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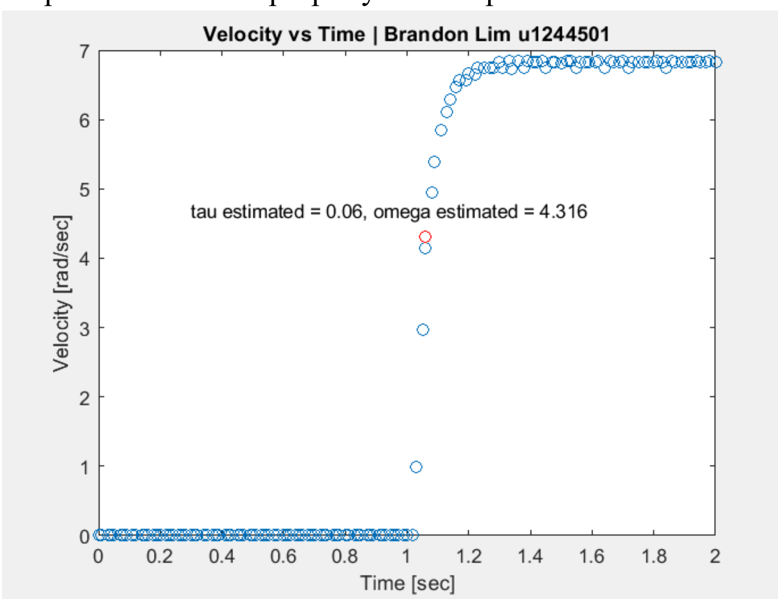
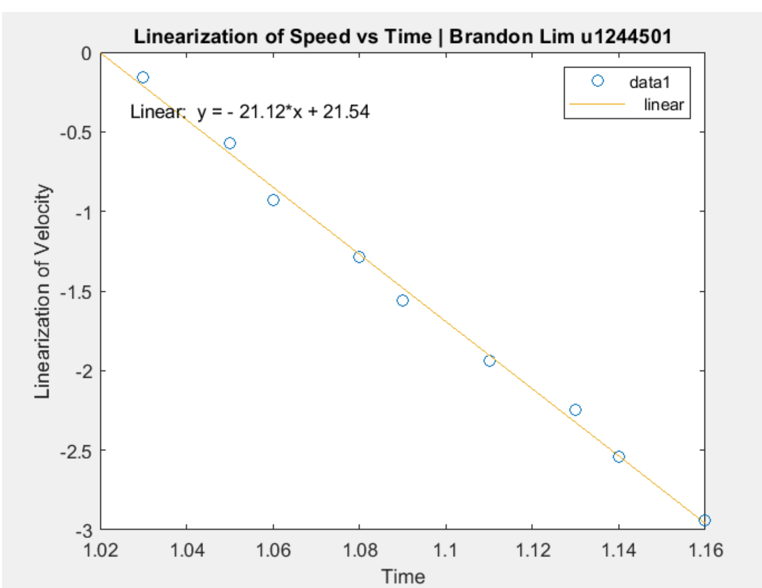
5. Post-Lab Exercises

Complete the following exercises per pre- and post-lab submission policy posted on Canvas. Remember, post-lab exercises are completed independently by each student unless otherwise specified. Include your name(s) and lab section in every plot title.

1. Using the step response data you measured in part 4.1:
   a. Plot the step response rotational velocity (rad/s) vs time (sec). Place a data point at the estimated time constant (τ, 0.632* $Omega_{ss}$). Display the estimated time constant on plot. Include the properly labeled plot.



   b. Now estimate the time constant using the semi-log method described in the lab documentation. Include your properly labeled plot and regression.



