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Assignment 5

Q 6)

A)

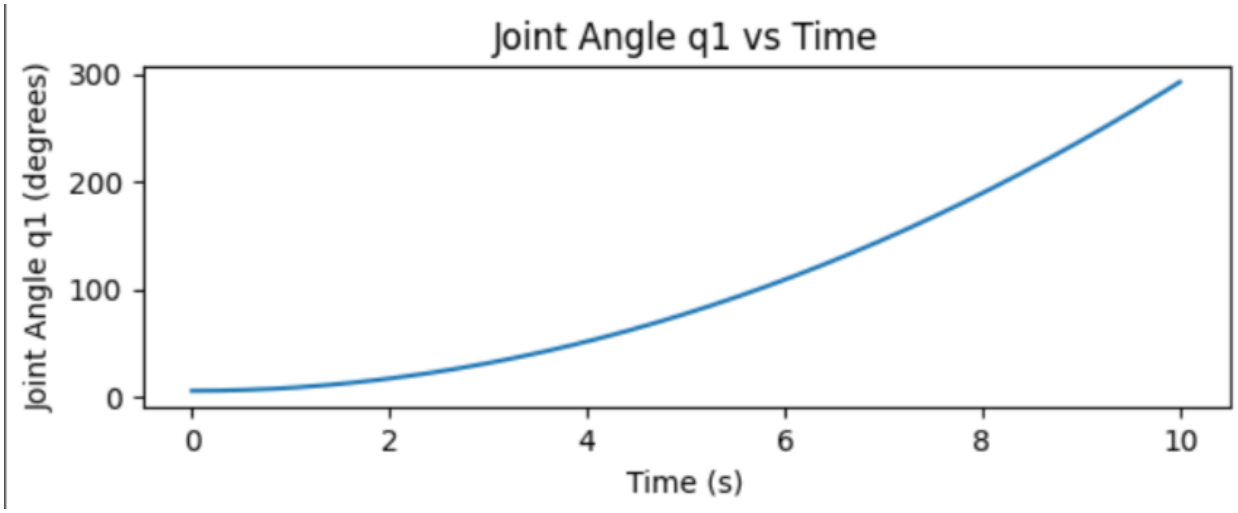
I have consider **UR5'first three degrees of freedom.**

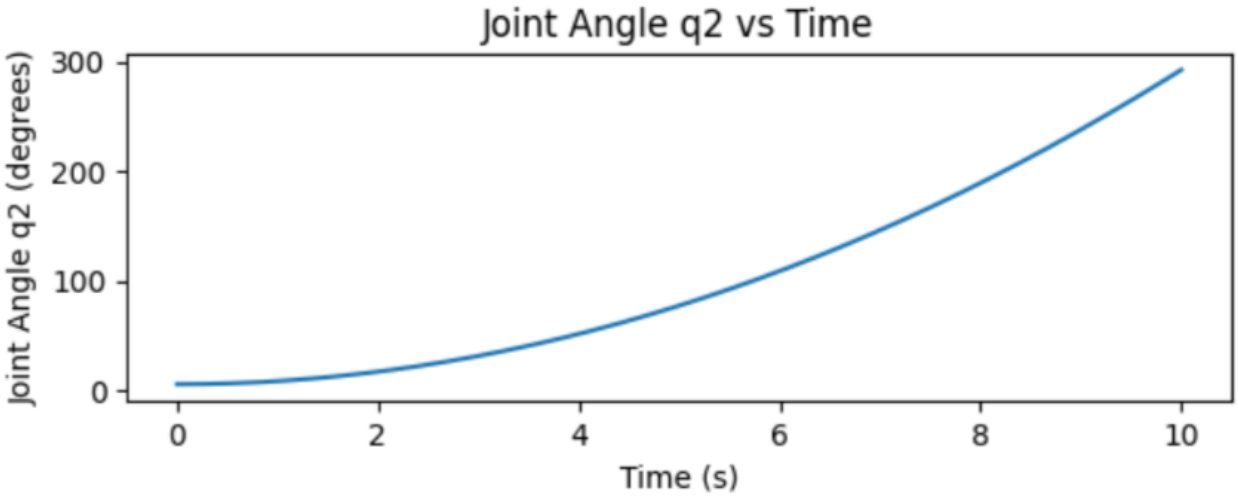
```
Enter length of link 1 (l1): 1
Enter length of link 2 (l2): 1.5
Enter length of link 3 (l3): 1
```

