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# Kinematics

## Robot arm

serial ( joint / link )

4 structures

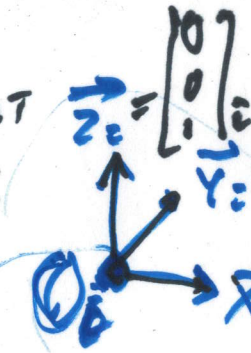
3-joints

Cartesian 3

Cylin. 1+2

Spher. 2+1

Articul. 3




Forward kinematics

Inverse kinematics

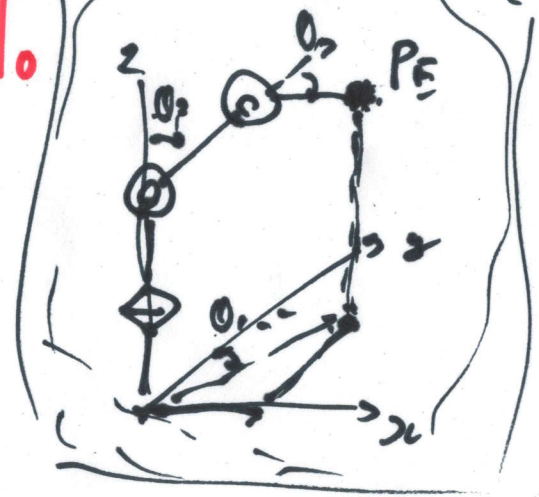
pm Scalar

Geometrical Stru-

Forward kinematics

V.M metric

$J^{-1}$



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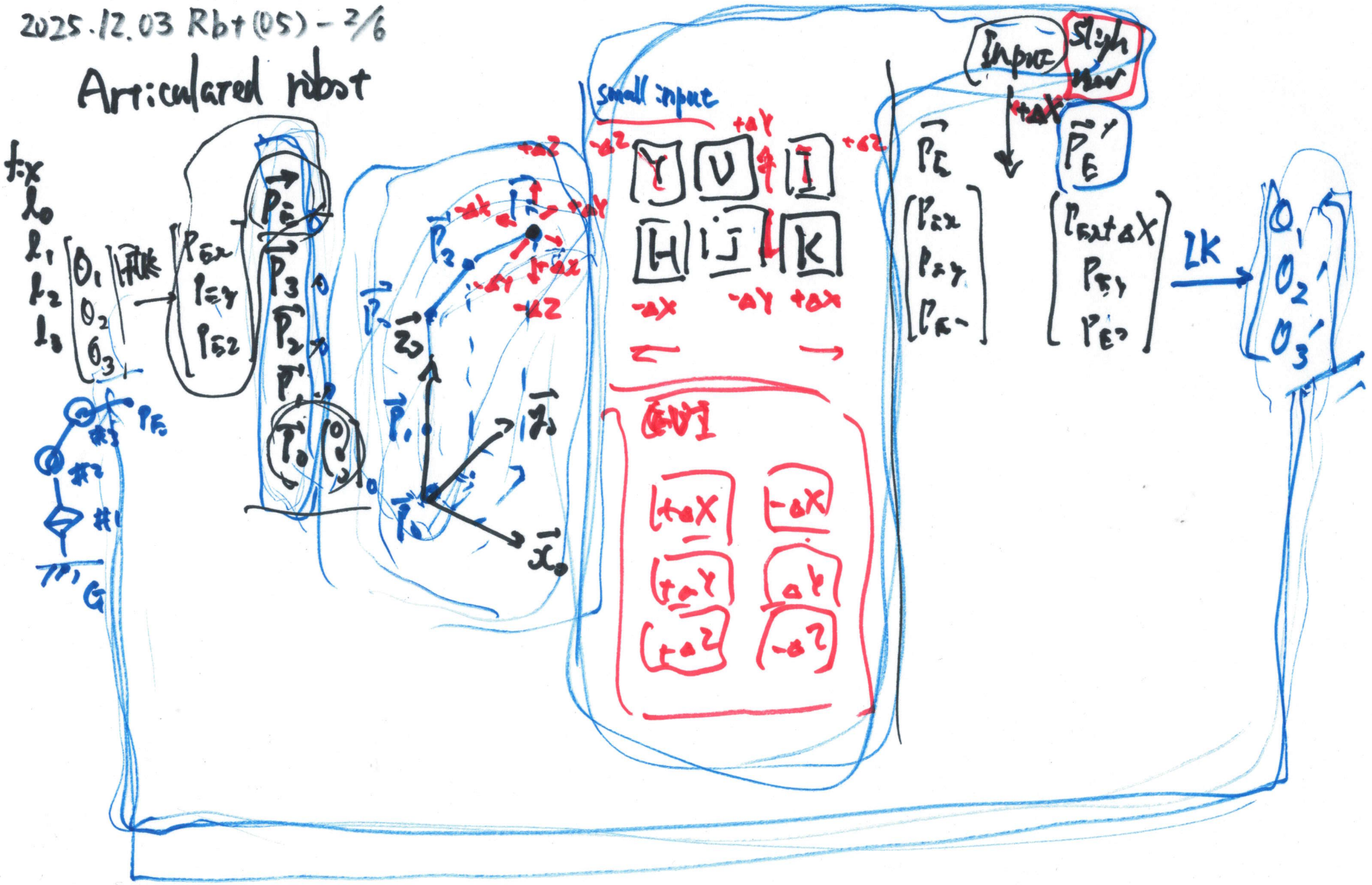
# Articulared robot



