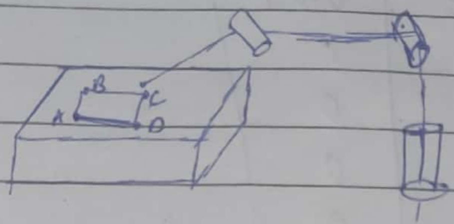
Name:- Dev Patel ME-639 Intro To Robotics

Roll No:- 18110113

Mid Sem Exam

Q1(d)



We need to move the end effector along the path A-B-C-D with a constant velocity of 0.01m/s.

As for each straight line motion, the velocity matrix of end effector is given as

A - B → $V = \begin{bmatrix} 0 \\ -0.01 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

B - C → $V = \begin{bmatrix} -0.01 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

C-D → $V = \begin{bmatrix} 0 \\ 0.01 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

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D - A $\quad V = \begin{bmatrix} 0.01 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

As we have the desired values of the joint parameters we can calculate the ~~than~~ desired Jacobian matrix for the given Robot.

Thus, ~~as~~ we have

$$\dot{X} = J\dot{q}$$

As we have $\dot{X}$ & J we can solve for joint angle velocities $\dot{q}$ by taking pseudo inverse of J.

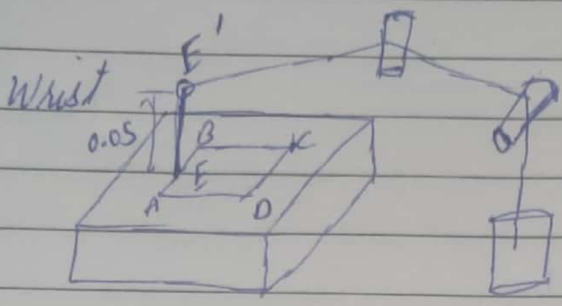
$$\dot{q} = J^{-1}\dot{X}$$

→ Even though the cartesian velocity is constant along any one line of the path, the joint velocities ~~does~~ are not ~~need to be~~ constant. This is because at every instant along the line the joint ~~angles are~~ parameters are different (i.e changing along the motion). Thus the Jacobian changes along the motion.

$\therefore$ We have $\dot{X} = J\dot{q}$

As $\dot{X}$ = constant, J = variable, $\dot{q}$ cannot be constant.

c,f



For the given ~~gripper~~ robot we need that the Tool point is perpendicular to the surface of the testing material.

Thus to calculate joint parameters, we can assume a pseudo end effector E' such that ~~...~~ the required position is $[\underbrace{\text{point } P}_{\downarrow} + [0, 0, 0.05]]$

~~...~~ Any Point on surface

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a) According to me, ~~a~~ for a ~~n~~ single pill picking operation, a compliant / soft gripper will be more suitable. Considering the dimensions of the pill (10x20 mm approx) as well the size of small cup, it is difficult to develop a hard gripper of such miniature size, also ensuring that only a single pill is picked at a time. ~~&~~ Apart from that considering the softness of the pill, force consideration is another challenge in developing hard grippers. Whereas with soft grippers ~~it~~ its easier to role a tail/fingers around the pill. ~~and~~

b) Soft Robotic Grippers can easily grip of soft and curved objects, which can be best used is pill picking operations.

→ Origami inspired robots is an another interesting concept which can be used to develop gripper for pill picking operation. Due to its small size, it can ~~enter~~ enter small cups and also ensure that single pill is picked at a time, ~~[illegible]~~ because of its folding mechanism.