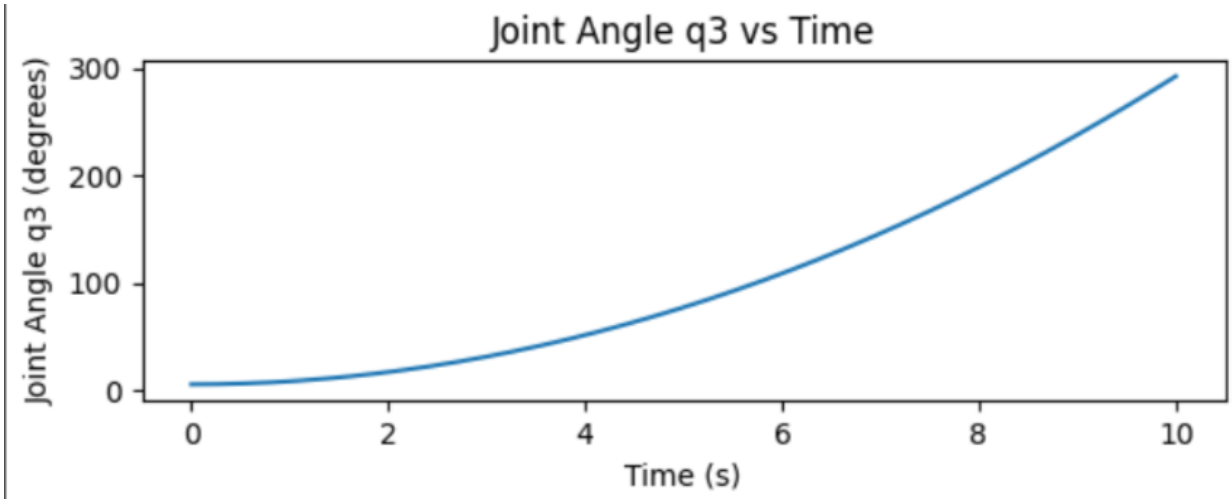
```
Enter mass of link 1 (m1): 0.1
Enter mass of link 2 (m2): 0.1
Enter mass of link 3 (m3): 0.1
```

```
Enter torque value for joint 1: 0.1
Enter torque value for joint 2: 0.1
Enter torque value for joint 3: 0.1
```

Results




Joint Angle q2 vs Time
Joint Angle q2 (degrees)
300
200
100
0
0
2
4
6
8
10
Time (s)


Joint Angle q3 vs Time
Joint Angle q3 (degrees)
300
200
100
0
0
2
4
6
8
10
Time (s)

B)

Simple PD Control:

- A proportional-derivative (PD) controller uses the error and its derivative to compute the control input.
- The control input is given by tau = Kp * (q_des - q) + Kd * (q_dot_des - q_dot), where Kp and Kd are proportional and derivative gains, respectively.

Slightly More Sophisticated Control:

- This version can include additional terms to improve performance, such as gravity compensation.
- The control input can be modified to include gravity compensation: tau = Kp * (q_des - q) + Kd * (q_dot_des - q_dot) + G(q).

Feedforward Control:

- Feedforward control anticipates the disturbance by including a term based on the desired trajectory.
- The control input includes both feedback and feedforward terms: tau = Kp * (q_des - q) + Kd * (q_dot_des - q_dot) + tau_feedforward.

Computed Torque Control:

- Computed torque control includes an inverse dynamics term to compensate for the nonlinear dynamics.
- The control input is calculated as follows: tau = D(q) * q_ddot_des + C(q, q_dot) * q_dot_des + G(q) + tau_feedforward.