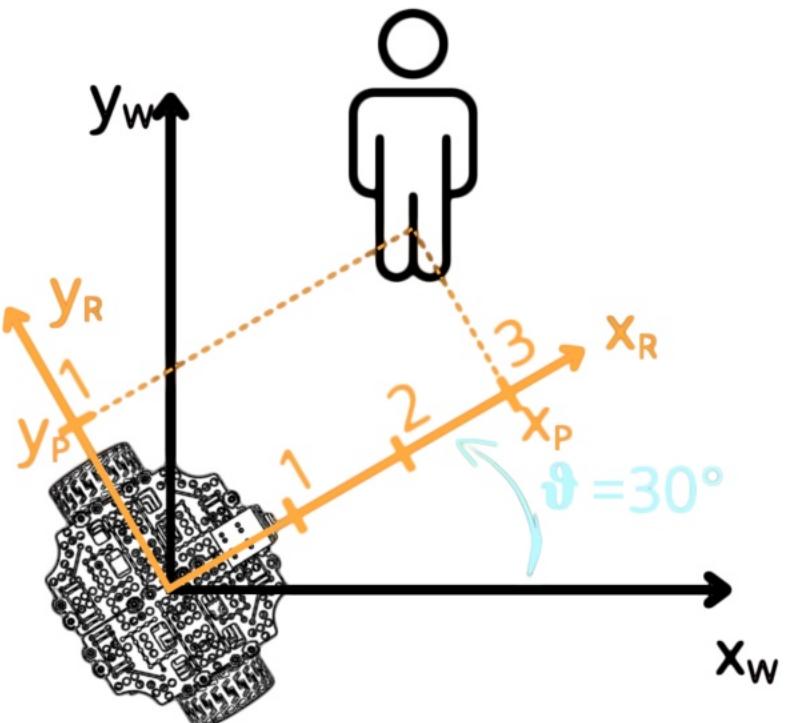




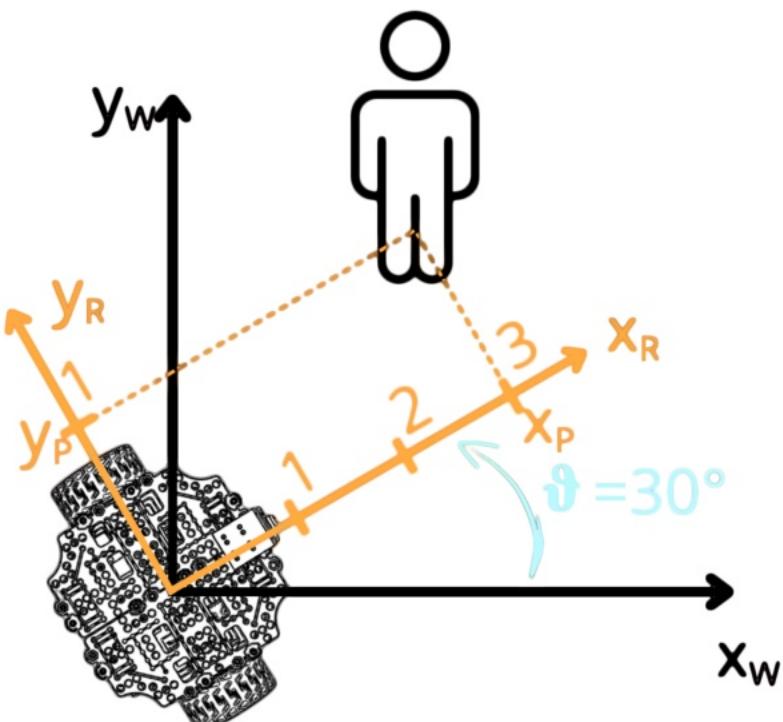




$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

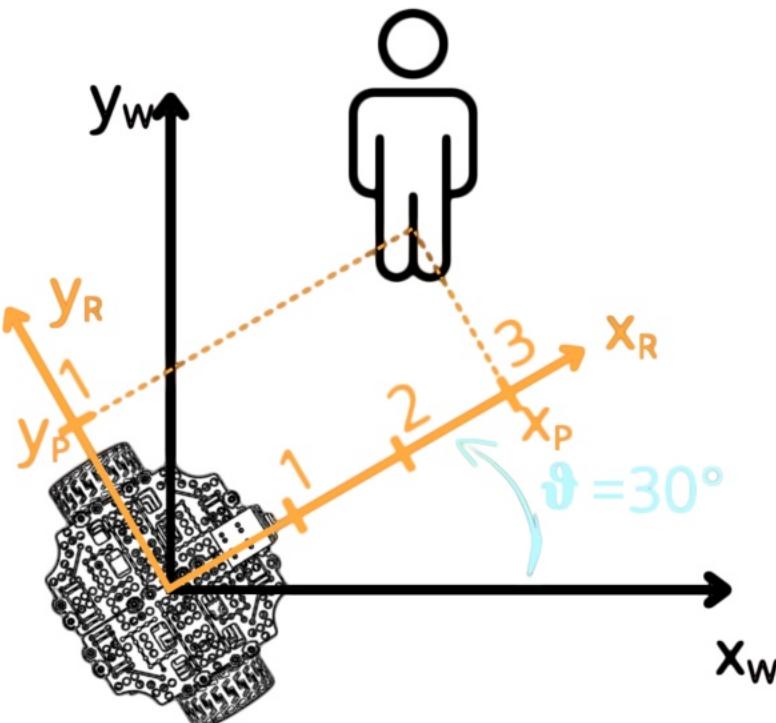


$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$



$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) \\ \sin(30) & \cos(30) \end{bmatrix} \begin{bmatrix} 3 \\ 1 \end{bmatrix}$$

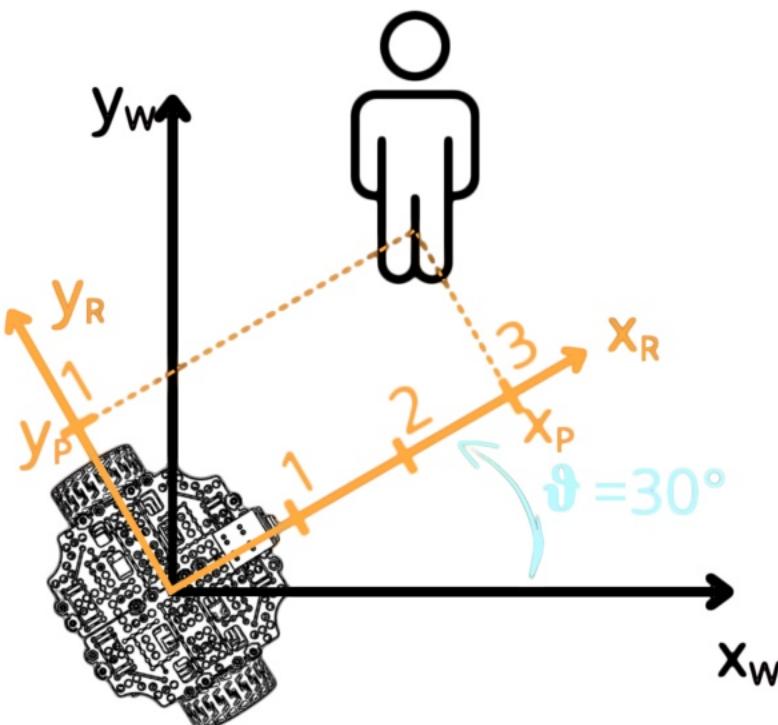


$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) \\ \sin(30) & \cos(30) \end{bmatrix} \begin{bmatrix} 3 \\ 1 \end{bmatrix}$$

