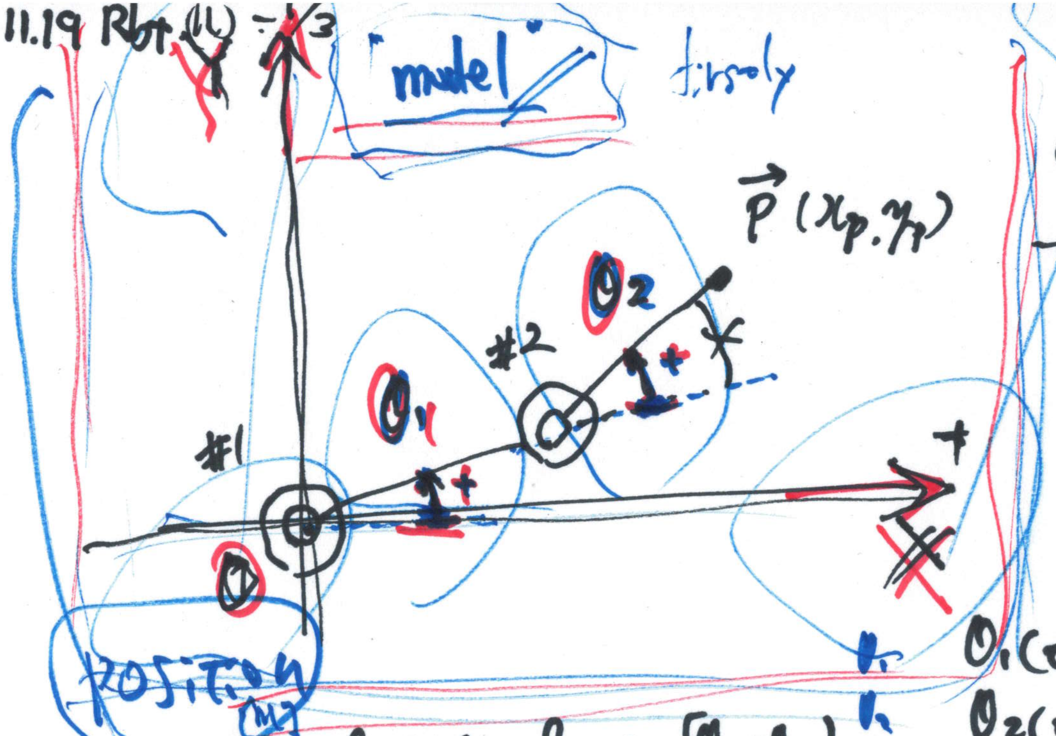
2025.11.19 Rbt (L) 1/3



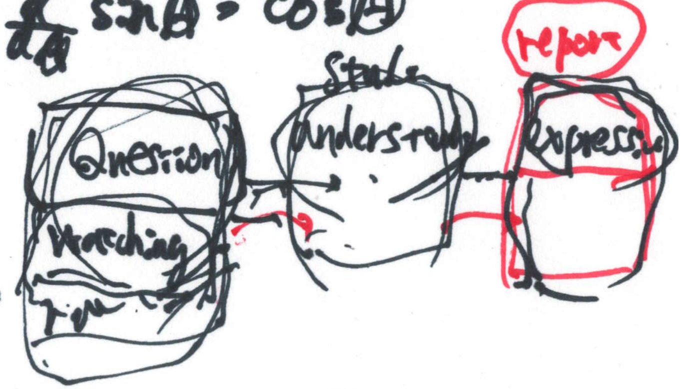
$x_p = l_1 \cos\theta_1 + l_2 \cos(\theta_1+\theta_2)$ [rad]

$y_p = l_1 \sin\theta_1 + l_2 \sin(\theta_1+\theta_2)$

$$\frac{dF[A(\tau)]}{d\tau} = \frac{dF}{dA} \times \frac{dA}{d\tau}$$

$\cos A(\tau) \rightarrow \frac{d}{dA}\cos A = -\sin A$

$\sin A \rightarrow \frac{d}{dA}\sin A = \cos A$



$\theta_1(\tau) - \frac{d\theta_1}{d\tau} = \dot{\theta}_1$

$\theta_2(\tau) - \frac{d\theta_2}{d\tau} = \dot{\theta}_2$

speed

$$\frac{dx_p}{d\tau} = l_1(-\sin\theta_1)\dot{\theta}_1 + l_2(-\sin(\theta_1+\theta_2))(\dot{\theta}_1+\dot{\theta}_2)$$

