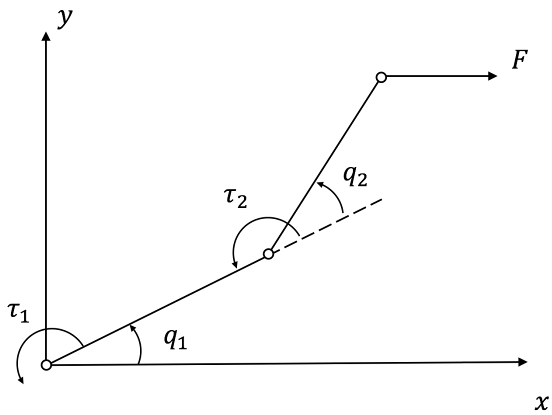
EECE 5552-Assistive Robotics
Assignment 9

Alireza Ramezani

***Due by 11:59 PM Eastern Time, Friday, Dec 4**

Problem 1

(a) Given the two-link planer manipulator shown below. Find out the joint torques τ_1 and τ_2 corresponding to the end-effector force $F = [-1, -1]^T$



(b) What are the natural and artificial constraints for the task of inserting a round peg shown below into a round hole? Sketch the compliance frame for this task.

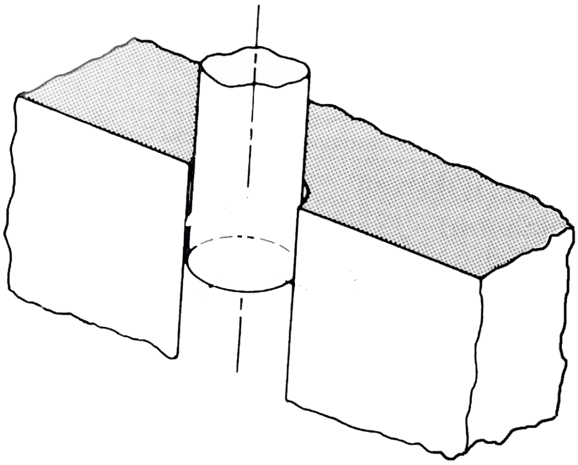


Figure 1: Inserting a peg into a hole.

(c) Describe the natural and artificial constraints associated with the task of opening a box with a hinged lid. Sketch the compliance frame.

(d) Discuss the task of opening a long two-handled drawer. How would you go about performing this task with two robotic arms?
Hint: Define compliance frames for the two arms and describe the natural and artificial constraints.

(e) Classify these environments as either inertial, capacitive or resistive according to the class notes:
1: Turning a crank.
2. Inserting a peg in a hole.
3. Polishing the hood of a car.
4. Cutting cloth.
5. Sheering a sheep.
6. Placing stamps on envelopes.
7. Cutting meat.
Hint: Some of the scenarios consist multiple environment classifications; e.g., case 1 in inertial tangent to the circle defined by crank rotation and capacitive along the crank rotation.

Problem 2

Show that for an inertial environment, position control can be used to specify a desired robot impedance.
Hint1: In the case that the environment impedance is inertial, we have the robot-environment interaction as shown below:

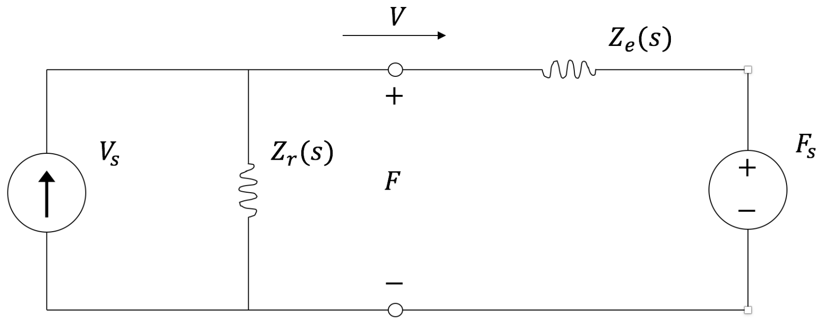


Figure 2: Inertial environment.

The environment One-port is a Thevenin network and the robot One-port is a Norton network. Suppose $F_s = 0$ and that V_s represents a reference velocity. From the diagram, obtain $\frac{V}{V_s}$.

Hint2: Obtain the steady state force error(e_{ss}) of $\frac{V}{V_s}$ to a step reference velocity command $V_s = \frac{V^d}{s}$. What is your answer? Apply your answer to conclude that position control is possible.
Hint3: Take a non-inertial robot impedance $Z_r(s) = M_c s + Z_{rem}(s)$ and substitute $a_x = \ddot{x}^d + \frac{1}{M_c} Z_{rem}(\dot{x}^d - \dot{x}) + \frac{1}{M_c} F$ into $\ddot{x} = a_x$ to show creating a desired robot impedance is possible.