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Problem 1)

$$1.1) \min \sum_{k=0}^{N-1} (t_{k+1} - t_k) \frac{\omega(t_{k+1}) + \omega(t_k)}{2}$$

here, $\omega(t)$ represents the torque.

Constraints:

$$\dot{q}(t_{k+1}) = \dot{q}(t_k) + (t_{k+1} - t_k) \frac{\ddot{q}(t_{k+1}) + \ddot{q}(t_k)}{2}$$

$$q(t_{k+1}) = q(t_k) + (t_{k+1} - t_k) \frac{\dot{q}(t_{k+1}) + \dot{q}(t_k)}{2}$$

Dynamics:

$$\ddot{q} = M^{-1}(\tau - C\dot{q} - N)$$

Initial conditions:

$$q(t_0) = \begin{bmatrix} -\pi/2 \\ 0 \end{bmatrix}, \quad \dot{q}(t_0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Final conditions:

$$q(t_f) = \begin{bmatrix} \pi/2 \\ 0 \end{bmatrix}, \quad \dot{q}(t_f) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Number of decision variables:

Here, $h = 0.028$, $\text{span} = 1.5s \rightarrow \text{timesteps: } 76$

$$\Rightarrow \text{decision variables} = 76 \times 4 = 304$$

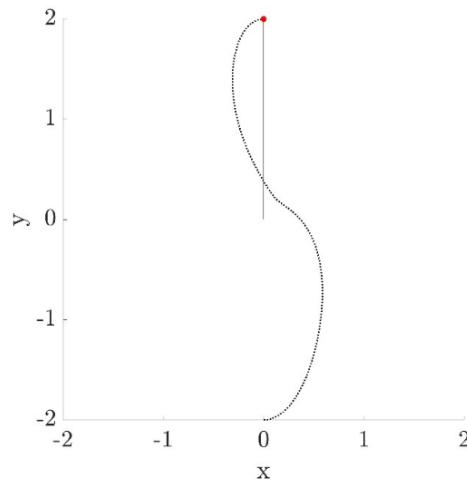
Number of constraints:

$$75 \times 4 + 8 = 308$$

1.3) Both cases have different trajectories, although they have similar shapes.

The cost increases on adding the constraint, and adding the constraint also increases the number of iterations necessary for the optimization to converge.

1.2 : unconstrained optimization



1.3 : constrained optimization

