Lab Section: T 3-5

Names: Elissa Ito

# Lab 5 – Active Gimbal Control– Dual-Axis Gimbal

## Prelab

$$s^2 + \frac{B}{J}s + \frac{K_p K}{J} = s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$$ char. eqn of CL P controlled system

$$\frac{B}{J} = 2\zeta\omega_n \qquad \frac{K_p K}{J} = \omega_n^2 \qquad \frac{K}{J} = \frac{\omega_n^2}{K_p}$$

$\omega_n, \zeta$ are measured = known

$$Js^2 + (B + KK_d)s + KK_p = 0$$ char. eqn of CL PD controlled system

$$s^2 + \left(\frac{B + KK_d'}{J}\right)s + \frac{KK_p'}{J} = s^2 + 2\zeta'\omega_n' s + \omega_n'^2 = 0$$

$$\frac{B}{J} + \frac{K}{J}K_d' = 2\zeta'\omega_n' \qquad \frac{K}{J}K_p' = \omega_n'^2$$

$$2\zeta\omega_n + \frac{\omega_n^2}{K_p}K_d' = 2\zeta'\omega_n' \qquad \frac{\omega_n^2}{K_p}K_p' = \omega_n'^2$$

$$K_d' = \frac{2\zeta'\omega_n' - 2\zeta\omega_n}{\omega_n^2}K_p \qquad K_p' = \frac{\omega_n'^2 K_p}{\omega_n^2}$$

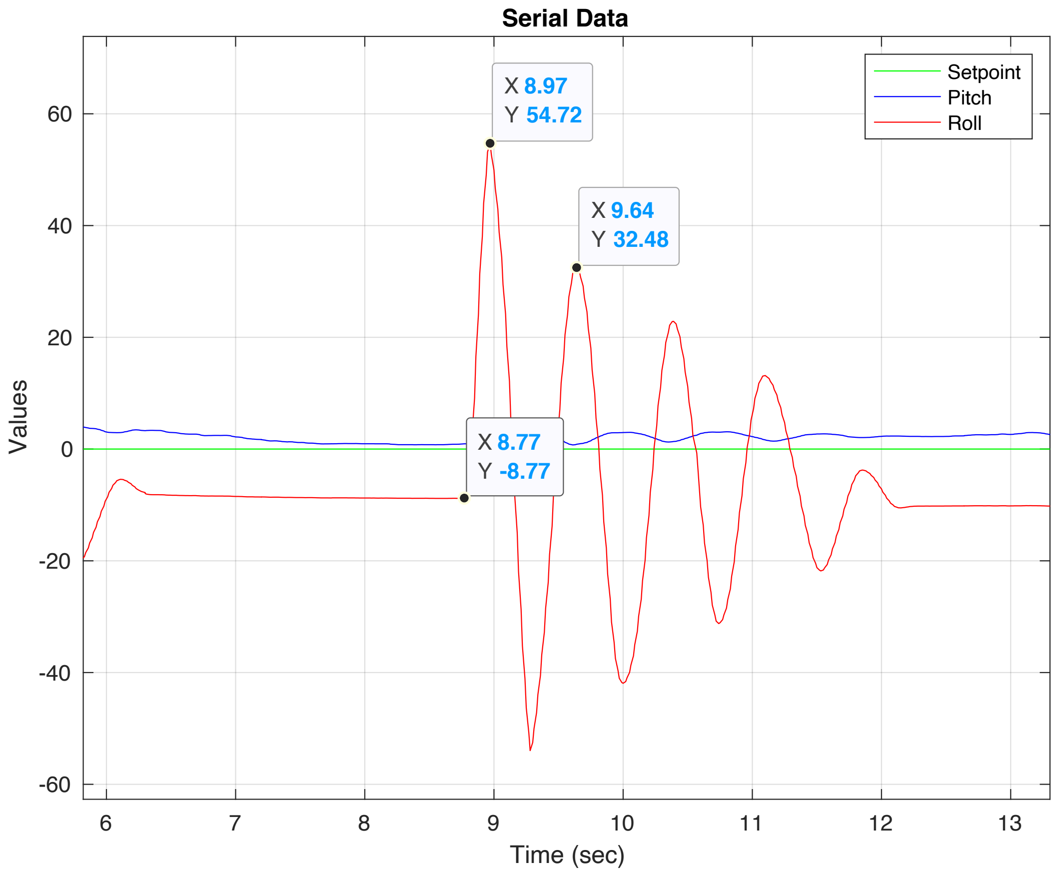
## Experiment #1

*Record your Gimbal #.*

*#7*

## Experiment #2

1. *Roll axis:*
   *(a) Damping ratio and natural frequency of P control with Kp = 10 (or some other value) and impulse response plot.*

