ENME 585 Fall 2022
Lab 03 – DC Motor Position Control
Lab Submission Form

YOUR GROUP INFORMATION

Lab section: **Date:**	B04 Oct. 25, 2023	**Laptop #:** **Hardware #:**	**N/A** **N/A**
First Name 1:	Marco	Last Name 1:	Suva
First Name 2:	Zachary	Last Name 2:	Uy
First Name 3:	**N/A**	Last Name 3:	**N/A**

YOUR FEEDBACK

A. How would you rate the difficulty of this lab? Self-explanatory

B. Were there any aspects of this lab that you struggled with or found confusing? If so, which? **N/A**

C. How long did it take you/your group to do the lab, including finishing this submission form? 2 hours

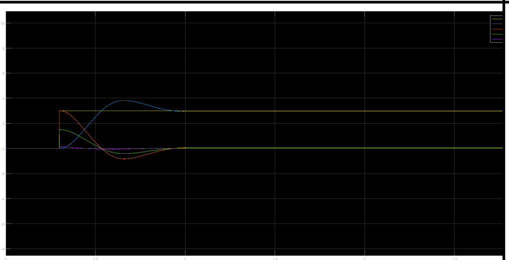
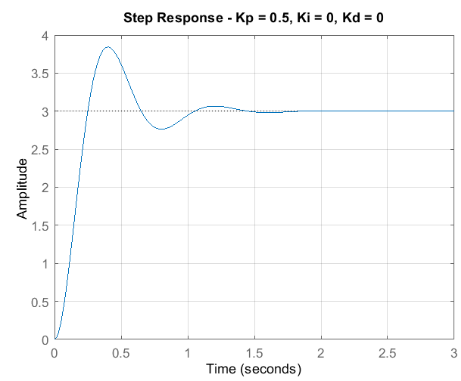
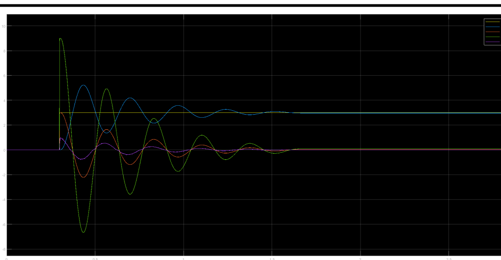
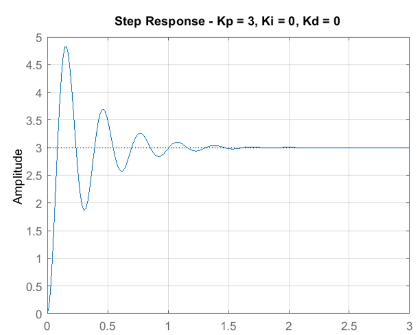
D. Suggest improvements, if any. **N/A**

QUESTIONS: Proportional (P) Control (12/32 marks)

Q1. Insert the figures of the physical and simulated step response plots for $k_p = 0.5$ and $k_p = 3$.

Answer the following questions in the space provided:

- Describe how the step response changes as k_p is increased. Specifically, does it become faster or slower, and what is the effect on overshoot and oscillations?
- Does this agree with your answer to prelab Question 4?
- Is there steady state error in the physical system? Does this agree with the simulated step response and with theory (i.e., prelab Question 3)? What could be the source of this error in the physical system?

Gains	Physical Step Response	Simulated Step Response
$k_p = 0.$		
$k_p = 3$		

- Step response becomes faster, and overshoot and oscillations increase as kp increases.
- Yes, it agrees with pre lab question 4.
- Yes, there is steady state error when compared to the physical system. This does not agree with the theory in question 3 since it states error should be zero. The source of error is the static friction that the system must overcome.

