

Implement the 2nd Ziegler-Nichols tuning of PID control. In order to do this, you will need to bring your haptic paddle under computer control, including the ability to read the encoder.

1. Revisit the relationship between input (D2A command) versus torque, using the set of weights again.
2. Starting with the proportional gain, increase the gain until small continuous oscillations are observed. Call the gain  $K_u$  and the period of oscillation  $P_u$ .
3. Set  $K_p = 0.6K_u$ ,  $T_I = P_u/2$ , and  $T_D = P_u/8$  where the PID controller is

$$D(s) = K_p \frac{T_D s^2 + s + (1/T_I)}{s}$$

4. Experimentally determine the step response for this controller for steps of  $10^\circ$  and  $20^\circ$ .