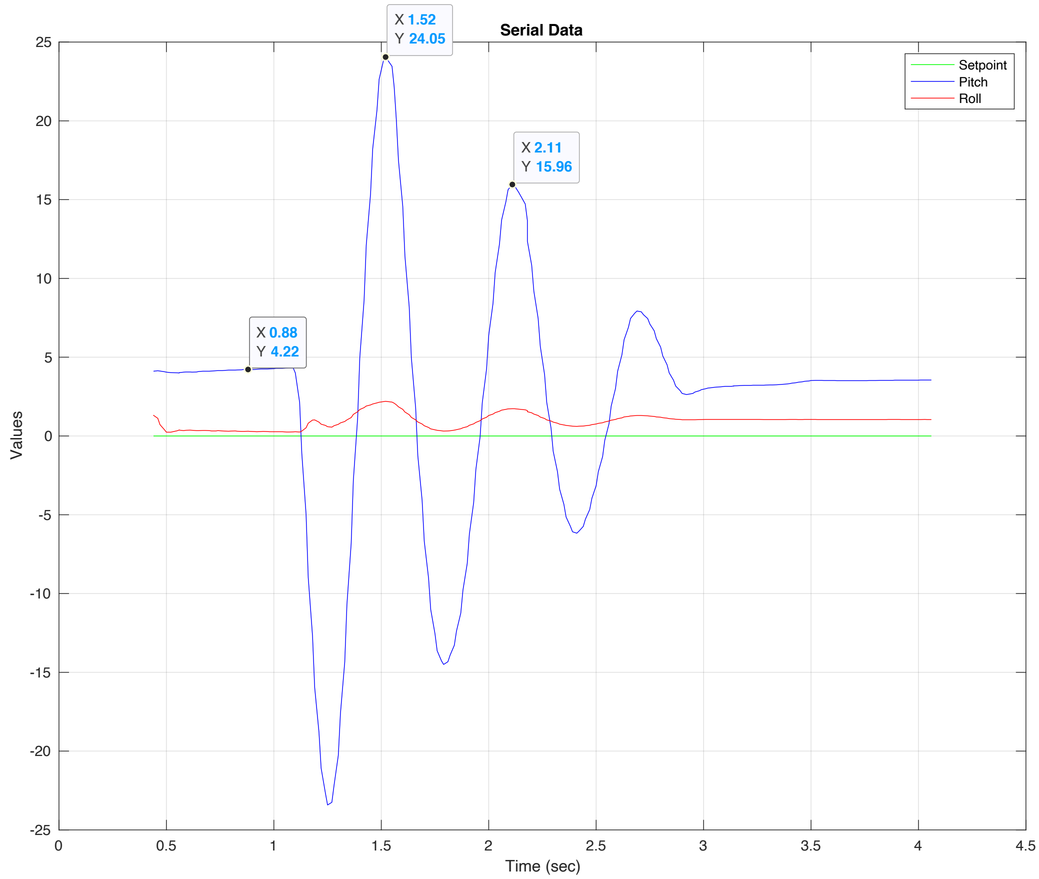



$\zeta$ =0.07
$\omega_n$ =9.40

*(b) Kp and Kd of PD controller.*

$G_c(s) = K_p + K_d s$ =40.21+4.12s

2. *Pitch axis:*
   *(a) Damping ratio and natural frequency of P control with Kp = 5 (or some other value) and impulse response plot.*
   *(graph)*



