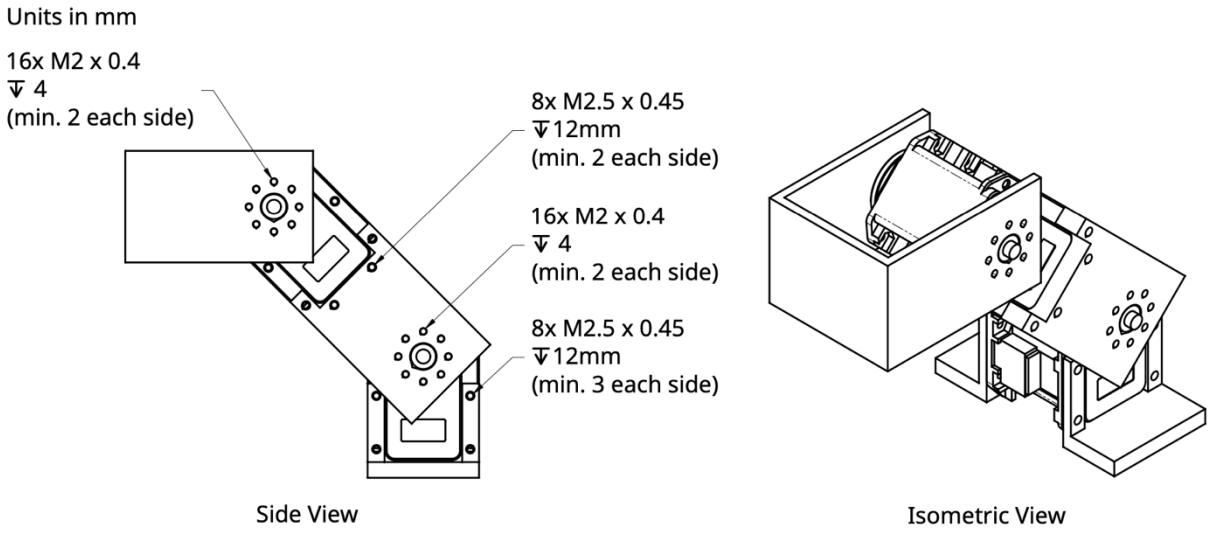
MAE C163C / C263C Mini-Lab #2

*(Due via Gradescope by **11:59pm on Friday, 5/16**)*

Mini-Lab #2: Design of a joint space PD controller with gravity compensation using multiple Dynamixel motors

1. Build a 2R planar manipulator

Assemble the 2R planar manipulator shown in the diagram below and **following the steps in the "minilab2_motor_assembly_instructions.pdf" file** (using the parts provided for this Mini-Lab and your Dynamixel motor kits).



2. Read joint velocity data from multiple Dynamixel motors

In the `start_control_loop` function of the `PDwGravityCompensationController` class in the `minilab2_hardware.py` file, complete the step labeled with **TODO** in order to simultaneously reads the current joint velocities of both motors in units of rad/s (more specific instructions and an example for joint positions are provided in the `minilab2_hardware.py` file).

3. Implement a joint space PD controller with gravity compensation control law

In the `start_control_loop` function of the `PDwGravityCompensationController` class in the `minilab2_hardware.py` file, complete the steps labeled with **TODO** in order to calculate the error term and control law for a joint space PD controller with gravity compensation (more specific instructions are provided in the `minilab2_hardware.py` file).

4. Send PWM commands to the motors

In the `start_control_loop` function of the `PDwGravityCompensationController` class in the `minilab2_hardware.py` file, simultaneously send PWM commands to both motors (more specific instructions are provided in the `minilab2_hardware.py` file).

5. Tune controller gains and plot joint position time histories

In the `minilab2_hardware.py` file, complete the remaining sections labeled with **TODO.** The initial and desired joint configurations of your manipulator should be in units of degrees and have values [135.0, 135.0] and [115.0, 155.0], respectively.

Tune your K_P and K_D gain matrices so that your controller achieves and maintains the desired joint configuration with less than 1° absolute error in each joint and in less than 1.5 sec.

Plot the joint position time histories for both joints of the manipulator on individual subplots. Each plot should have a purple black dotted line at 1.5 sec and two blue dashed lines above and below the corresponding desired joint angle by 1° (i.e. at 114° and 116° for joint 1 and at 154° and 156° for joint 2).

Each member of the team must tune and report distinct gains for their own individual Mini-Lab #2 submissions.

Summary of deliverables:

Your submission should include:

- Your K_P and K_D gain matrices
- Labeled time history plots
- Your **completed** `minilab2_hardware.py` file converted to a PDF.

NOTE: Each student must submit their own independent work. **For full credit, you must submit to Gradescope all custom Python code** (e.g. `minilab2_hardware.py`) **and requested plots with labels.** You may save this content to PDF or take screenshots for electronic submission via Gradescope. Files of the *.py* and *.toml* format cannot be directly uploaded to Gradescope and should not be e-mailed to instructors for grading. The more intermediate results and comments you provide, the greater the opportunity for partial credit.