$$x_P^W = \cos(30) \cdot 3 - \sin(30) \cdot 1$$

$$y_P^W = \sin(30) \cdot 3 + \cos(30) \cdot 1$$



$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

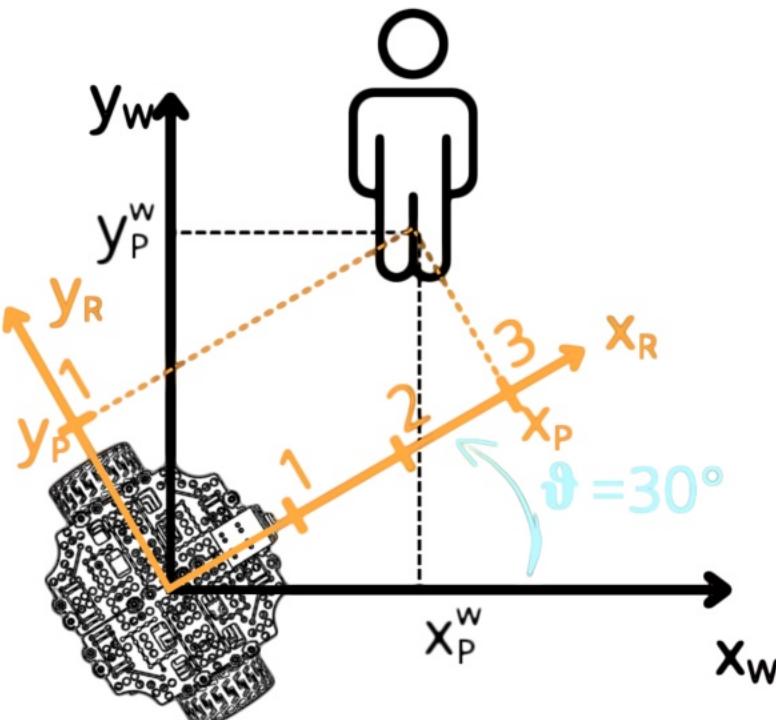
$$\begin{bmatrix} x_P^W \\ y_P^W \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) \\ \sin(30) & \cos(30) \end{bmatrix} \begin{bmatrix} 3 \\ 1 \end{bmatrix}$$

$$x_P^W = \cos(30) \cdot 3 - \sin(30) \cdot 1$$

$$y_P^W = \sin(30) \cdot 3 + \cos(30) \cdot 1$$

$$x_P^W = 2.6 - 0.5 = 2.1$$

$$y_P^W = 1.5 + 0.87 = 2.37$$



$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

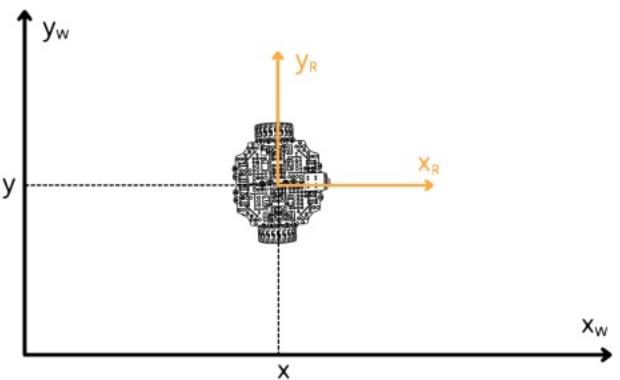
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) \\ \sin(30) & \cos(30) \end{bmatrix} \begin{bmatrix} 3 \\ 1 \end{bmatrix}$$

$$x_P^w = \cos(30) \cdot 3 - \sin(30) \cdot 1$$

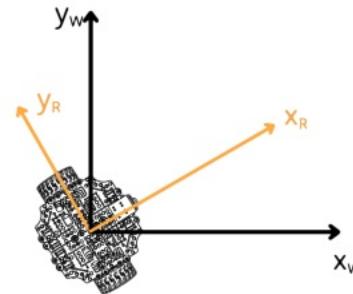
$$y_P^w = \sin(30) \cdot 3 + \cos(30) \cdot 1$$