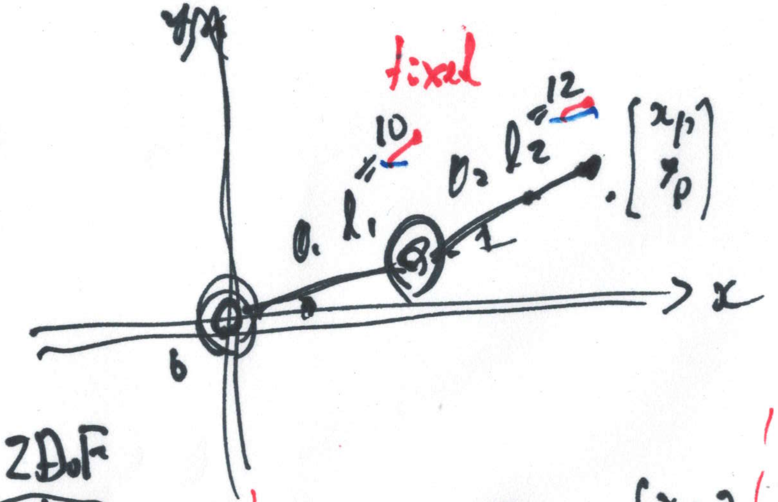
$$= \{-l_1\sin\theta_1 - l_2\sin(\theta_1+\theta_2)\}\boxed{\dot{\theta}_1} + \{-l_2\sin(\theta_1+\theta_2)\}\boxed{\dot{\theta}_2}$$ ok!!

$$\frac{dy_p}{d\tau} = l_1\cos\theta_1\dot{\theta}_1 + l_2\cos(\theta_1+\theta_2)(\dot{\theta}_1+\dot{\theta}_2)$$

$$= \{l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2)\}\boxed{\dot{\theta}_1} + \{l_2\cos(\theta_1+\theta_2)\}\boxed{\dot{\theta}_2}$$ ok!

output — Jacobian — input

$$\underbrace{\begin{bmatrix} \frac{dx_p}{d\tau} \\ \frac{dy_p}{d\tau} \end{bmatrix}}_{2\times1} [m/s] = \underbrace{\begin{bmatrix} \bigcirc & \bigcirc \\ \bigcirc & \bigcirc \end{bmatrix}}_{2\times2} \underbrace{\begin{bmatrix} \frac{d\theta_1}{d\tau} \\ \frac{d\theta_2}{d\tau} \end{bmatrix}}_{2\times1} [rad/s]$$

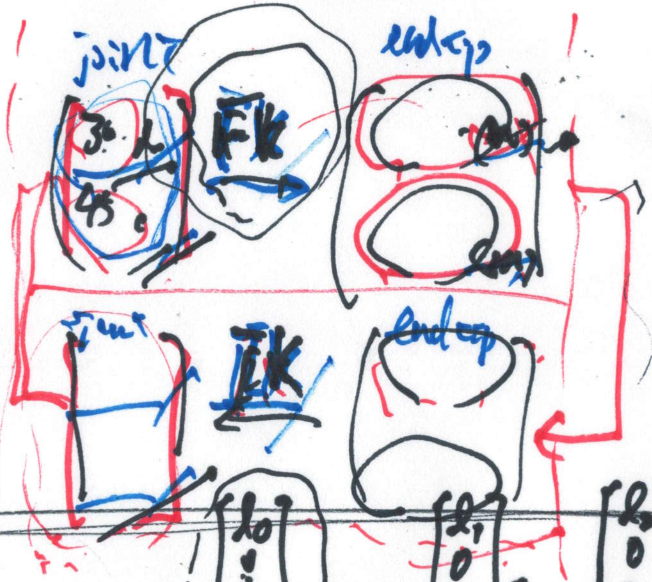


2DoF

$\boxed{\text{scalar}}$

FK $\quad \begin{bmatrix}\theta_1\\ \theta_2\end{bmatrix} \xrightarrow{\text{FK}} \begin{bmatrix}x_p\\ y_p\end{bmatrix}$

IK $\quad \begin{bmatrix}\theta_1\\ \theta_2\end{bmatrix} \xleftarrow{\text{IK}} \begin{bmatrix}x_p\\ y_p\end{bmatrix}$