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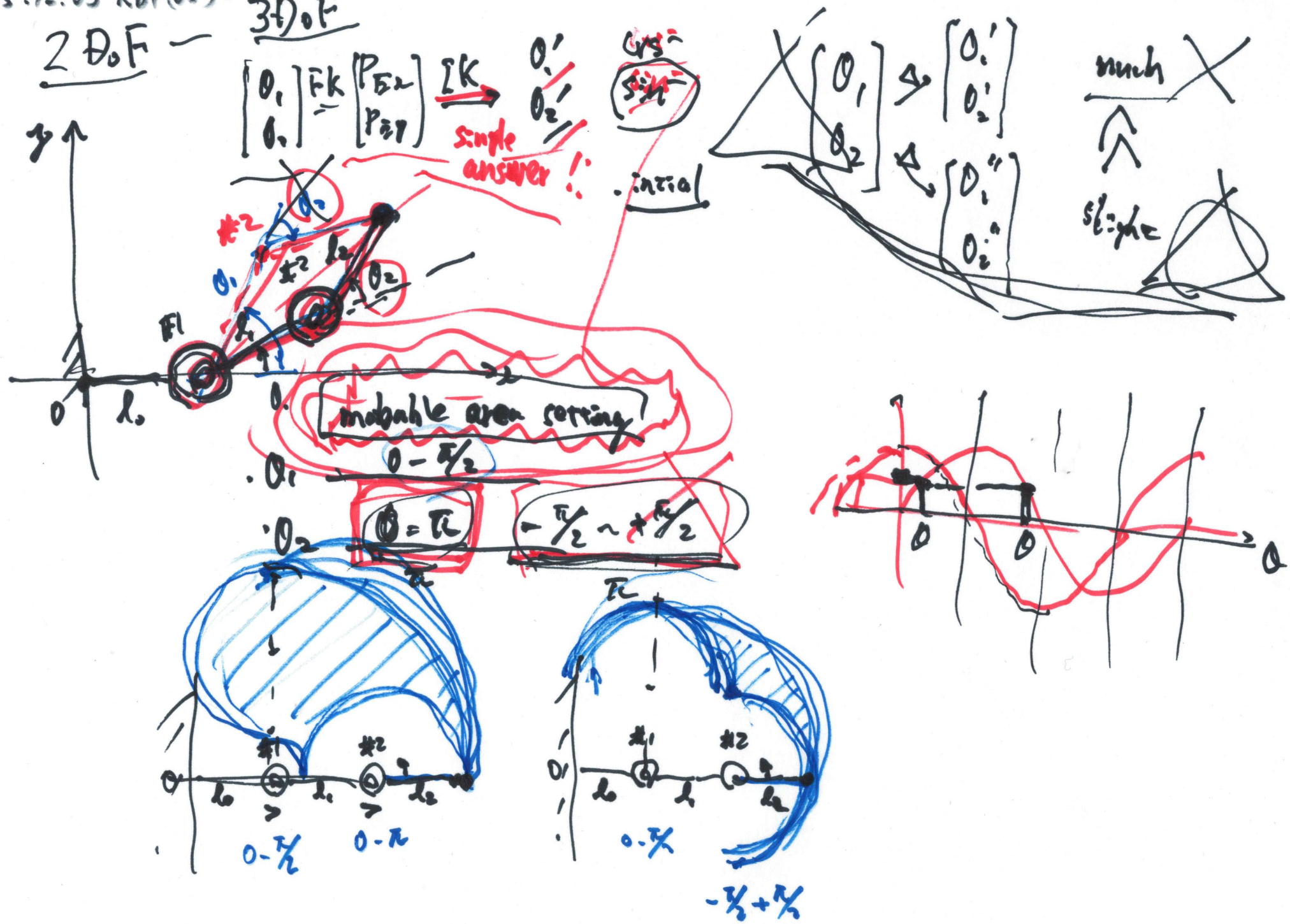
# 2 DoF — 3 DoF