$$x_P^w = 2.6 - 0.5 = 2.1$$

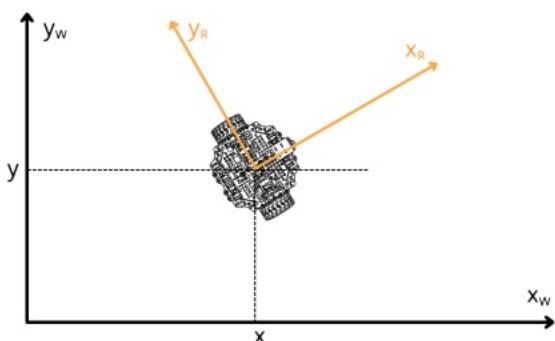
$$y_P^w = 1.5 + 0.87 = 2.37$$



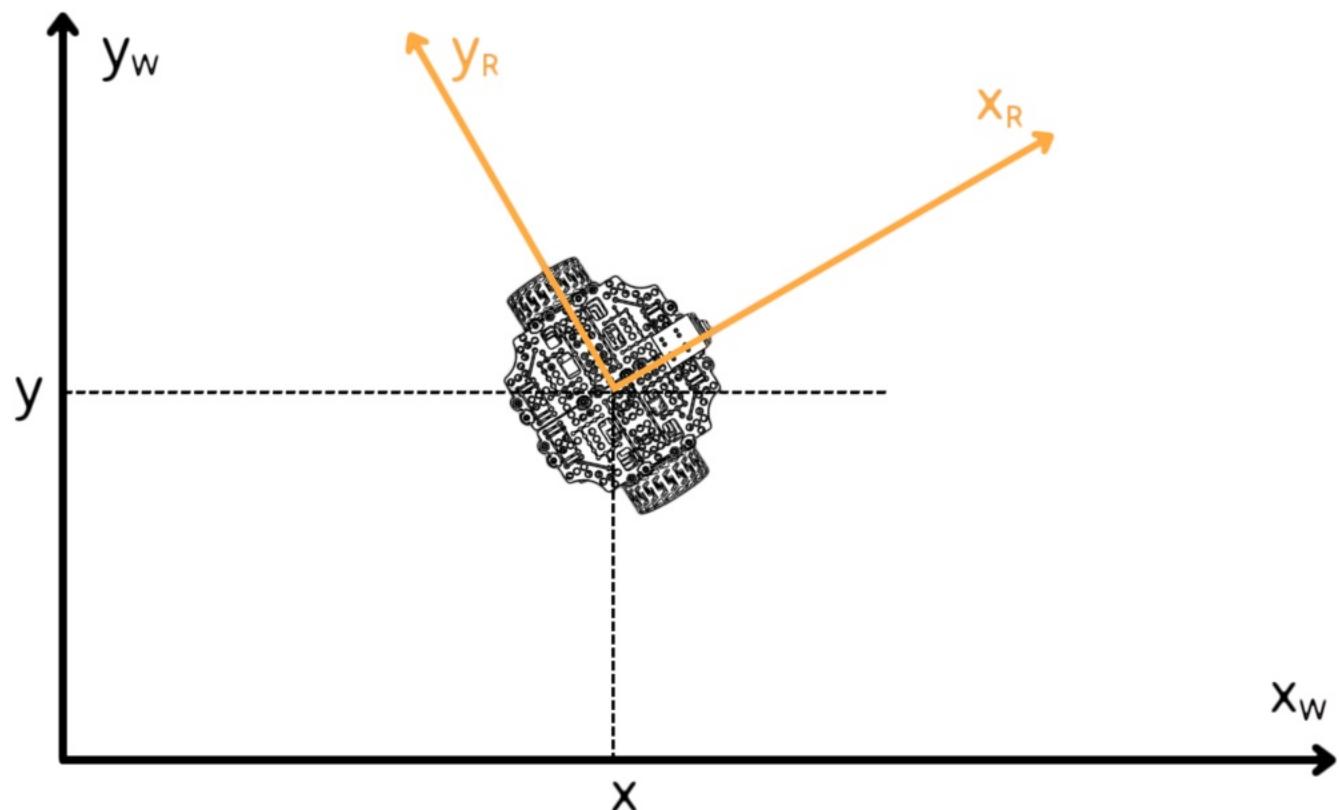
Translation

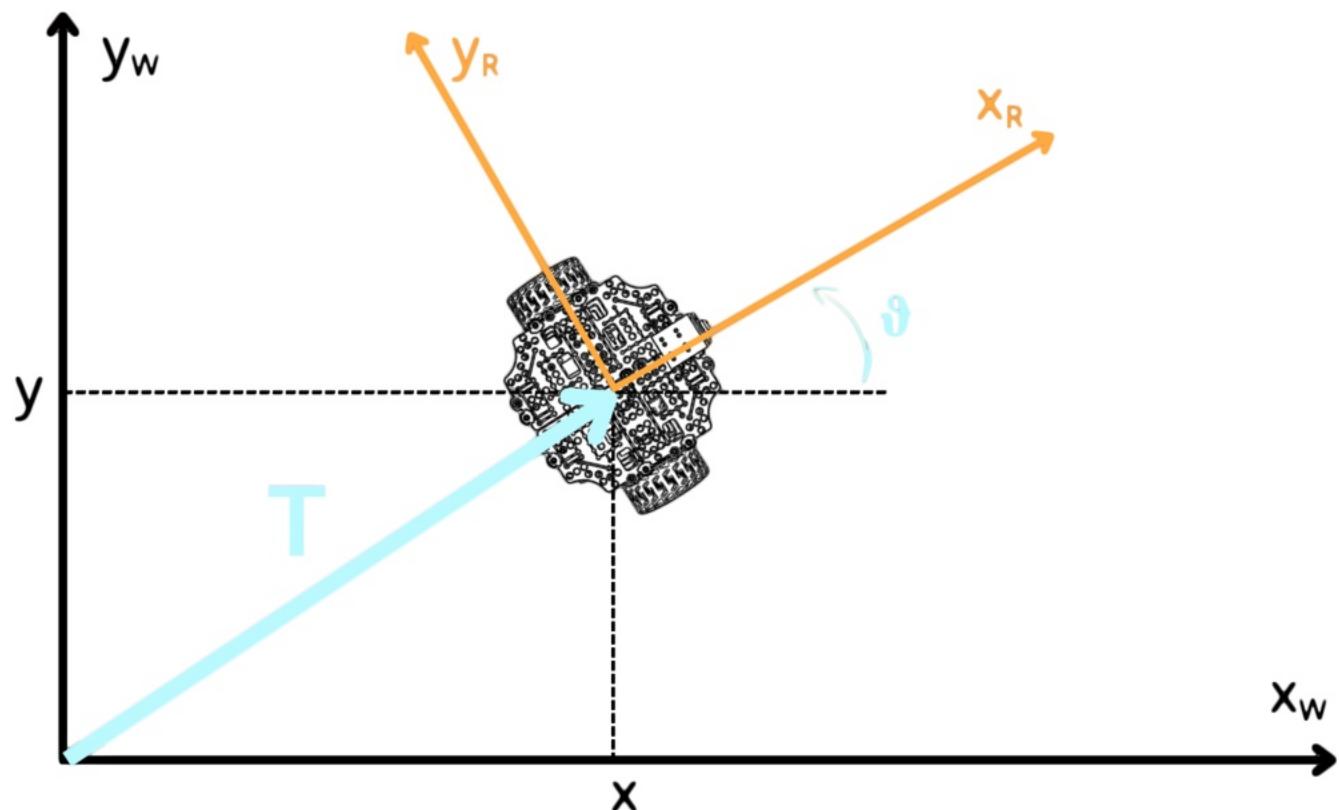


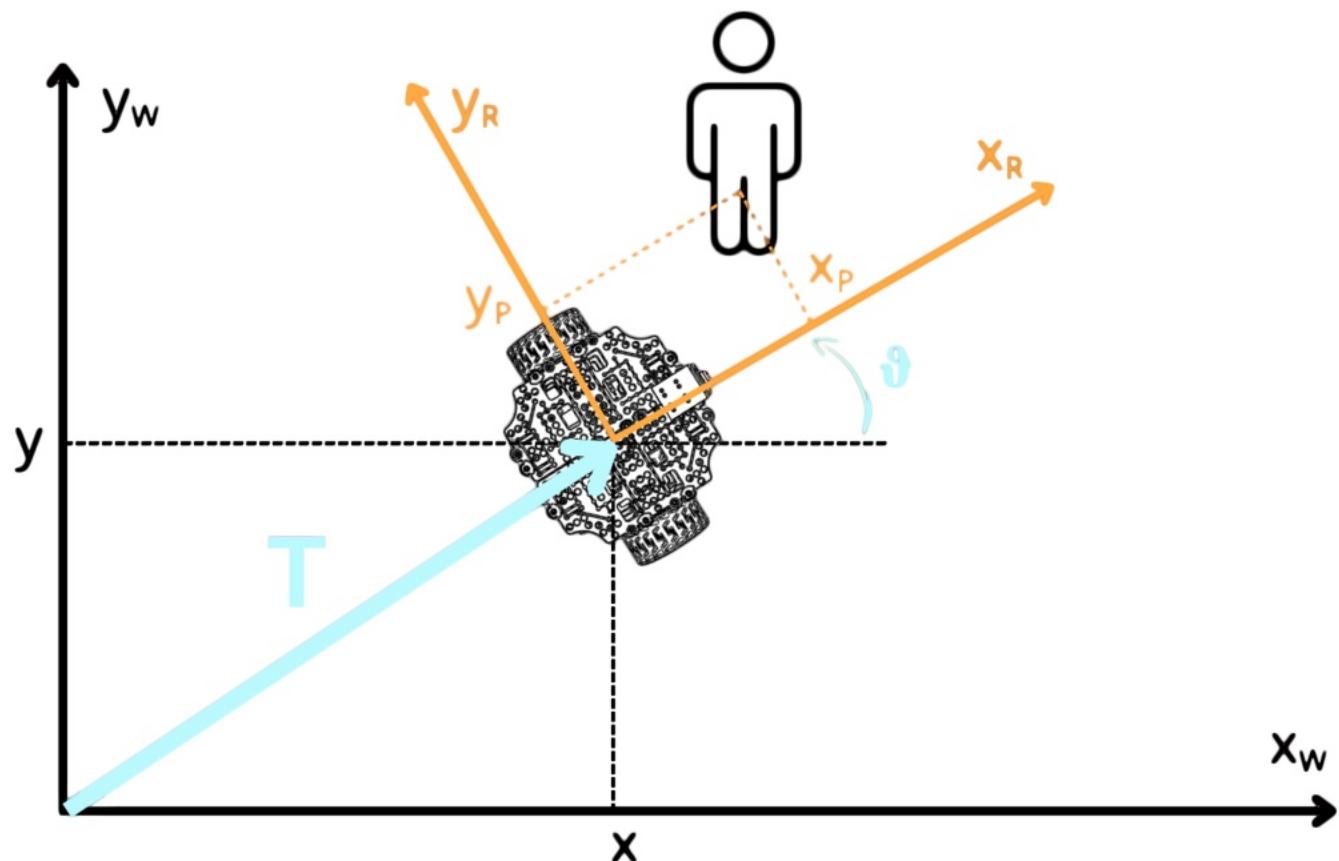
Rotation