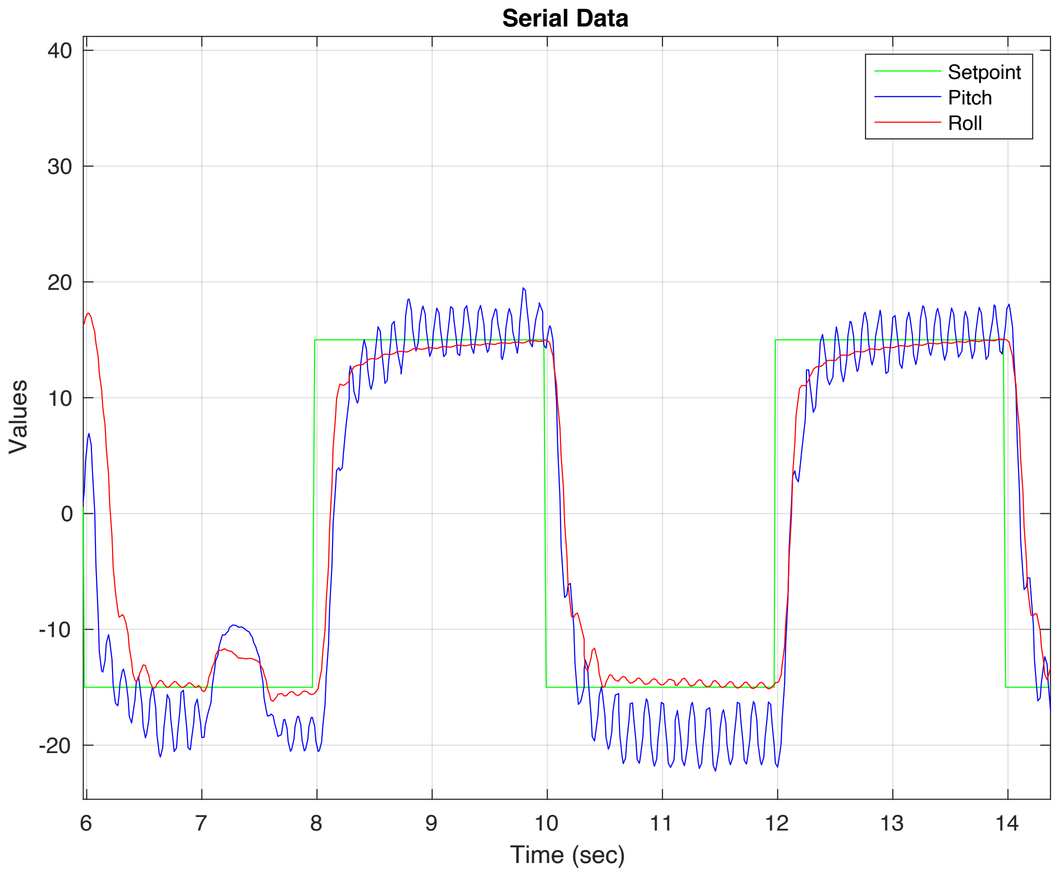

*$\zeta$ =0.08*
*$\omega_n$ =10.69*

*(b) Kp and Kd of PD controller.*

$G_c(s) = K_p + K_d s$ *=31.11+3.15s*

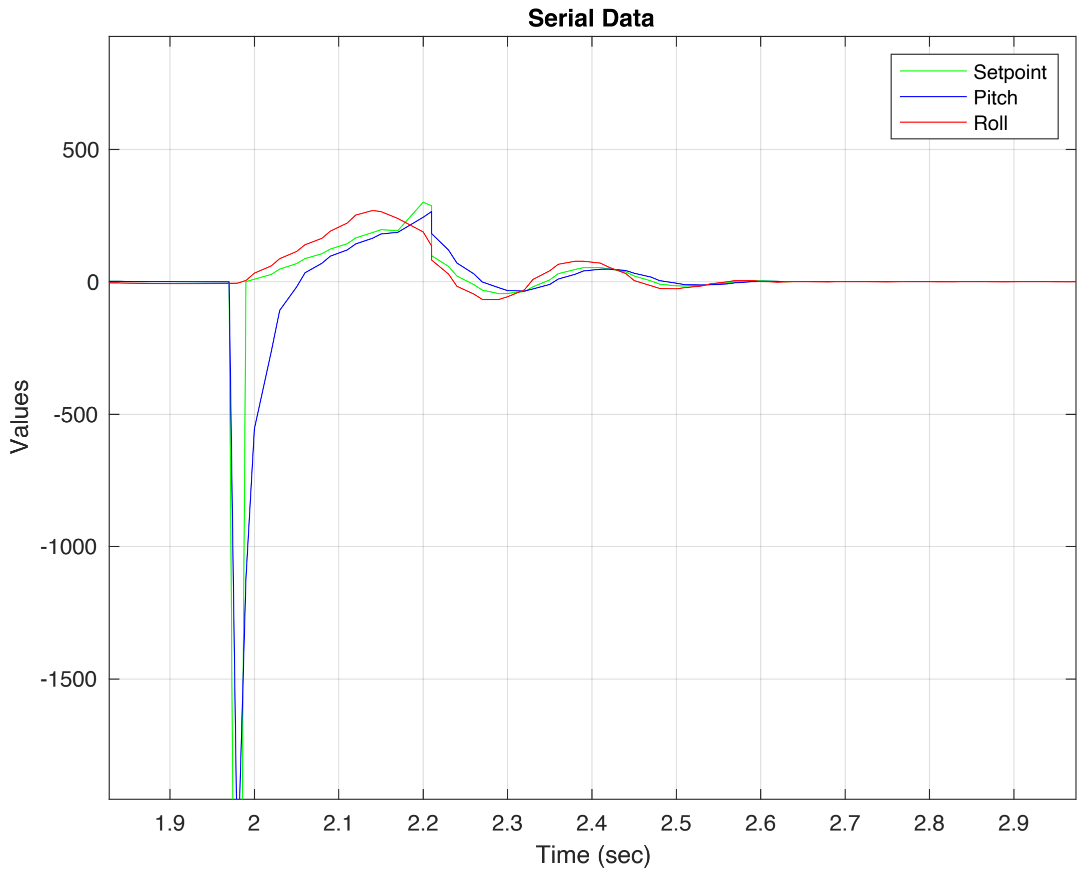
*Explain why pitch and roll axes have different controller gains.*
*The moment of inertia in roll is greater than that of pitch.*