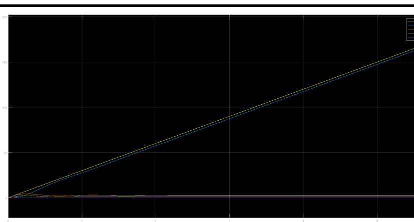
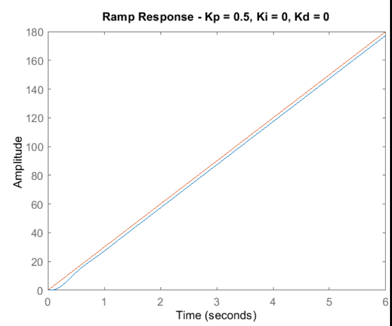
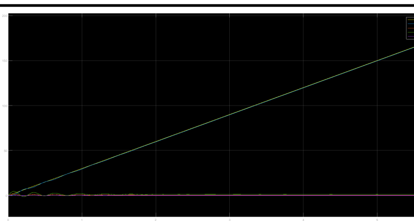
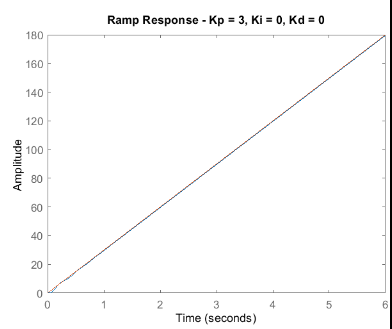
When turning the disc away from its set point under P control, does the stiffness increase in proportion to k_p?

- Stiffness increases as the kp value increases from 0.5 to 3.

Q2. Insert the figures of the physical and simulated ramp response plots for $k_p = 0.5$ and $k_p = 3$.

Answer the following questions in the space provided:

- Is the steady-state error still zero?
- If not, how does it depend on k_p?
- Does this match your prediction in prelab Question 3?

Gains	Physical Ramp Response	Simulated Ramp Response
$k_p = 0.5$		
$k_p = 3$		

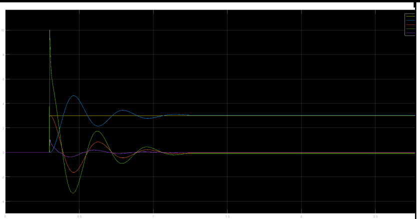
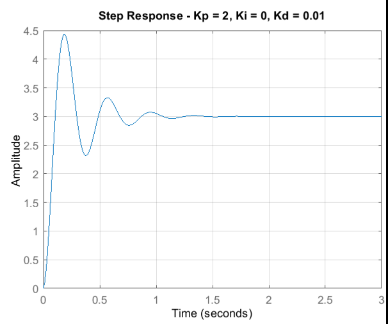
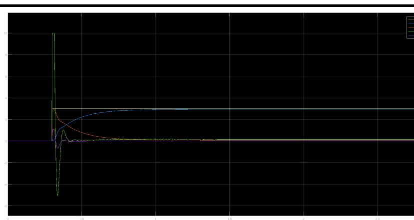
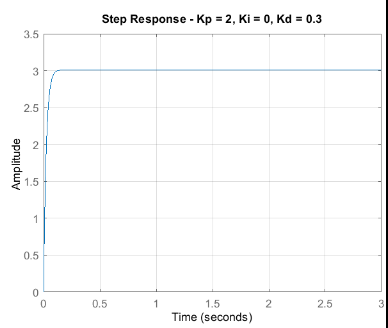
- Steady state error is not zero.
- kp value is inversely proportional, therefore as kp increases, error response decreases.
- This matches the results found in pre lab question 3.

QUESTIONS: PD Control (8/32 marks)

Q3. Insert the figures of the physical and simulated step response plots for $k_d = 0.01$ and $k_d = 0.3$.

Answer the following questions in the space provided:

- How does the step response change as k_d is increased?
- Does this agree with your answer to prelab Question 4?
- How does the addition of derivative control affect the control voltage compared with the control voltage when only proportional control was applied (Q1)? Why is this?

Gains	Physical Step Response	Simulated Step Response
$k_d = 0.01$		
$k_d = 0.3$		

- As kd increases, the step response has decreased oscillations and no overshoot. Settling time increases significantly so the system becomes slower.
- This agrees with the results from question 4.
- Control voltage does not oscillate as much and has a higher peak. The voltage reaches saturation point on start up (10 V) because the error is near 0, and the derivative of the error is voltage. Then, the derivative of error means that voltage is infinity but we cap the actual voltage at 10V.

