

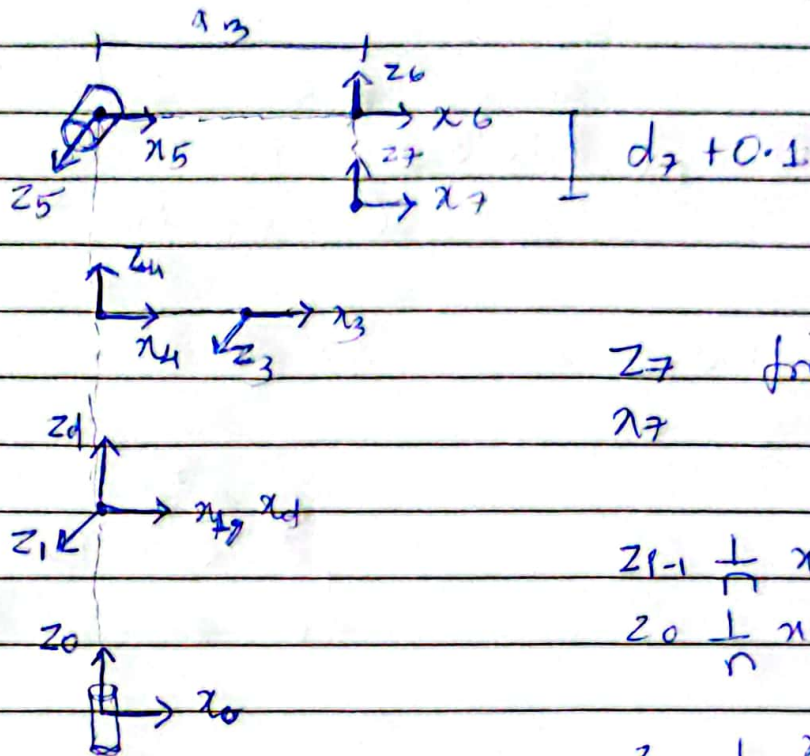
Home Work-4

ENPM-662

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1)



z_7 frame of pen
 x_7

$$z_{i-1} \perp x_i$$

$$z_0 \perp x_1$$

$$z_1 \perp x_2$$

D-H table

Joint-3 is locked, $\theta_3 = 0$

	α	θ	d	a
0-1	$\pi/2$	θ_1	d_1	0
1-2	$-\pi/2$	θ_2	0	0
2-3	$-\pi/2$	0	d_3	a_3
3-4	$\pi/2$	θ_4	0	$-a_3$
4-5	$\pi/2$	θ_5	d_5	0
5-6	$-\pi/2$	θ_6	0	a_3
6-7	0	θ_7	$-d_7$	0

$$z_2 \perp x_3$$

$$z_3 \perp x_4$$

$$z_4 \perp x_5$$

$$z_5 \perp x_6$$

$$z_6 \perp x_7$$

$$d_1 = 0.33$$

Transformation Matrix

$$= R(z, a) T(z, d) T(x, a) R(x, \lambda)$$

$$= \begin{bmatrix} \cos a & -\sin a & 0 & 0 \\ \sin a & \cos a & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & a \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \lambda & -\sin \lambda & 0 \\ 0 & \sin \lambda & \cos \lambda & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} c_a & -s_a c_\lambda & s_a s_\lambda & a c_\lambda \\ s_a & c_a c_\lambda & -c_a s_\lambda & a s_\lambda \\ 0 & s_\lambda & c_\lambda & d \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$c_a = \cos a$$

$$s_a = \sin a$$

$$c_\lambda = \cos \lambda$$

$$s_\lambda = \sin \lambda$$

$$H_1 = {}^0T_1$$

$$H_2 = H_1 \times {}_2^1T = {}^0T_2$$

x_p = Translation part of H_6
i.e. the 4th col of final transformation matrix

$$H_3 = H_2 \times {}_4^2T = {}^0T_4$$

$$H_4 = H_3 \times {}_5^4T = {}^0T_5$$

0_2 = 3rd col of H_9 , $p = 1 \rightarrow 6$

$$H_5 = H_4 \times {}_6^5T = {}^0T_6$$

$$H_6 = H_5 \times {}_7^6T = {}^0T_7$$

$$J_i = \begin{bmatrix} \frac{\partial x_i}{\partial q_1} \\ \frac{\partial x_i}{\partial q_2} \\ \frac{\partial x_i}{\partial q_3} \end{bmatrix} \quad p = 1 \rightarrow 6$$

$$J = [J_1, J_2, J_3, \dots, J_6]$$

Circle radius = 10 cm = 0.1 m

Center co-ordinates = (0.679, 0, 0.725)

$$S = (0.679, 0, 0.725)$$

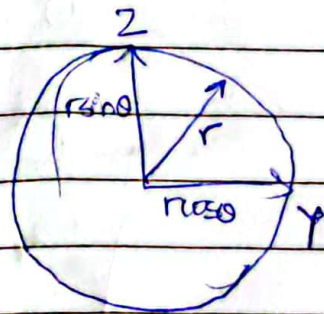
Polar coordinates,

$$x = 0.679, \quad y = 0.1 \cos \theta, \quad z = 0.1 \sin \theta + 0.725$$

$$\dot{x} = 0 = \dot{V}_x$$

$$\dot{y} = -0.1 \sin \theta \cdot \dot{\theta} = V_y$$

$$\dot{z} = 0.1 \cos \theta \cdot \dot{\theta} = V_z$$



$$\dot{\theta} = \frac{d\theta}{dt} = \frac{2\pi}{5} \quad \left(\begin{array}{l} \theta - \text{Angle} \\ t - \text{time} \end{array} \right)$$

