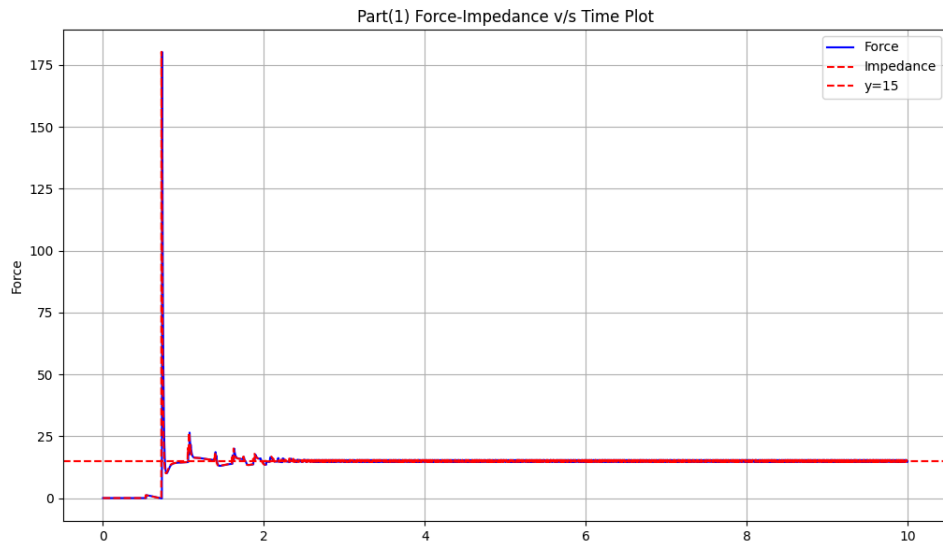


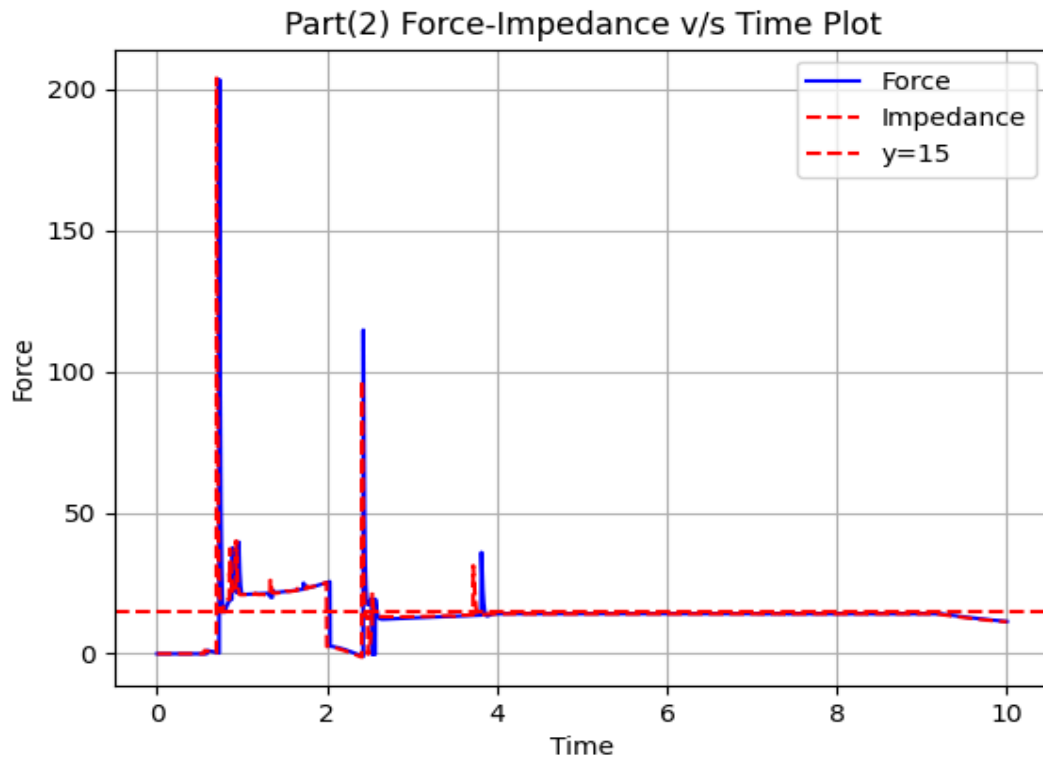
Robot Autonomy Assignment-1

PID Control

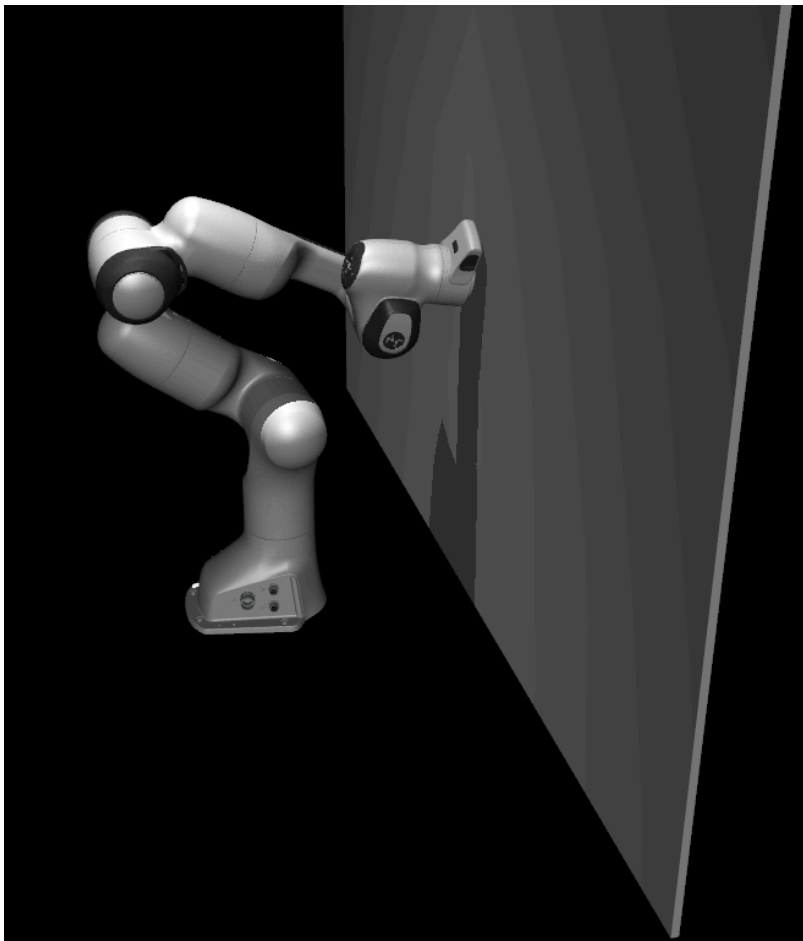
(A) Force plots for the case where the whiteboard is static.



(B) Force plots for the case where the whiteboard is oscillating



(C) Franka robot when the board is near its maximum amplitude



(D) Differences in the behavior of the force and impedance controller

Criteria	Force Controller	Impedance Controller
Control Objective	Force controllers generate a specific force or torque at the end-effector, regardless of the external environment's interaction.	The response is based on the interaction forces encountered. They focus on controlling the robot's compliance, allowing it to adapt its behavior in response to external forces.
Behavior and Adaptability	It tends to exhibit rigid or non-adaptive behavior. They maintain a fixed force or torque output, which can lead to limited adaptability in dynamic environments or when interacting with objects with varying properties.	By adjusting the robot's response based on the encountered forces, impedance controllers can exhibit varying levels of stiffness or compliance, making them more suitable for tasks where the interaction with the environment requires flexibility and adaptation.

Kinematics for Franka