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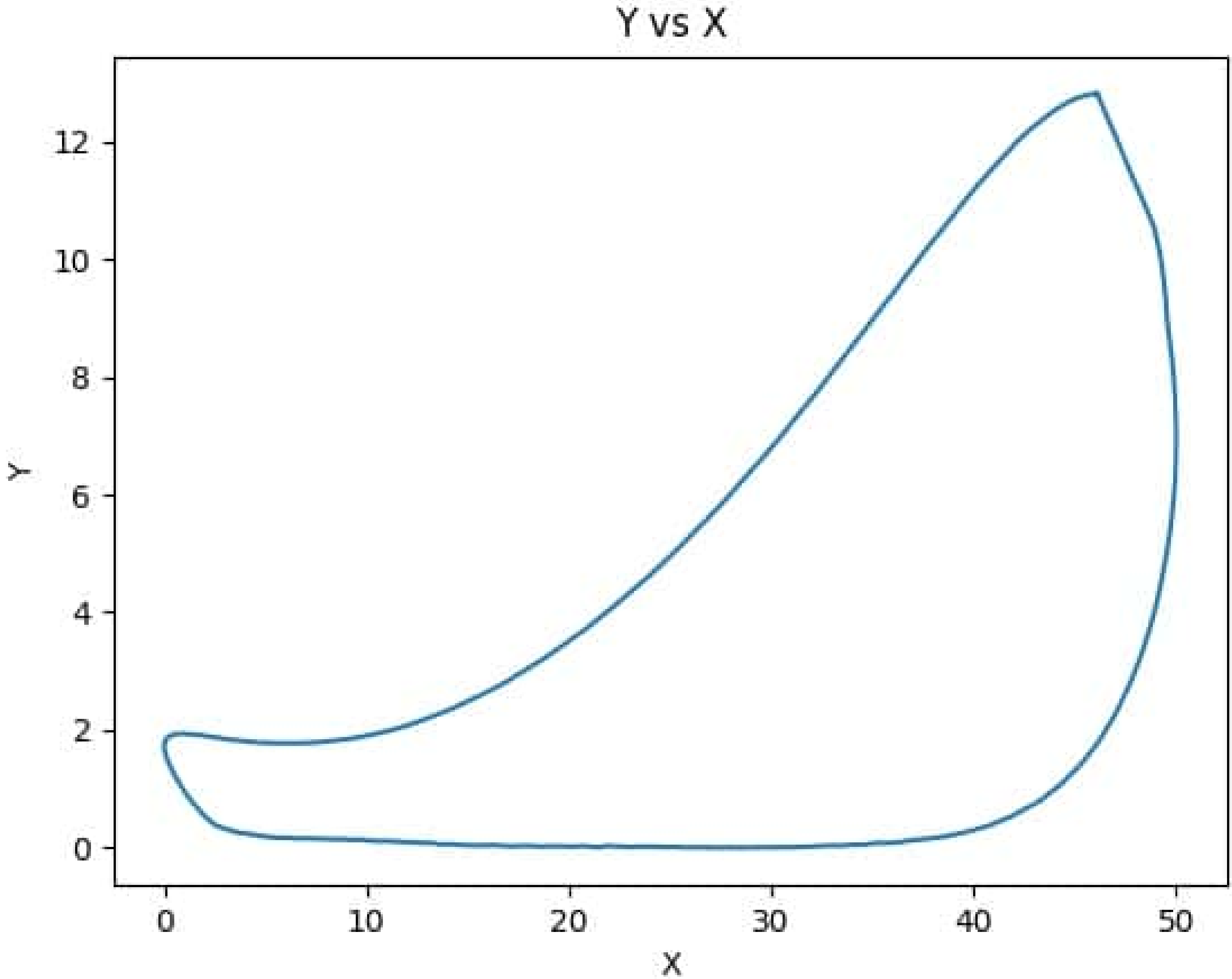
3(a) Link - 1 (Hip to knee) - 41 cm (Approx measurement)
Link - 2 (Knee to ankle) - 38 cm (Approx measurement)

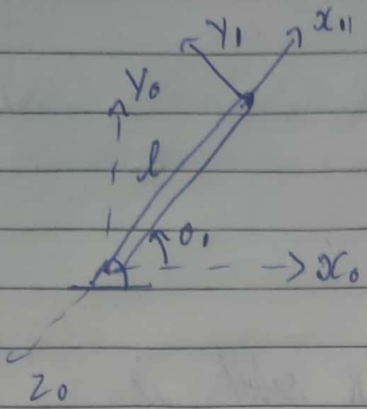
-> Gait Trajectory - Gait is defined as person's pattern of walking and the Trajectory followed by a human foot while walking is called as Gait Trajectory.