Coordinate setting

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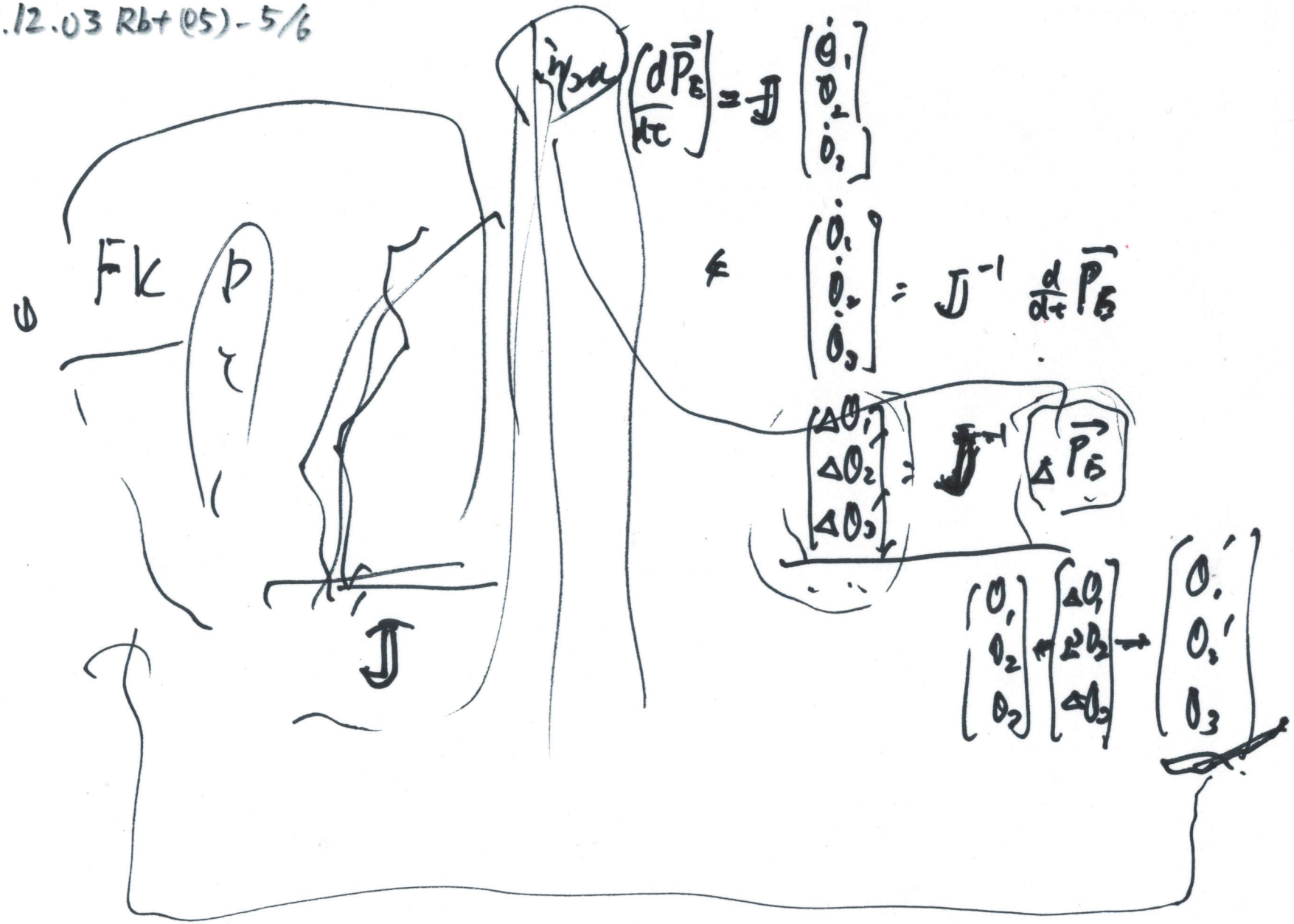
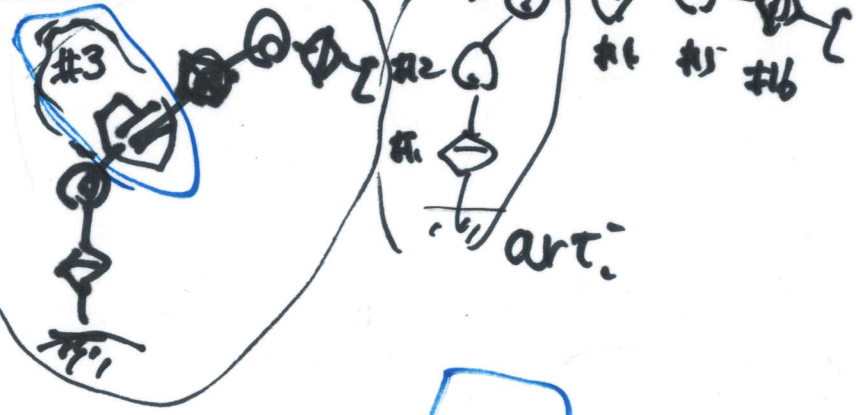