Tau = -1/-21.12 = 0.047

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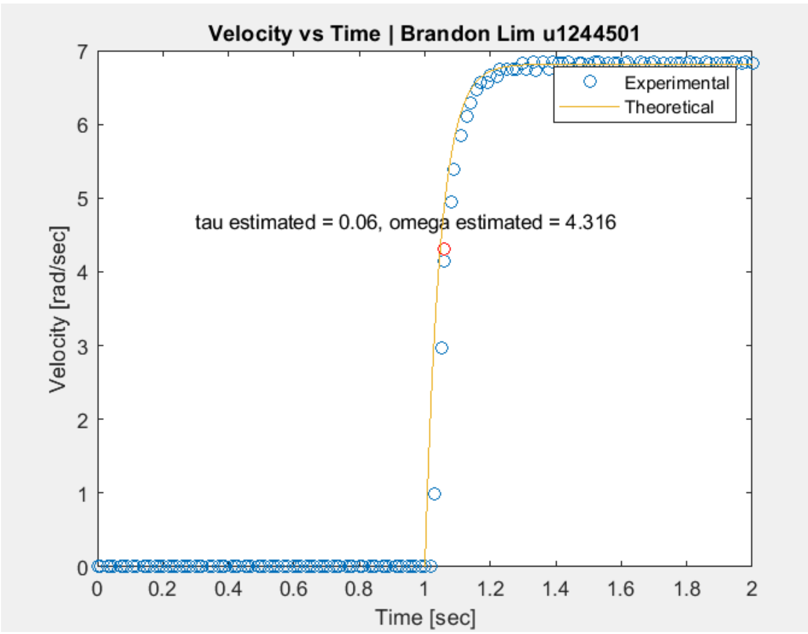
c. Estimate the transfer function in equation (7) for your system using the time constant and steady-state speed from your step response.

$$H(s) \ = \ \frac{0.863}{0.047s+1}$$

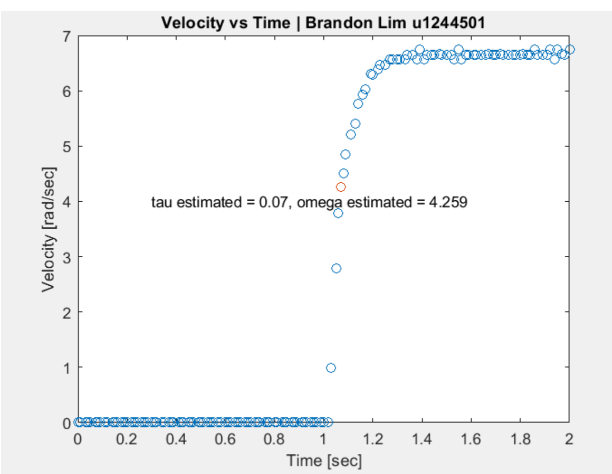
d. Use the *tf()* and *step()* commands in MATLAB to simulate the theoretical step response of your transfer function and plot it overtop of your experimental step response. Discuss any discrepancies. (Note: The *step()* function assumes an input of 1, so be sure to scale the output based on our input of *d)*.



Plots are very similar, with almost no discrepancies. Only a slight shift to the left but that can be due to truncation error on my end.

2. Using the step response data you measured in part 4.2:

a. Plot the step response average velocity (rad/s) vs. time (sec), and estimate the steady-state average velocity.



b. Use the semi-log method to estimate the time constant.