3. *Implement both PD controllers. Insert a closed-loop step response plot of both pitch and roll responses when driven by a square wave. Use d_error_1 and d_error_2 for this task.*



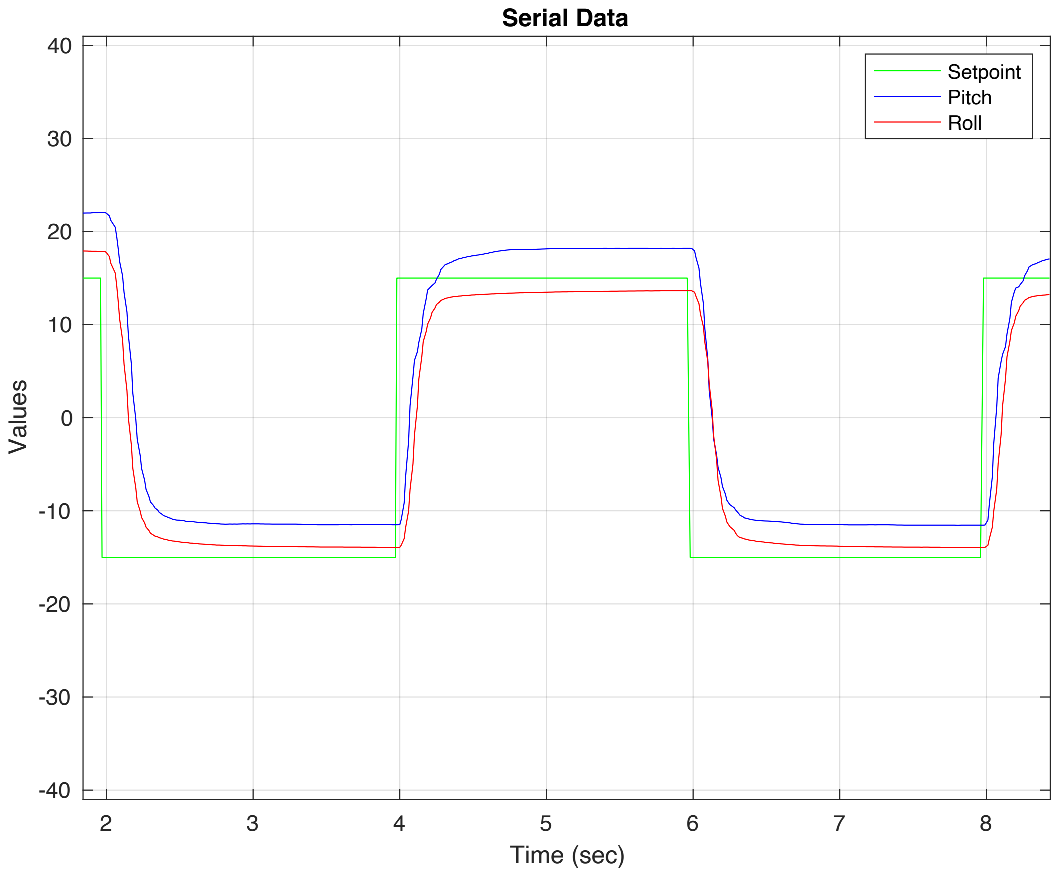

## Experiment #3

1. *Insert a plot showing d_error_2, filt_d_error_2, and roll_rate for the* ***roll axis*** *when subject to a square wave input. Comment on the three signals. Use alpha = 0.5 for the low-pass filter.*