-> Step height - The peak of the height reached from the ground during a gait trajectory.

-> Step length - The distance between the two foots, while walking is defined as step length.


Y vs X
Y
X
0
2
4
6
8
10
12
0
10
20
30
40
50

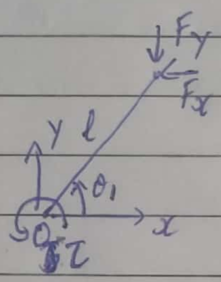
4(a)



DH Parameters for 1R robot is

Link	a_i	d_i	α_i	θ_i
1	l	0	0	θ_1

b)



$$x = l\cos\theta_1$$
$$y = l\sin\theta_1$$

From static Equillibrium we have

$$\Sigma M_0 = 0$$
$$F_y\, l\cos\theta_1 - F_x\, l\sin\theta_1 = \tau$$

For end effector to behave like spring we have forces on end effector as

$$F_x = k_1(x - x_0)$$
$$F_y = k_2(y - y_0)$$

$$\therefore \tau_i = l\cos\theta_1\, k_2(y - y_0) - l\sin\theta_1\, k_1(x - x_0)$$

$$\tau_i = k_2 l \cos\theta_1 (l \sin\theta_1 - y_0) - k_1 l \sin\theta_1 (l\cos\theta_1 - x_0)$$

$$\tau_i = (k_2 - k_1) l^2 \cos\theta_1 \sin\theta_1 - k_2 l y_0 \cos\theta_1 + k_1 l x_0 \sin\theta_1$$

if $k_1 = k_2 = k$

$$\tau_i = k l x_0 \sin\theta_1 - k l y_0 \cos\theta_1$$

From the dynamics of 1R robot we have

$$\cancel{m l^2 \frac{d^2 q_1}{dt^2} + mgl \sin(\theta_1) = \tau}$$

~~Thus we are need to apply torque $= \tau_i + mgl\sin\theta_1$ at the joint motor, for end effector to act like spring.~~

$$K = \frac{1}{2} I \omega^2 = \frac{1}{2}\left(\frac{1}{3} m l^2 \dot{q}_1^2\right)$$

$$= \frac{1}{6} m l^2 \dot{q}_1^2$$

$$V = \frac{mgl}{2} \sin q_1$$

$$\therefore \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_1}\right) - \frac{\partial L}{\partial q_1} = \tau$$

$$L = K - V$$

$$\therefore \frac{1}{3} m l^2 \ddot{q}_1 - \frac{mgl}{2} \cos q_1 = \tau$$

Thus we need to apply torque $\tau_i + \tau$ at the joint motor, for end effector to act like spring.

c) Taking the link of length ($l = 10$), mass ($m = 10$) and spring constant ($k_1 = k_2 = 100$).

The mean position $(x_0, y_0) = (10, 0)$ & Initial position $(x, y) = (9.5, 3.122)$, the following plots for position vs time and Energy vs Time are obtained.

Here we see that the Total Energy is not constant because we have not taken into consideration the virtual spring work (i.e work done by F_x & F_y). Thus a periodic curve is obtained for total energy as there is no loss and only transfer of energy takes place.