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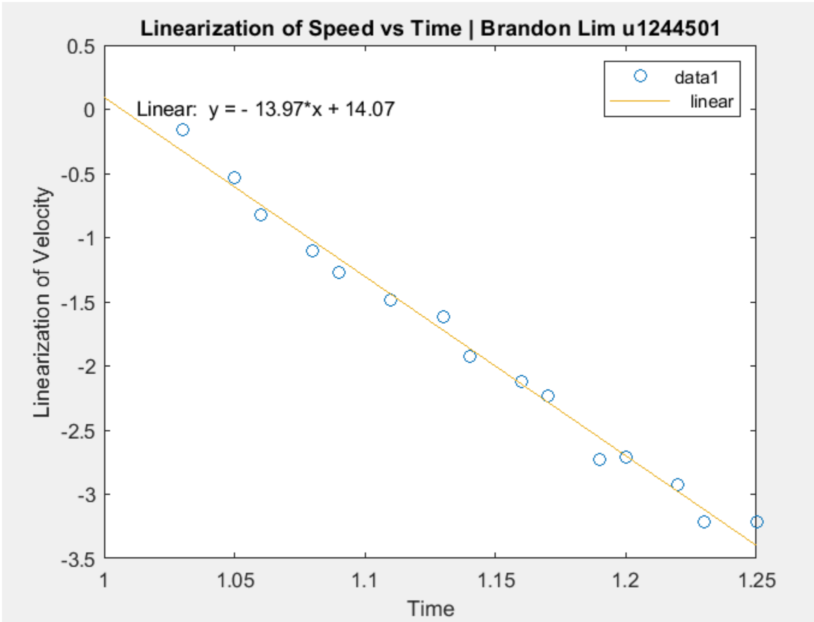
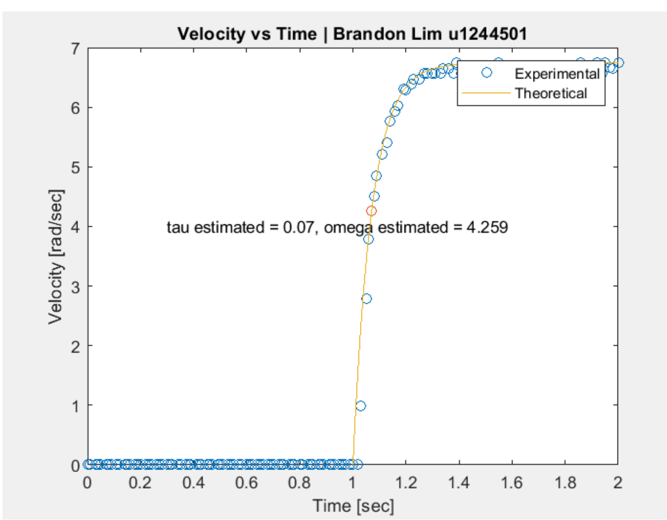


Tau = 1/13.97 = 0.071

c. Using the steady-state average velocity and time constant, write a 1st order transfer function for your robot., , where Ω is the average velocity of the wheels, and V is the motor voltage. Note that this transfer function will be slightly different than the one in exercise 4.1, because it will now include the inertia of the entire robot, rather than just the inertia of the wheel.

$$H(s) \;=\; \frac{1.348}{0.071s + 1}$$

d. Use the *tf()* and *step()* commands in MATLAB to simulate the theoretical step response of your transfer function and plot it overtop of your experimental step response.



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```
% Brandon Lim
clear, clc, close all
No_Drive_Data = load("Lab11Data.mat");
M = No_Drive_Data.M;
V = No_Drive_Data.V;
t = No_Drive_Data.t;

omega_ss = V(end);
omega_tau = omega_ss * 0.632;

plot(t,V,"o");
xlabel("Time [sec]")
ylabel("Velocity [rad/sec]")
title("Velocity vs Time | Brandon Lim u1244501")
hold on
plot(1.06,omega_tau,"ro")
text(0.3,4.7,"tau estimated = 0.06, omega estimated = 4.316")

omega = V<0.96*omega_ss & V>0;

hold on
G = tf(1.363 * 5,[0.047 1]);
newt = linspace(1,t(end),length(omega));
newt = newt - 1;
x = step(G, newt);
plot(newt+1,x)
legend("Experimental","","Theoretical")
```

```
figure
plot(t(omega),log(1-(V(omega)./omega_ss)),"o")
title("Linearization of Speed vs Time | Brandon Lim u1244501")
xlabel("Time")
ylabel("Linearization of Velocity")
```

```
%% Brandon Lim
clear, clc, close all
Drive_Data = load("Lab11DataDrive.mat");
M = Drive_Data.M;
V = Drive_Data.V;
t = Drive_Data.t;

plot(t,V,"o");
xlabel("Time [sec]")
ylabel("Velocity [rad/sec]")
title("Velocity vs Time | Brandon Lim u1244501")

Omega_ss = V(end);
Omega_tau = 0.632 * Omega_ss;
index = V<0.96*Omega_ss & V>0;
```

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```
hold on
plot(1.07,Omega_tau,"o")
text(0.3,4,"tau estimated = 0.07, omega estimated = 4.259")
newt = linspace(1,t(end),length(index));
newt = newt - 1;
G = tf(1.348, [0.071, 1]);
stepinput = step(G,newt)*5;
plot(newt+1,stepinput)
legend("Experimental","","Theoretical")



figure
plot(t(index),log(1-(V(index)./Omega_ss)),"o")
title("Linearization of Speed vs Time | Brandon Lim u1244501")
xlabel("Time")
ylabel("Linearization of Velocity")
```