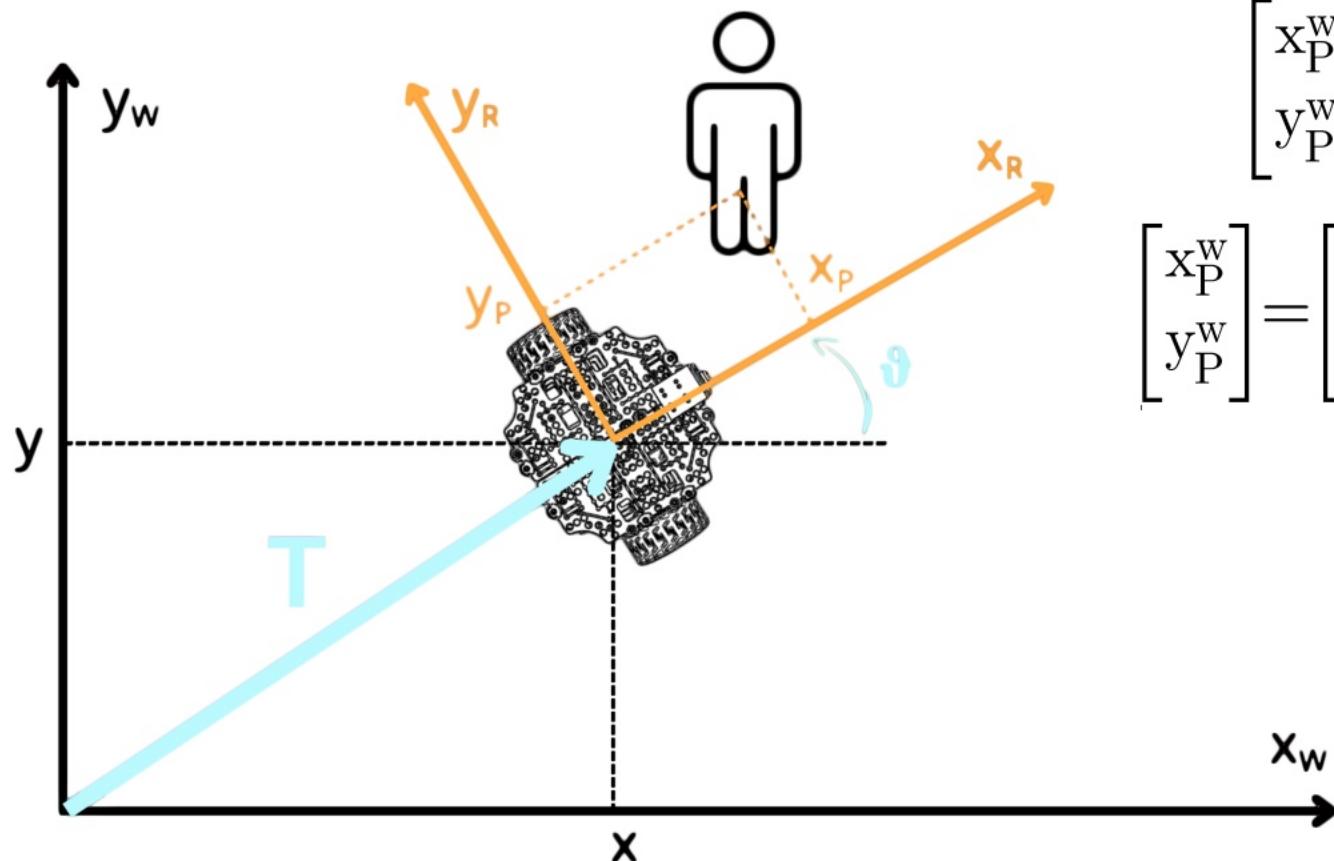


Roto-Translation



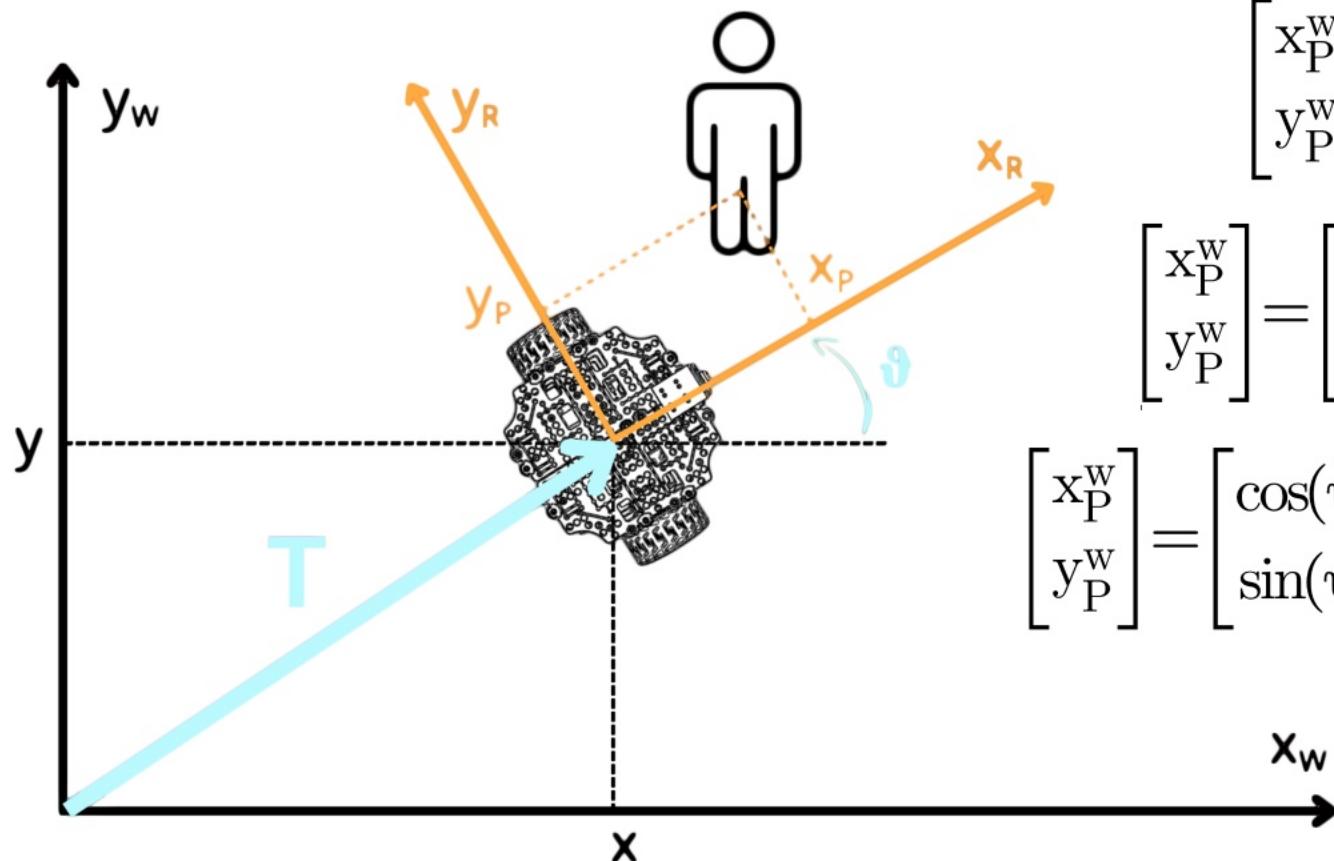






$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

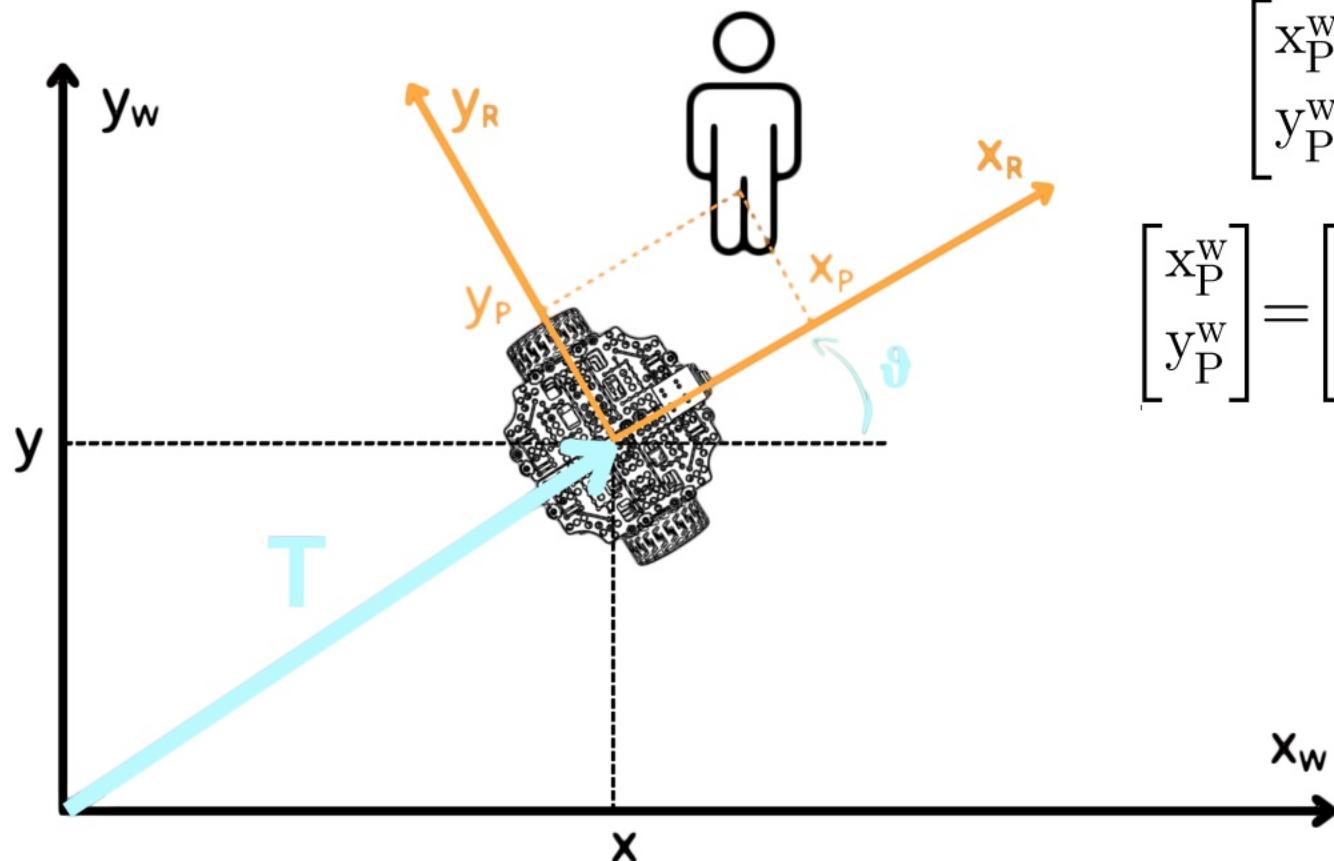
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$



