Problem 1

Given the two-link manipulator as used in midterm takehome. Suppose the end effector is subject to an environment force $F_e = [-2, -1]^\intercal$, derive the modified dynamic equation of the system in the joint space. Recall

$$M(q)\ddot{q} + C(q, \dot{q})\dot{q} + N(q) = \tau + J^\intercal(q)F_e$$

note the gravity term will not be there.

Problem 2

This is a matlab programming implementation exercise. See Fig. 1, Starting at a configuration in the free space (up to your choice), suppose the two-link manipulator aims to reach a set point $(L_1 + L_2, 0) = (2, 0)$ and there is a rigid and stationary object at position $(1.8, 0)$ and oriented perpendicular to the x axis. Design an impedence controller for the plannar arm to achieve a desired interaction performance: Feel free to select M_d, K_d, B_d (inertia, spring, and damping coefficients matrices). Justify your choice based on the reason of human motion control.

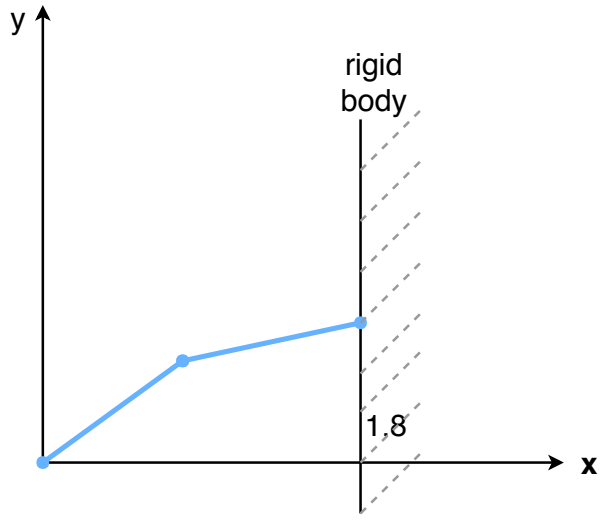

Figure 1: Interaction between a two-link plannar arm with rigid environment