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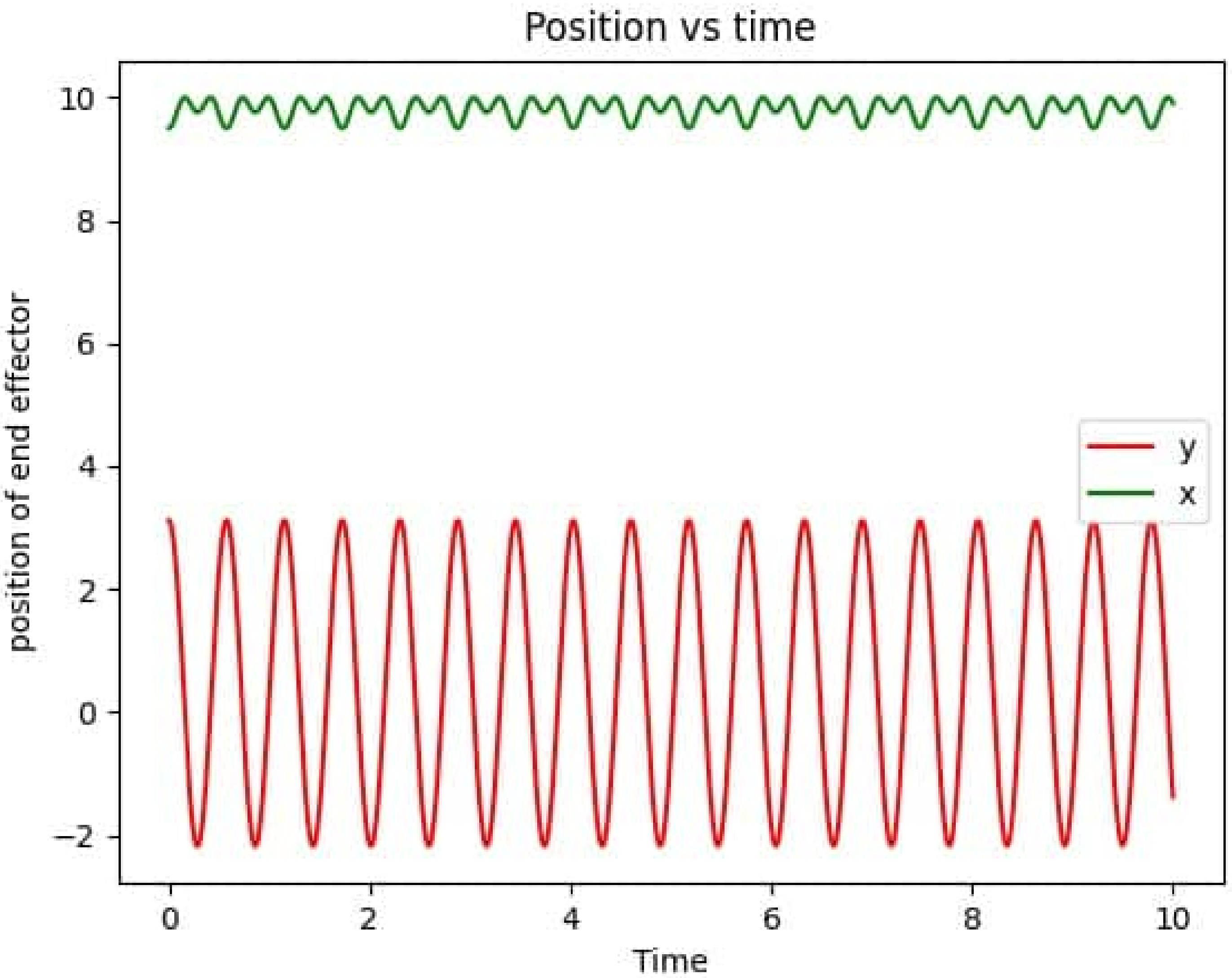
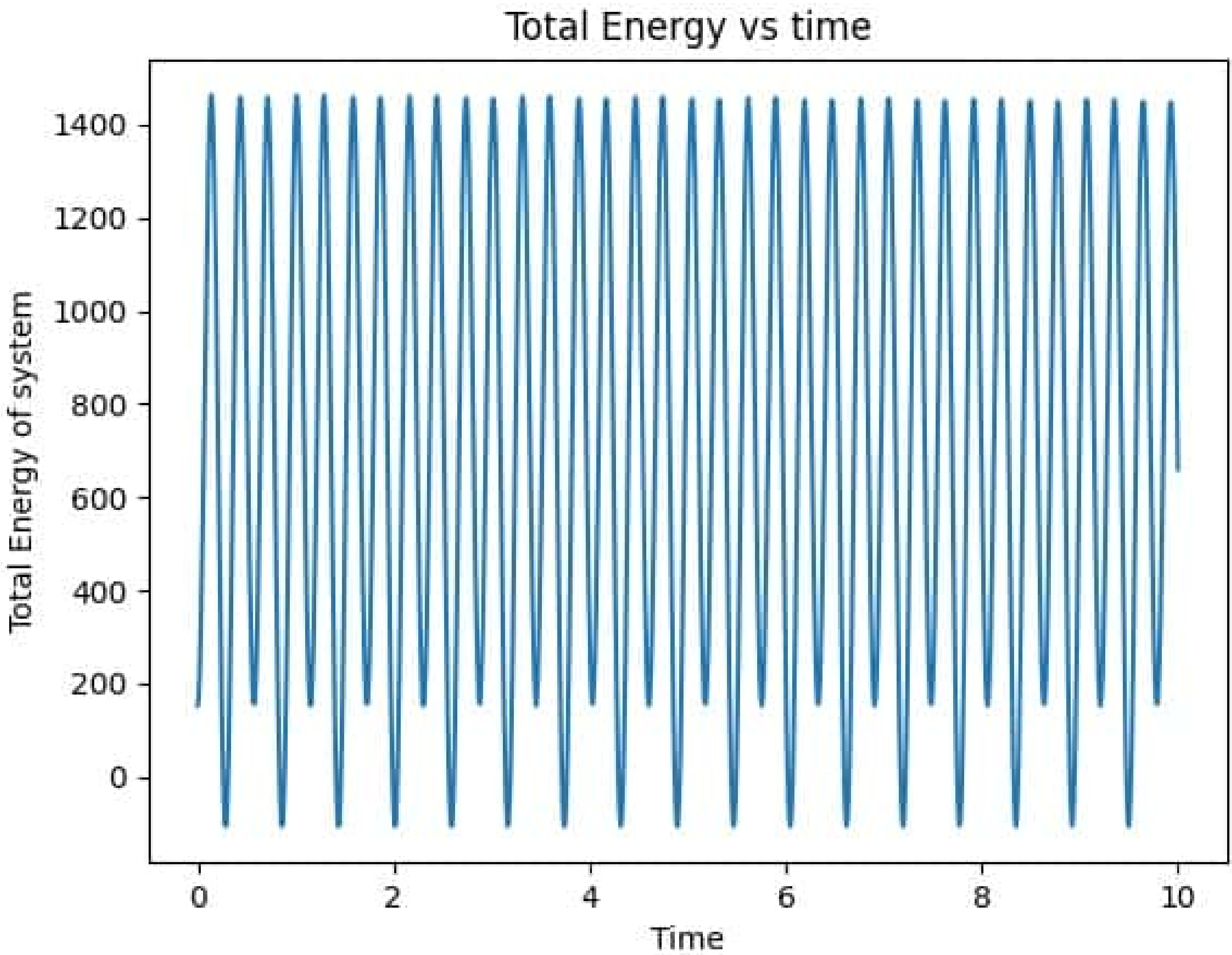

Position vs time
10
8
6
4
2
0
−2
0
2
4
6
8
10
Time
position of end effector
y
x



Total Energy vs time
Total Energy of system
Time
0
200
400
600
800
1000
1200
1400
2
4
6
8
10

5 Yes

6 Yes

7 Yes

8 Yes, In a ~~the~~ given order

9 Yes

Q2

b) Soft Robotic Grippers - https://onlinelibrary.wiley.com/doi/full/10.1002/adma.201707035

Origami Robots - https://www.youtube.com/watch?v=ZVYz7g-qLjs