$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

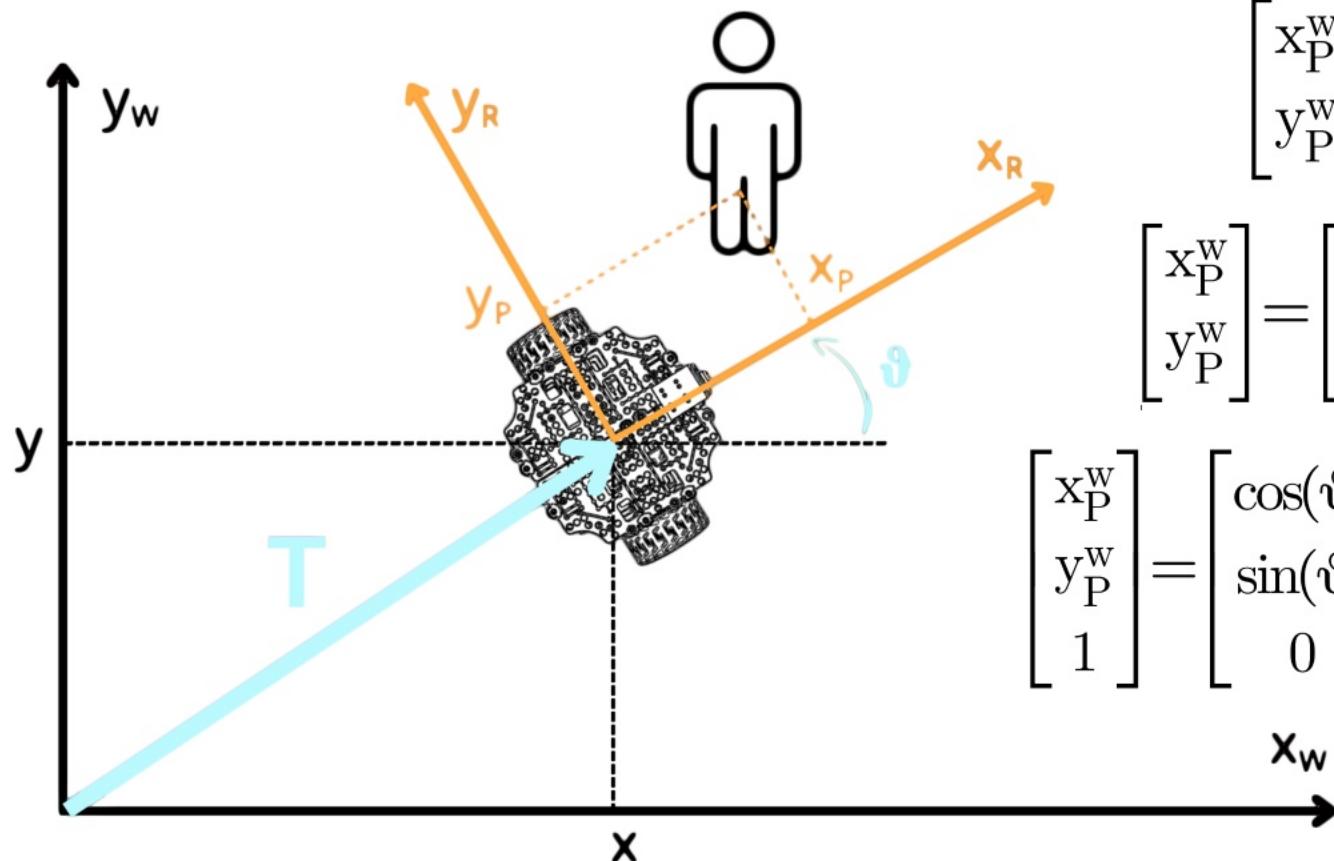
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & T_x \\ \sin(\theta) & \cos(\theta) & T_y \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$



$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

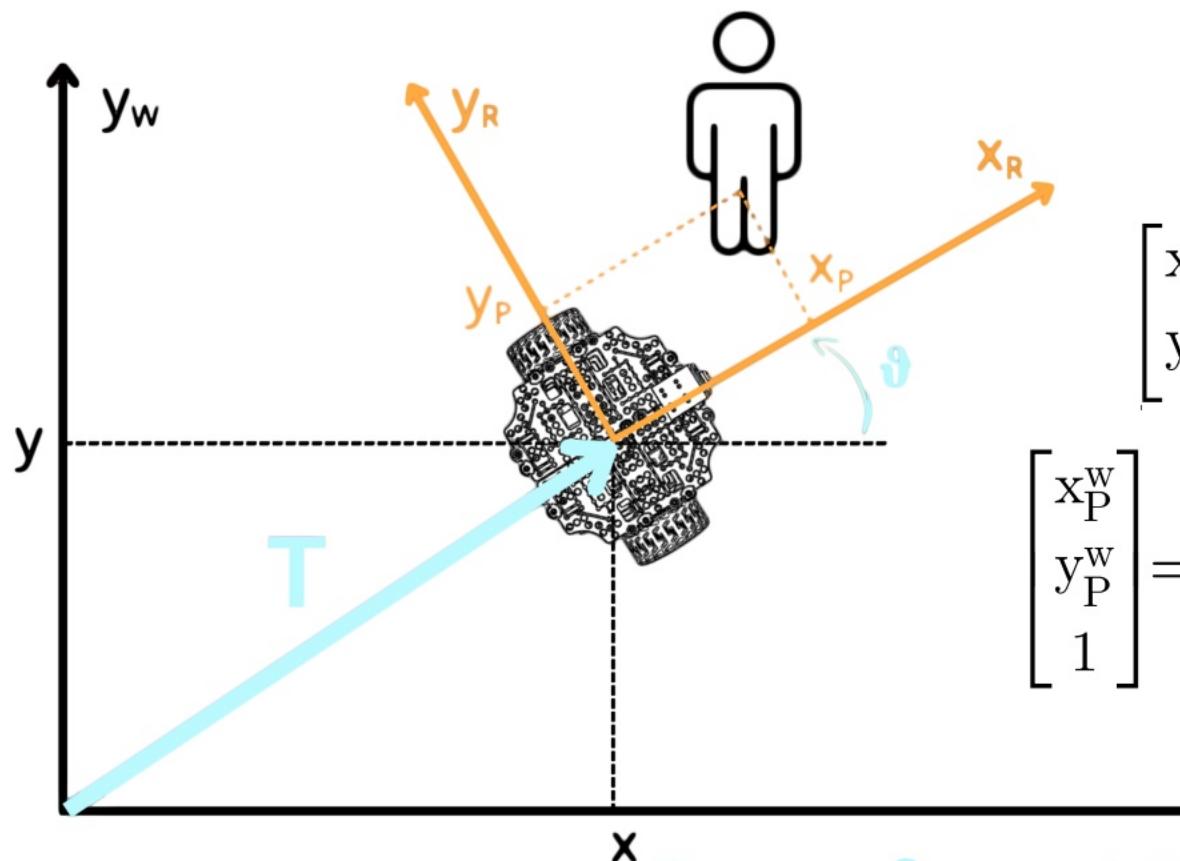
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$



