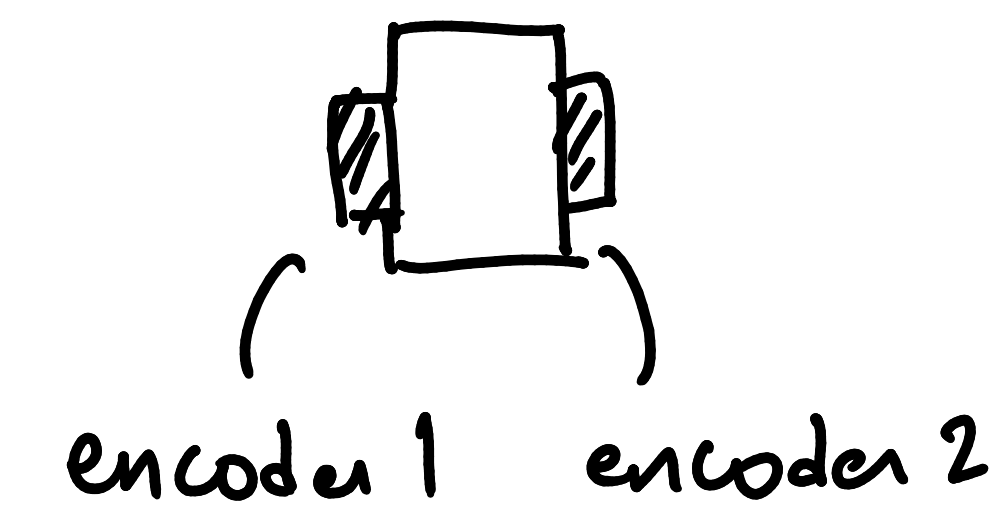


# SLAM Youtube Course:

## • Step 1:

→ Create a motion model that converts raw data from sensors into real-world co-ordinate estimates.

→ In the assignment, the sensors are incremental encoders.

