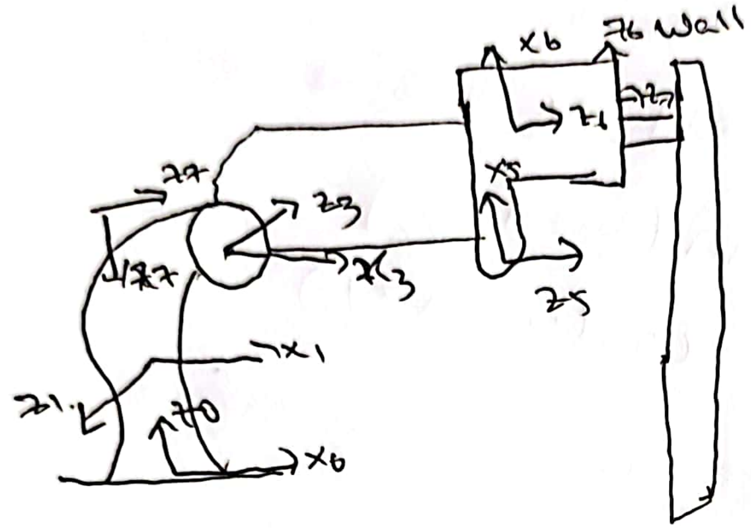
HW-4

Mano Batrna
~~11-85464~~
118546490



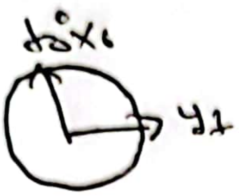
D-H table

link	θ_i	d_i	a_i	α_i
1	θ_1	d_1	0	90
2	θ_2	0	0	-90
3	θ_3	d_3	a_3	-90
4	θ_4	0	$-a_3$	90
5	θ_5	d_5	0	90
6	θ_6	0	a_3	-90
7	θ_7	$-d_7$	0	0

add 10cm to d_7 for pen length

$\therefore d_7 = -(d_7 + 10)$ cm

End effector frame:



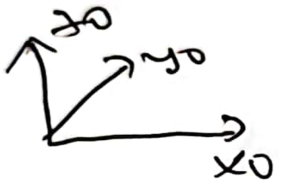
At $t=0$, $x_E, y_E = r$

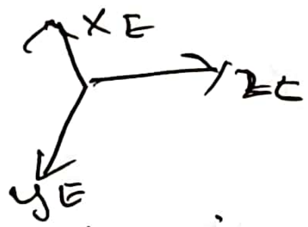
so when add $\pi/2$ this is possible.

$$\therefore \; x_E = r\sin(\omega t + \pi/2)$$

$$y_E = r\cos(\omega t + \pi/2)$$

End effector to base frame conversion





$x_0 = z_0 \rightarrow \dot{x}_E = \dot{z}_E$ (differentiate x_E & y_E we get them)

$y_e = -y_0 \rightarrow \dot{y}_e = -\dot{y}_0$

$$\therefore \; \dot{z}_0 = 0.1\,\omega\cos(\omega t + \pi/2)$$

$$\dot{y}_0 = 0.1\,\omega\sin(\omega t + \pi/2)$$

$$\dot{x} = \begin{bmatrix} v_x \\ v_y \\ v_z \\ \omega_x \\ \omega_y \\ \omega_z \end{bmatrix}$$

Substituting values we get

$$\dot{x} = \begin{bmatrix} 0 \\ y_0 \\ z_0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\dot{q} = J^{-1} \dot{x}$$

$$\begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_4 \\ \dot{\theta}_5 \\ \dot{\theta}_6 \\ \dot{\theta}_7 \end{bmatrix} = J^{-1} \begin{bmatrix} 0 \\ \dot{y}_0 \\ \dot{z}_0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\theta_{new} = \theta_{old} \times \theta_{dot}$$

Put θ_{new} in transformation matrix

$$\Rightarrow \begin{bmatrix} \cdot & \cdot & \cdot & x \\ \cdot & \cdot & \cdot & y \\ \cdot & \cdot & \cdot & z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Jacobian matrix

1) Differentiate x_p w.r.t θ_i ($i = 1$ to 7) from end effector transformation matrix excluding θ_3 as it is zero

$${}^{i}P = \begin{array}{cccc} & & z_1 & x_P \\ \end{array} \begin{bmatrix} \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & & \end{bmatrix}$$

$$J = \begin{bmatrix} \frac{\partial x}{\partial \theta_1} & \frac{\partial x_P}{\partial \theta_2} & \frac{\partial x_P}{\partial \theta_3} & \frac{\partial x_P}{\partial \theta_4} & \frac{\partial x_P}{\partial \theta_5} & \frac{\partial x_P}{\partial \theta_6} & \frac{\partial x_P}{\partial \theta_7} \\ z_1 & z_2 & z_3 & z_4 & z_5 & z_6 & z_7 \end{bmatrix} \rightarrow 3\times7$$

∂

∂x_b

$$z_3 = 0 \quad \frac{\partial x_P}{\partial \theta_3} = 0$$