$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

$$\begin{bmatrix} x_P^w \\ y_P^w \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) & T_x \\ \sin(\vartheta) & \cos(\vartheta) & T_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_P \\ y_P \\ 1 \end{bmatrix}$$

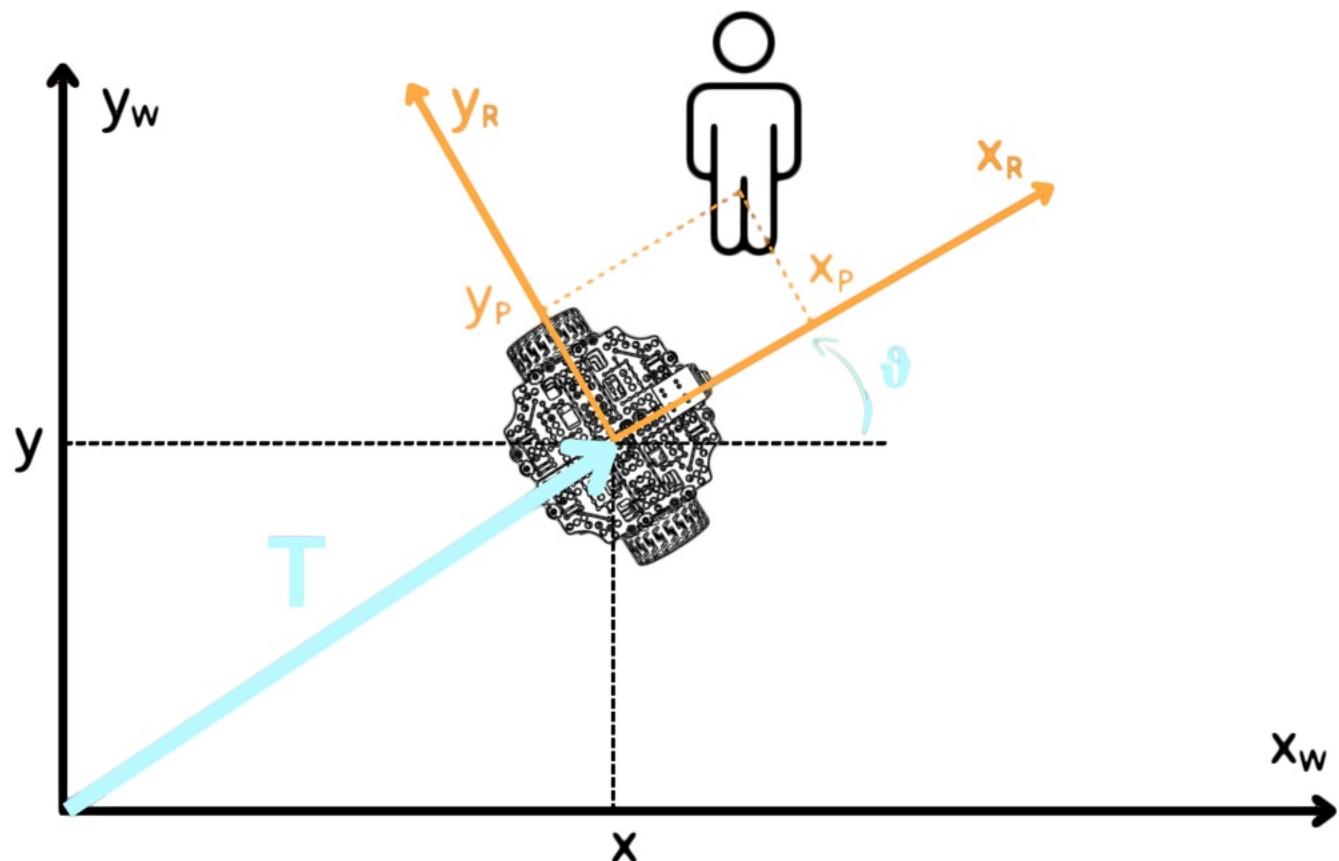


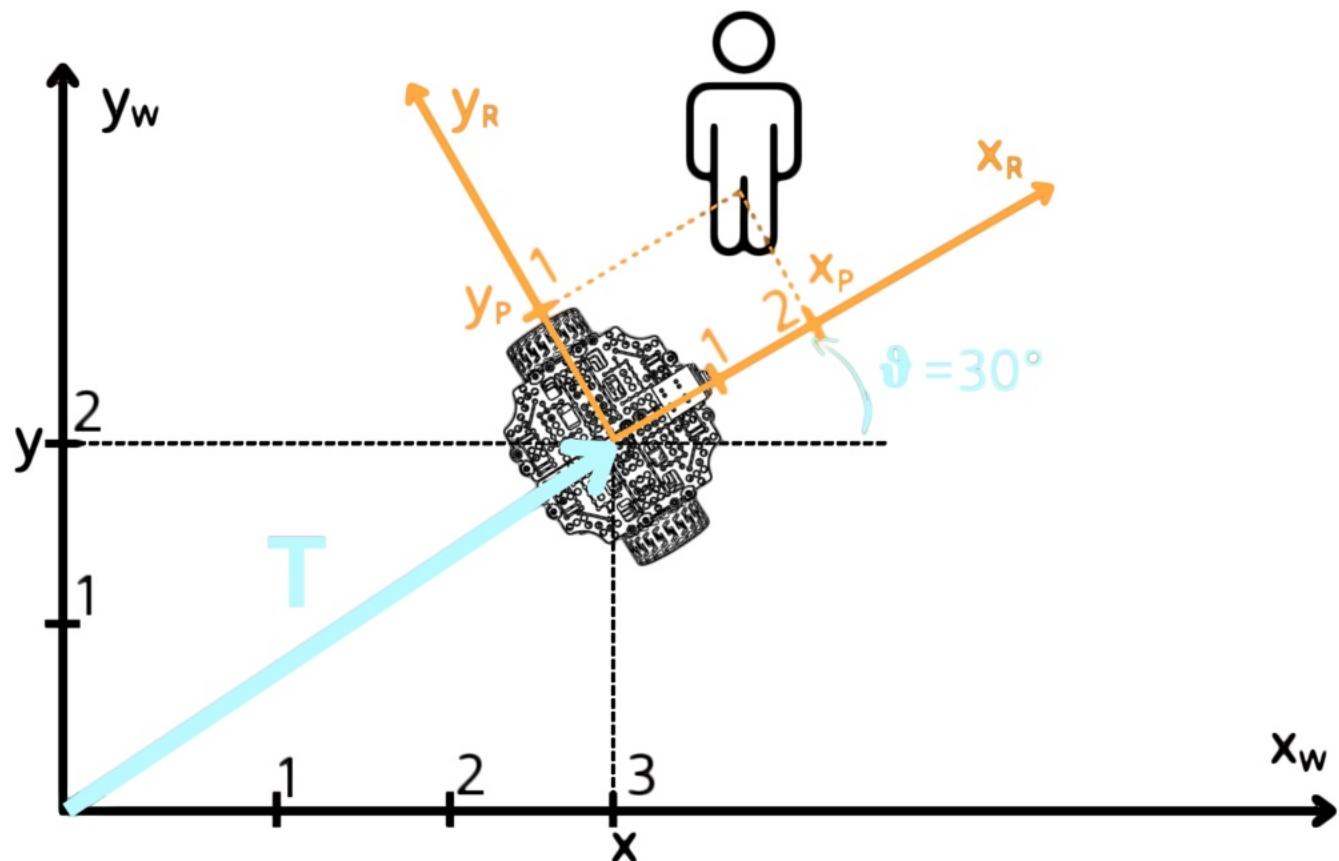
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \end{bmatrix} + \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