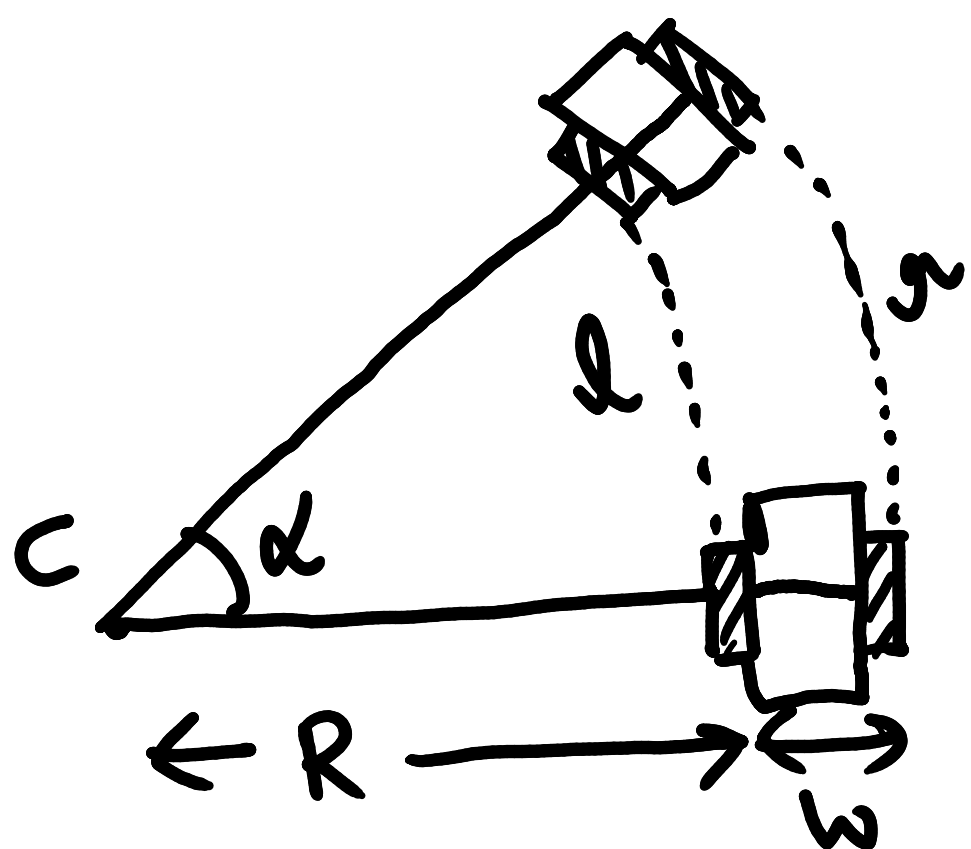


(Differential Drive robot)

It was found empirically that,

$$1 \text{ tick} \approx 0.349 \text{ mm}$$

→ Now, we need to convert distance covered by right and left wheels ( $l$  and  $r$ ) to rotation angle  $\alpha$  about center of rotation  $C$ .



