Controls Development

- The controller for the reaction wheel system is a simple PID loop
- The microcontroller receives feedback from a 9-DoF IMU over analog-in, and sends signals via GPIO to the DC motors.
- The top-level controller design procedure was as follows:
  1. Determine the transfer functions from dynamics analysis of free body diagrams of the system
  2. Create simulation in GNU Octave
  3. Design the controller using iterative testing (with comparisons to the model) and classical Bode techniques
- The forces acting on the cube are the torques created by the motors T_i^0, damping effects $b_1\dot{\theta}_{cube}$, and spring effects $G_1\theta_{cube}$. Summing the moments around the center of gravity gives the following equation (for the x-axis):

$$\sum M_0^{+\circlearrowleft} = I_{x,cube}\ddot{\theta}_{x,cube} = T_{Ax}^0 + T_{Bx}^0 - T_{Cx}^0 - T_{Dx}^0 + T_x^0 - \dot{\theta}_{x,cube} - G_x\theta_{x,cube}.$$

- By setting the system to Standard Equilibrium Position (at SEP the input perturbations are set to zero), considering only a single input, substituting the torque-inertia relation, and taking the Laplace transform we have the transfer function of the cube:

$$G_A(s) = \frac{\theta_{x,cube}(s)}{\theta_A(s)} = \frac{s^2}{\frac{I_{x,cube}}{\sin(45^\circ)I_{rw}}s^2 + \frac{b_x}{\sin(45^\circ)I_{rw}}s + \frac{G_x}{\sin(45^\circ)I_{rw}}}.$$