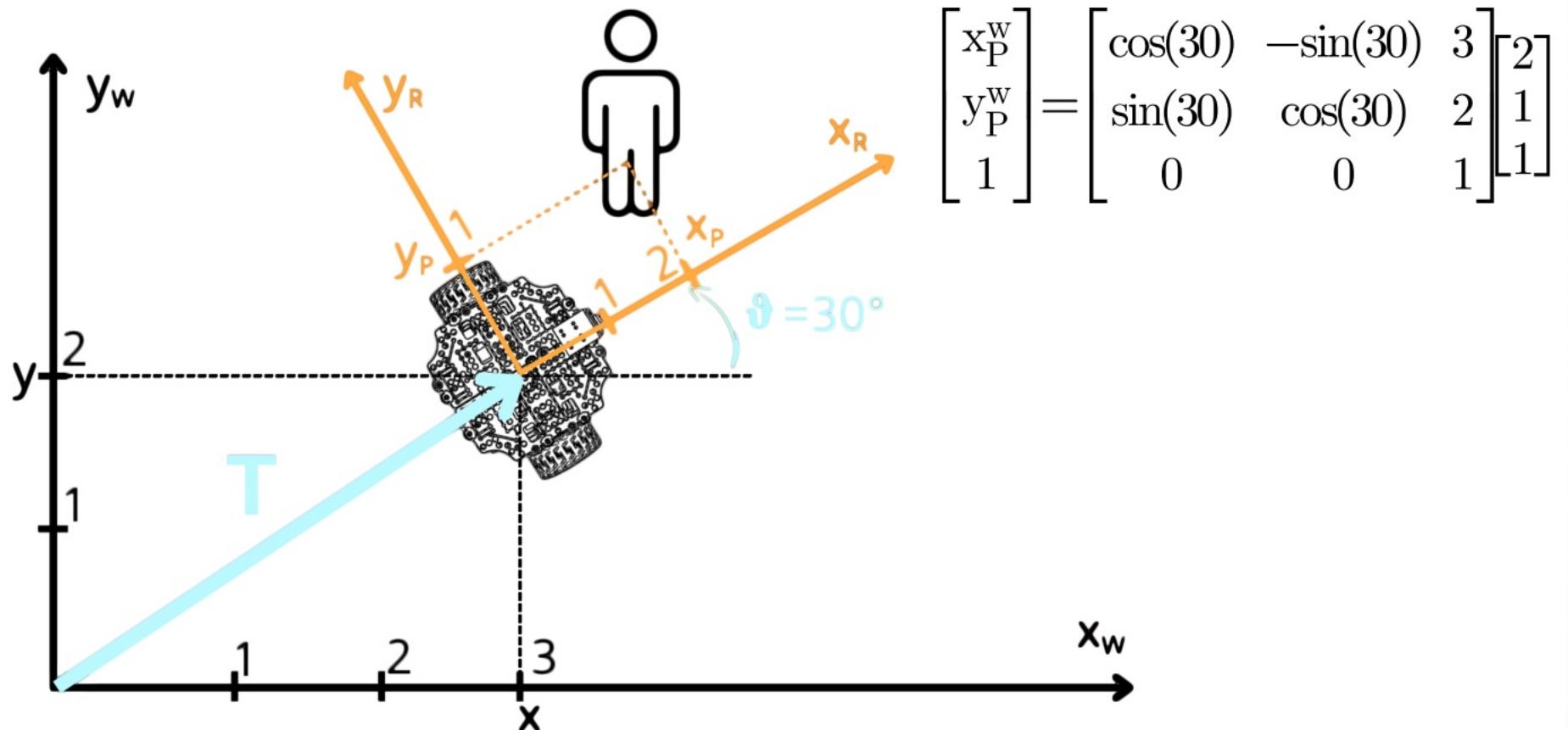
$$\begin{bmatrix} x_P^w \\ y_P^w \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) \\ \sin(\vartheta) & \cos(\vartheta) \end{bmatrix} \begin{bmatrix} x_P \\ y_P \end{bmatrix}$$

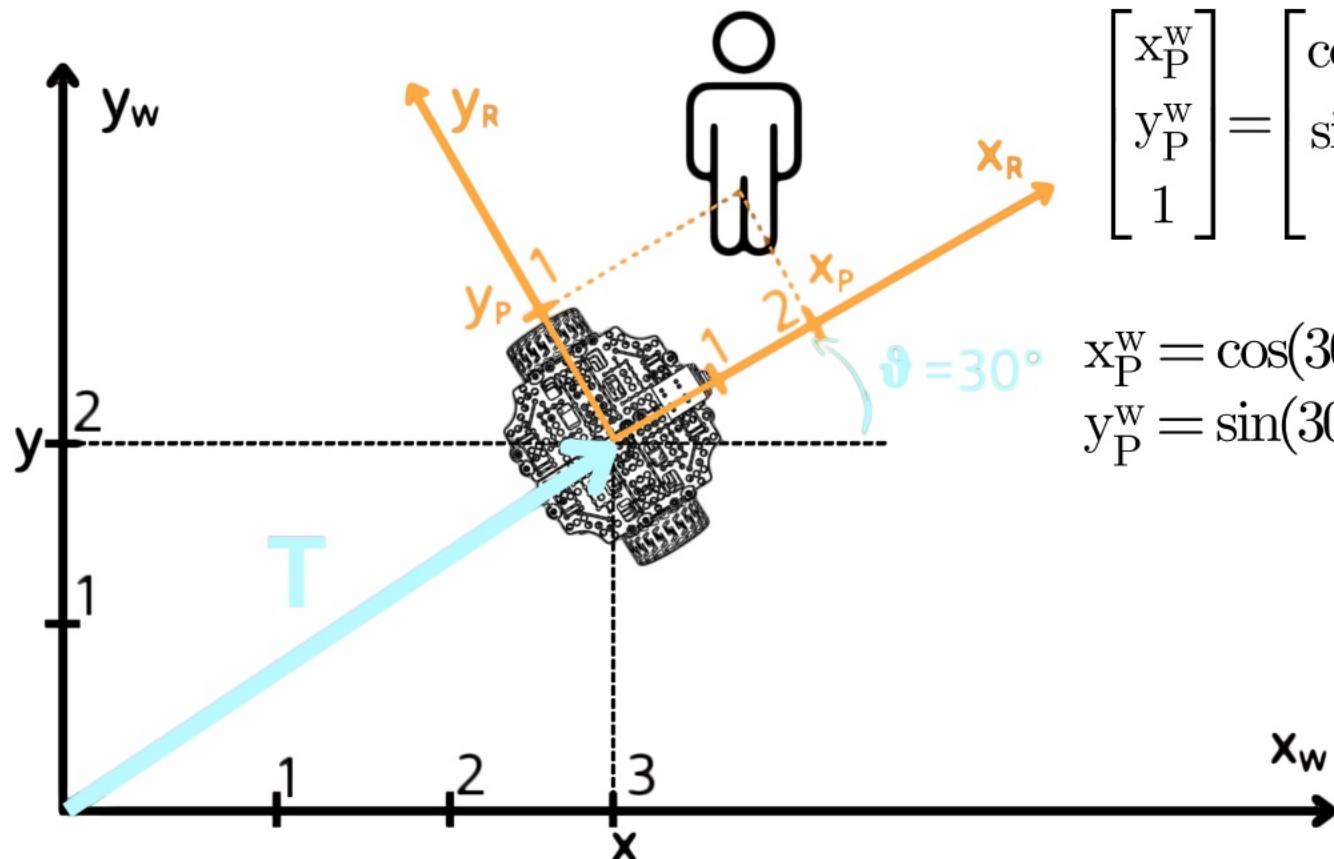
$$\begin{bmatrix} x_P^w \\ y_P^w \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(\vartheta) & -\sin(\vartheta) & T_x \\ \sin(\vartheta) & \cos(\vartheta) & T_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_P \\ y_P \\ 1 \end{bmatrix}$$