$$\begin{bmatrix} \frac{d\vec{P}_E}{dt} \\ \vec{\omega}_E \end{bmatrix} = \underbrace{\begin{bmatrix} \vec{P}_1 \times (\vec{P}_E - \vec{P}_1) & \vec{P}_2 \times (\vec{P}_E - \vec{P}_2) & \vec{P}_3 \times (\vec{P}_E - \vec{P}_3) & \vec{P}_4 \times (\vec{P}_E - \vec{P}_4) & \vec{P}_5 \times (\vec{P}_E - \vec{P}_5) & \vec{P}_6 \times (\vec{P}_E - \vec{P}_6) \\ \vec{P}_1 & \vec{P}_2 & \vec{P}_3 & \vec{P}_4 & \vec{P}_5 & \vec{P}_6 \end{bmatrix}}_{J} \begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \\ \dot{\theta}_4 \\ \dot{\theta}_5 \\ \dot{\theta}_6 \end{bmatrix}$$




$$\begin{bmatrix} \frac{d\vec{P}_E}{dt} \\ \vec{\omega}_E \end{bmatrix} = \underbrace{\begin{bmatrix} \vec{P}_1 \times (\vec{P}_E - \vec{P}_1) & \vec{P}_2 \times (\vec{P}_E - \vec{P}_2) & \vec{P}_3 & \cdots \\ \vec{0} & \vec{P}_2 & \vec{0} & \cdots \end{bmatrix}}_{J} \begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \\ \dot{\theta}_4 \\ \dot{\theta}_5 \\ \dot{\theta}_6 \end{bmatrix}$$

$J^{(3)}$