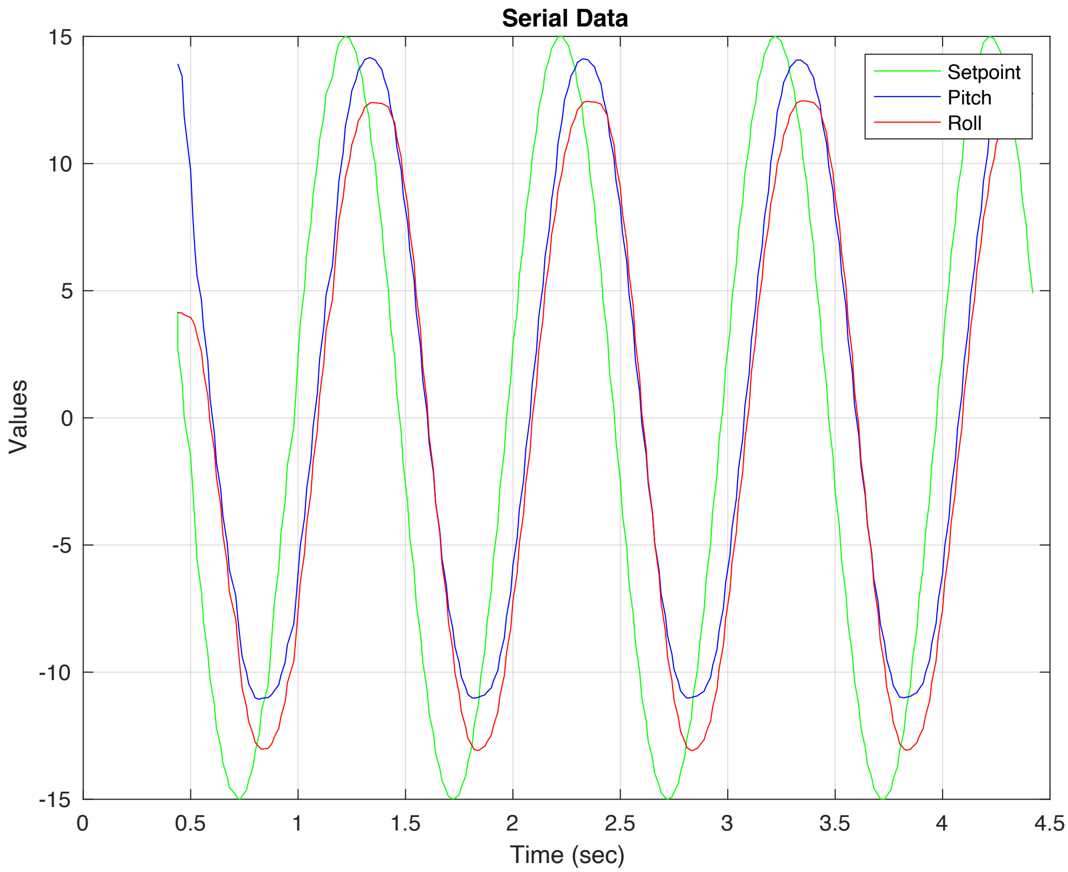

****** Use pitch_rate and roll_rate for D control actions for the following tasks.***

2. *Insert a closed-loop step response plot of both pitch and roll responses when driven by a square wave. Use pitch_rate and roll_rate for this task. Compare the responses to the ones in Exp. #2.3 above, and comment on the responses.*




*The response is a lot smoother, a little faster, and without any oscillations.*

3. *Include a plot showing roll response when subject to a 1 Hz sine wave input. Make comments on the behavior of the gimbal based on your observations.*




*The gimbal appears to be consistently rocking.*

## <u>★Additional Task ★</u>

1. *Estimated spring constant and oscillation frequency of the mass-spring setup.*

2. *Demonstrate your tracking system to a staff member.*