Transformation
Matrix





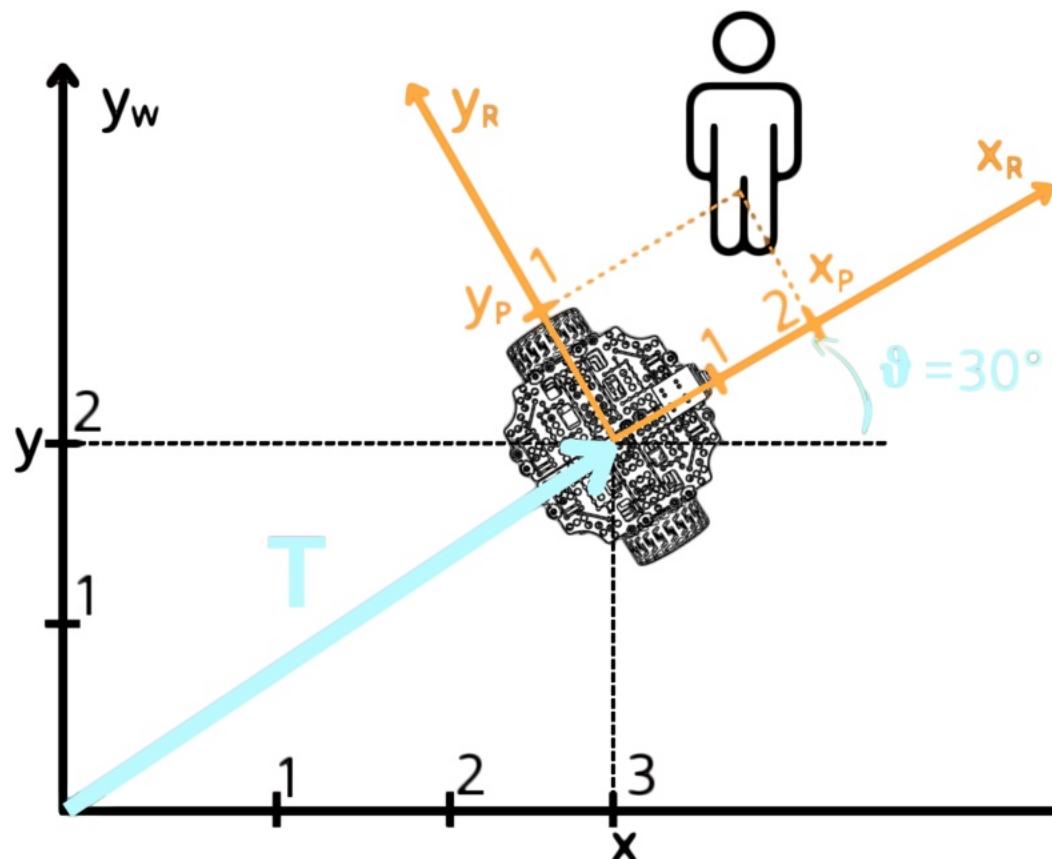




$$\begin{bmatrix} x_P^w \\ y_P^w \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) & 3 \\ \sin(30) & \cos(30) & 2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix}$$

$$x_P^w = \cos(30) \cdot 2 - \sin(30) \cdot 1 + 3 \cdot 1$$

$$y_P^w = \sin(30) \cdot 2 + \cos(30) \cdot 1 + 2 \cdot 1$$



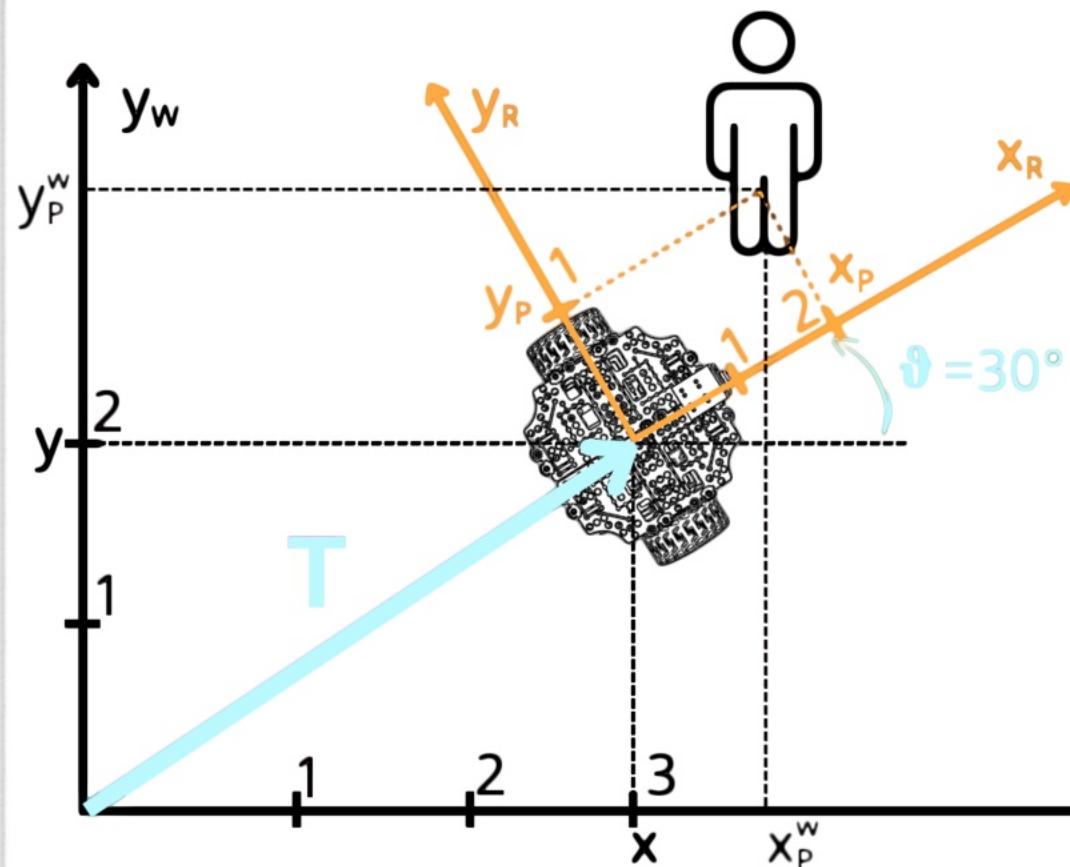
$$\begin{bmatrix} x_P^w \\ y_P^w \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) & 3 \\ \sin(30) & \cos(30) & 2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix}$$

$$x_P^w = \cos(30) \cdot 2 - \sin(30) \cdot 1 + 3 \cdot 1$$

$$y_P^w = \sin(30) \cdot 2 + \cos(30) \cdot 1 + 2 \cdot 1$$

$$x_P^w = 1.73 - 0.5 + 3 = 4.23$$

$$y_P^w = 1 + 0.87 + 2 = 3.87$$

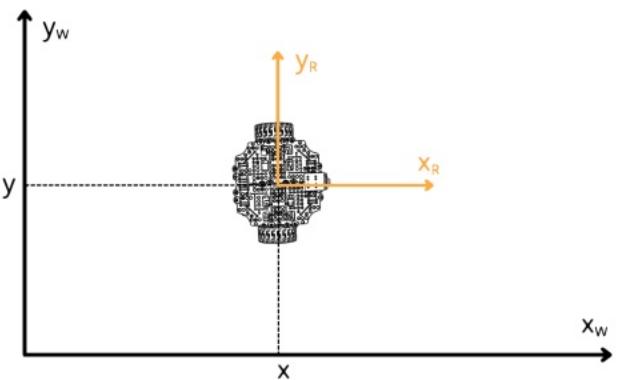


$$\begin{bmatrix} x_P^w \\ y_P^w \\ 1 \end{bmatrix} = \begin{bmatrix} \cos(30) & -\sin(30) & 3 \\ \sin(30) & \cos(30) & 2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix}$$

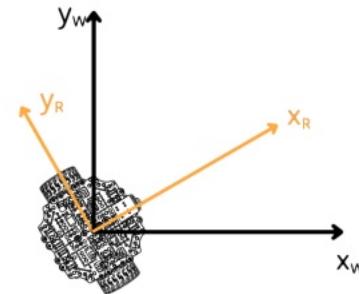
$$x_P^w = \cos(30) \cdot 2 - \sin(30) \cdot 1 + 3 \cdot 1 \\ y_P^w = \sin(30) \cdot 2 + \cos(30) \cdot 1 + 2 \cdot 1$$

$$x_P^w = 1.73 - 0.5 + 3 = 4.23$$

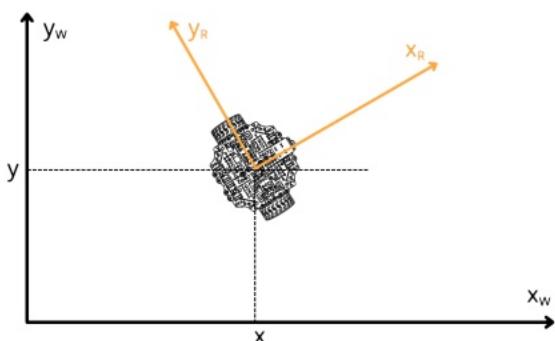
$$y_P^w = 1 + 0.87 + 2 = 3.87$$



Translation



Rotation



Roto-Translation

Kinematics