(A) The 3 end effector poses (in matrix form) corresponding to q_1 , q_2 , and q_3 .

```
Joints:
[0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
computed FK ee position
[ 8.80000000e-02 -8.93992163e-18  9.26000000e-01]
computed FK ee rotation
[[ 1.0000000e+00  0.0000000e+00  0.0000000e+00]
 [ 0.0000000e+00 -1.0000000e+00 -1.2246468e-16]
 [ 0.0000000e+00  1.2246468e-16 -1.0000000e+00]]

Joints:
[0, 0, -0.7853981633974483, -0.2617993877991494, 0.3490658503988659, 0.2617993877991494, -1.3089969389957472]
computed FK ee position
[ 0.15710277 -0.10259332  0.93602711]
computed FK ee rotation
[[ 0.64935398  0.75871099  0.05193309]
 [ 0.7552124  -0.65137389  0.07325497]
 [ 0.08940721 -0.00834789 -0.99596017]]

Joints:
[0, 0, 0.5235987755982988, -1.0471975511965976, -1.1344640137963142, 0.7853981633974483, 0.0]
computed FK ee position
[0.40136375 0.08742801 0.85526363]
computed FK ee rotation
[[ 0.98015816 -0.18113365 -0.08050201]
 [-0.17410263 -0.5925751  -0.78647507]
 [ 0.09475362  0.78488557 -0.61235316]]
```

(B) The final joint angles for moving to the end effector goal pose of R_g , t_g .

```
Error 7.119287853727876e-07 0.0003672339588113134
Computed IK angles [0.6861859276510833, 0.34630181018357475, -0.8233220687997146, -2.075870299687756, -0.14744290658976544, 3.919305788784955, -2.7831659162987696]
```

(C) Image of the robot at the joint position that the inverse kinematics returns.