$$\dot{X} = \begin{bmatrix} V_x \\ V_y \\ V_z \\ W_x \\ W_y \\ W_z \end{bmatrix}$$

$$q = \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \\ q_5 \\ q_6 \end{bmatrix}$$

$$\dot{q} = \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \vdots \\ \dot{q}_6 \end{bmatrix}$$

$$\begin{aligned} q_1 &= \theta_1 \\ q_2 &= \theta_2 \\ q_3 &= \theta_4 \\ q_4 &= \theta_5 \\ q_5 &= \theta_6 \\ q_6 &= \theta_7 \end{aligned}$$

$$\dot{q} = J(q) \cdot \dot{X}$$

classmate

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$$q_i = q_{i-1} + q_i \Delta t$$

$$\Delta t = \frac{T}{N} = \frac{5}{50}$$

C:\Users\Rishikesh17\Desktop> 4.1 Franka.py > ...

```
59
60 # Z component of frames
```

```
61
```

```
62 Z0 =
```

```
63 Z1 =
```

```
64 Z2 =
```

```
65 Z3 =
```

```
66 Z4 =
```

```
67 Z5 =
```

```
68 Z6 =
```

```
69
```

```
70 #Trans
```

```
71
```

```
72 Xp =
```

```
73
```

```
74 #Diffe
```

```
75
```

```
76 C1 =
```

```
77 C2 =
```

```
78 C3 =
```

```
79 C4 =
```

```
80 C5 =
```

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...
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...
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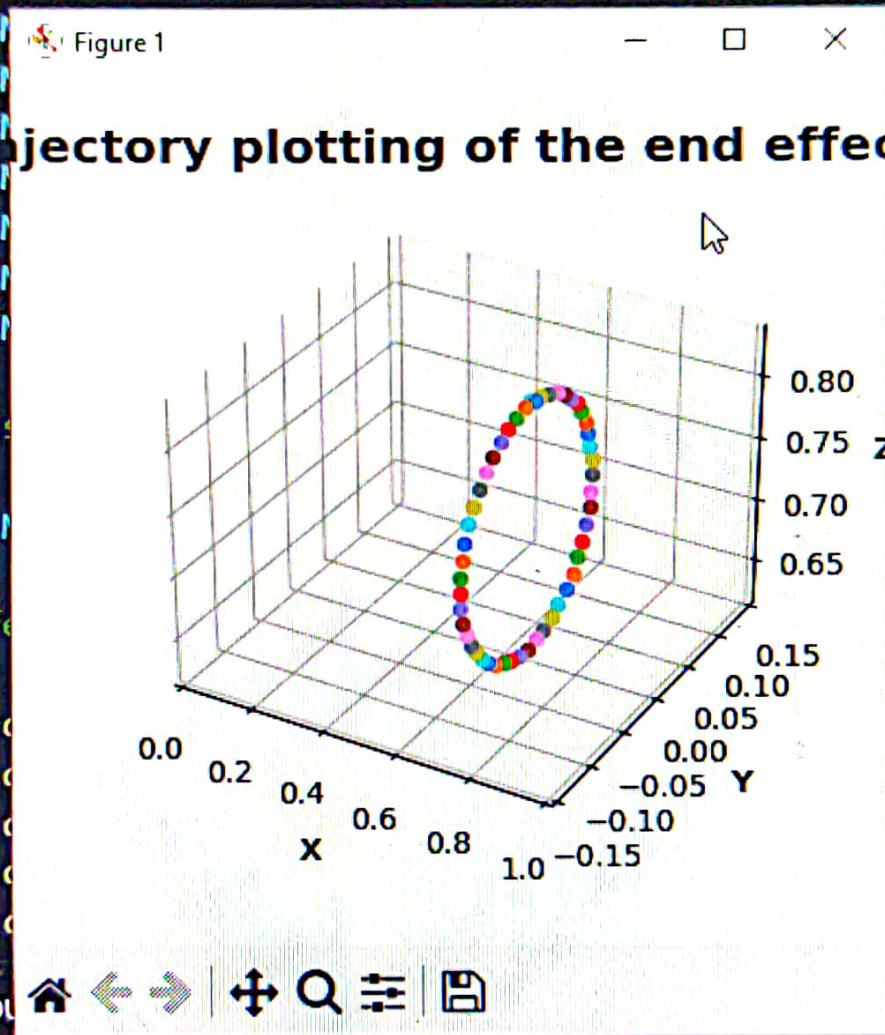
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...
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```
+ (-sin(Theta1)*sin(Theta2)*cos(Theta4) + sin(Theta1)*sin(Theta4)*cos(Theta2) - sin(Theta4)*cos(Theta2))*sin(Theta6)*cos(Theta5)
```