$$\text{Total peri} = 2\pi R$$

$$\frac{l}{\text{Total peri}} = \frac{\alpha}{2\pi}$$

$$\frac{l}{2\pi R} = \frac{\alpha}{2\pi}$$

$$l = \alpha R \quad (1)$$

$$r = \alpha(R+w) \quad (2)$$

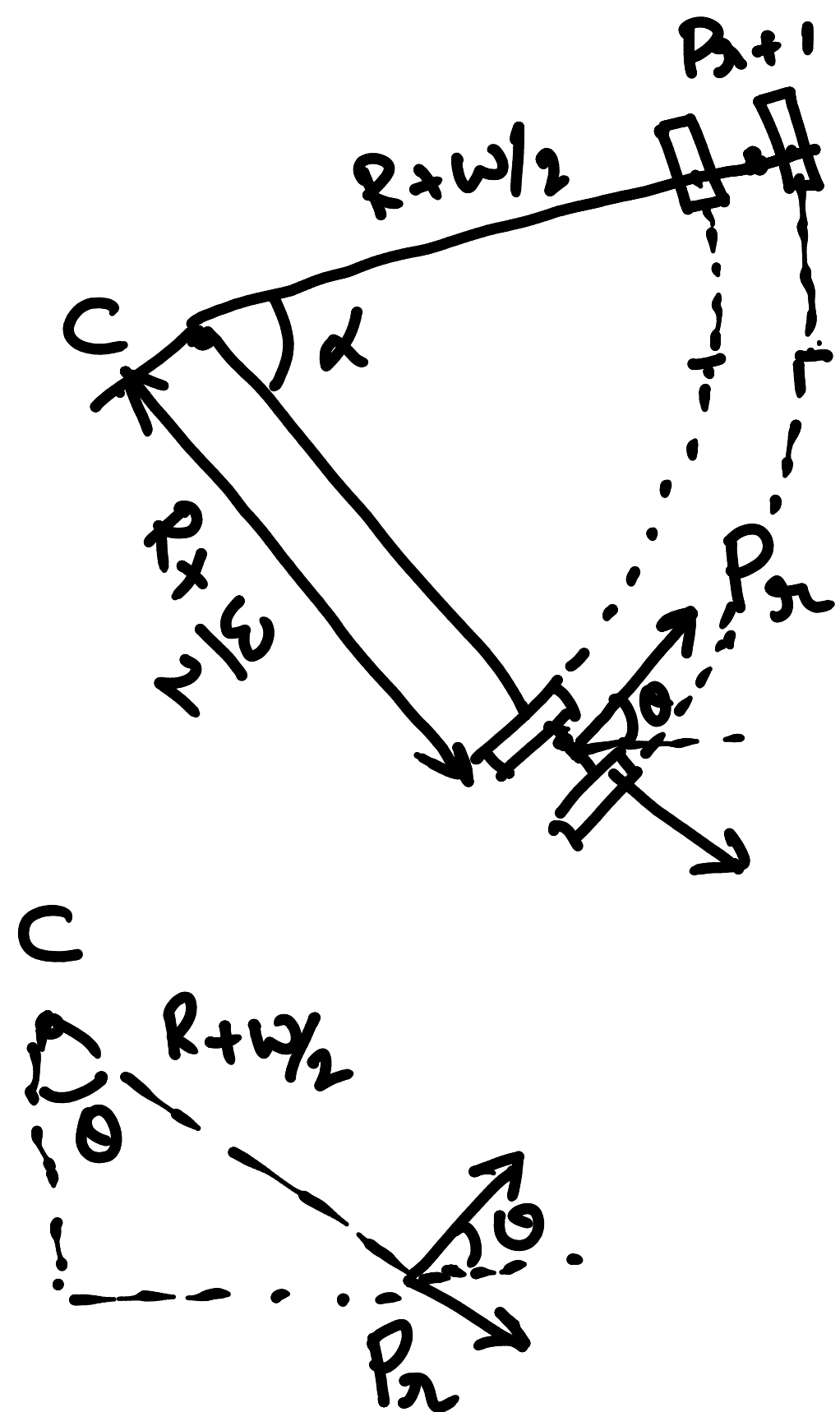
$$(2) - (1)$$

$$\Rightarrow r - l = \alpha \cdot w$$

$$\Rightarrow \alpha = \frac{r - l}{w}$$

$$\Rightarrow R = \frac{l}{\alpha}$$

where  $\alpha \neq 0$



⇒ Consider a Robot frame  $\{R\}$  where  $P_0 = (0, 0)$  and  $\theta_0 = 0$  are the initial position and heading angle of the robot.

⇒  $(P_n, \theta_n)$  is the pose (position and heading) of the robot at encoder tick  $n$

$$\theta_{n+1} = \theta_n + \alpha$$

⇒ We know that the position of  $C$  is constant between pose  $n$  and pose  $n+1$

$$C = \begin{bmatrix} P_{nx} - (R + \frac{w}{2}) \sin \theta \\ P_{ny} + (R + \frac{w}{2}) \cos \theta \end{bmatrix} = P_n - (R + \frac{w}{2}) \begin{bmatrix} \sin \theta \\ -\cos \theta \end{bmatrix}$$

⇒ Now, find  $P_{n+1}$ :  $C = P_{n+1} + (R + \frac{w}{2}) \begin{bmatrix} -\sin(\theta + \alpha) \\ \cos(\theta + \alpha) \end{bmatrix}$

$$P_{n+1} = C + (R + \frac{w}{2}) \begin{bmatrix} \sin(\theta + \alpha) \\ -\cos(\theta + \alpha) \end{bmatrix}$$

where  $\theta \in [0, 2\pi]$

Therefore, when  $\boxed{r \neq l}$  or  $\boxed{\alpha \neq 0}$

$$(1) \quad \alpha = \frac{r-l}{\omega} \quad \text{and} \quad R = \frac{l}{\alpha}$$

$$(2) \quad \begin{bmatrix} C_x \\ C_y \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} - \left(R + \frac{\omega}{2}\right) \begin{bmatrix} \sin \theta \\ -\cos \theta \end{bmatrix}$$

$$\theta' = (\theta + \alpha) \bmod 2\pi$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} C_x \\ C_y \end{bmatrix} + \left(R + \frac{\omega}{2}\right) \cdot \begin{bmatrix} \sin \theta' \\ -\cos \theta' \end{bmatrix}$$

But, if  $\boxed{r = l}$  or  $\boxed{\alpha = 0}$

$$\theta' = \theta \Rightarrow \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + l \begin{bmatrix} \cos \theta \\ \sin \theta \end{bmatrix}$$