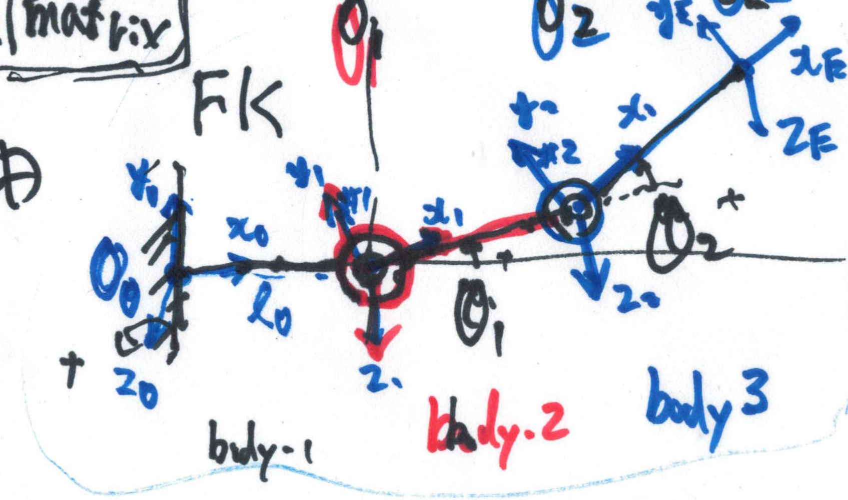


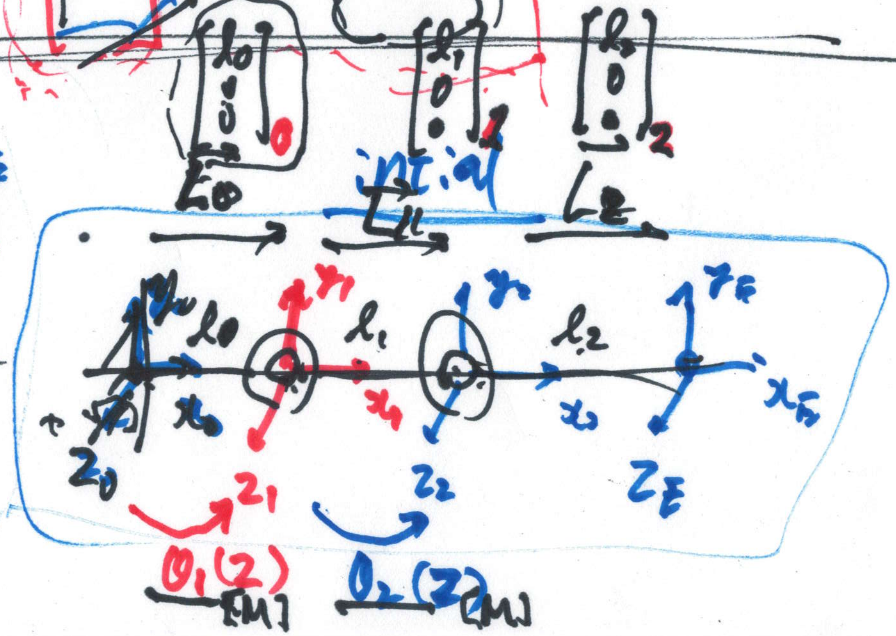
OK

$\boxed{\text{vector matrix}}$

FK

2D





2025.11.19 Rbt(11) - 3/3

$$
\begin{array}{cc}
\mathbb{C}_1 & \mathbb{C}_2 \\
\begin{bmatrix} C_1 & -S_1 & 0 \\ S_1 & C_1 & 0 \\ 0 & 0 & 1 \end{bmatrix} &
\begin{bmatrix} C_2 & -S_2 & 0 \\ S_2 & C_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}
\end{array}
$$

$$
\vec{L}_0 \xrightarrow{\mathbb{C}_1} \vec{L}_1 \xrightarrow{\mathbb{C}_2} \vec{L}_2 \longrightarrow \vec{P}_E
$$

$$
\begin{bmatrix} l_0 \\ 0 \\ 0 \end{bmatrix}_0 \quad
\begin{bmatrix} l_1 \\ 0 \\ 0 \end{bmatrix}_1 \Big\downarrow C_1 \quad
\begin{bmatrix} l_2 \\ 0 \\ 0 \end{bmatrix}_2 \Big\downarrow C_1C_2
$$

FK

$$
\begin{bmatrix} l_0 \\ 0 \\ 0 \end{bmatrix}_0 + \begin{bmatrix} - \\ - \\ 0 \end{bmatrix}_0 + \begin{bmatrix} - \\ - \\ 0 \end{bmatrix}_0 = \vec{P}_E \begin{bmatrix} - \\ - \\ 0 \end{bmatrix}_0
$$

check!!

articulated robot

3軸