Q4. How does the resistance torque that you feel depend on the speed that you wiggle the disc, and how does this depend on k_d?

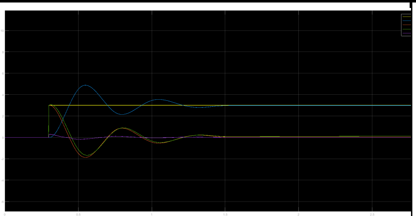
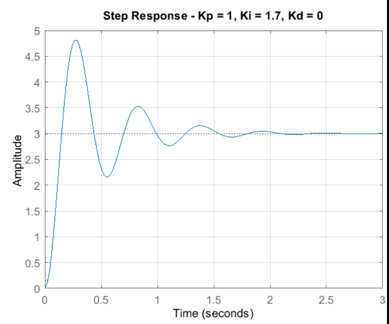
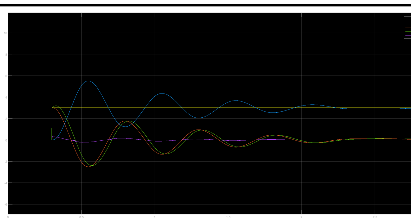
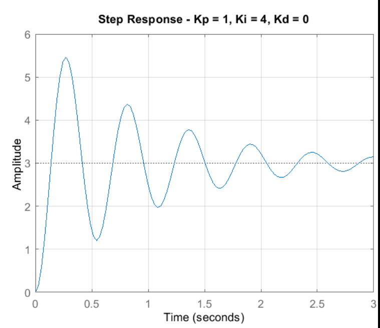
- The resistance torque feel stronger when kd is increased and when we manually wiggle the disc faster.

QUESTIONS: PI Control (12/32 marks)

Q5. Insert the figures of the physical and simulated step response plots for $k_i = 1.7$ and $k_i = 4$.

Answer the following questions in the space provided:

- Describe how the step response changes as k_i is increased. Specifically, does it become faster or slower, and what is the effect on overshoot and oscillations?
- Does the integral control eliminate the steady state error due to static friction observed when only proportional control was applied? Why?

Gains	Physical Step Response	Simulated Step Response
$k_i = 1.7$		
$k_i = 4$		

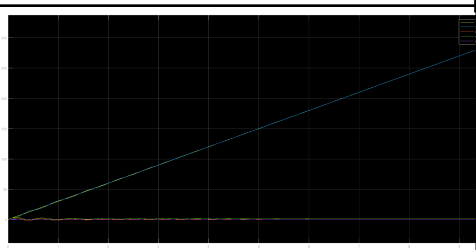
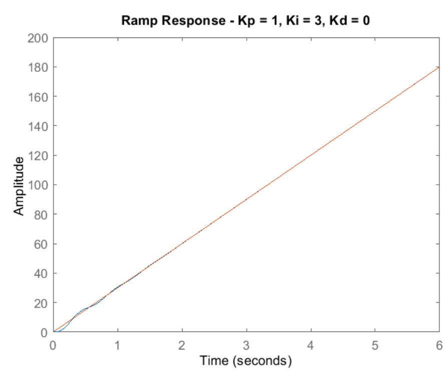
- As ki increases, the overshoot of the oscillation increases and becomes faster and has more oscillations. Settling time increases as ki increases.
- No, the integral control does not eliminate the steady-state error due to static friction as can be seen by non zero steady-state error in our measurements.

Q6. Answer the following questions to describe what happened as you turned the motor with PI control applied.

- How does the motor torque change with time as you hold the disc at 0 degrees?
- What happens when you release the disc?
- Does the response after releasing the disc depend on how long you hold the disc?

- Motor torque increases as the time held at zero degrees is increased.
- The oscillations increase in magnitude and settling time increases.
- The output increases the longer we hold the disc and steady state error increases.

Q7. Insert the figure of the physical and simulated ramp response plot for $k_i = 3$. Does the steady-state error match with your prediction in prelab Question 2?

Physical Ramp Response	Simulated Ramp Response
	

- The steady-state error reaches zero which matches the prediction in prelab question 2.

Q8. What is the result of having $k_p = 0$ with a non-zero k_i?

- The result is that the system becomes unstable.