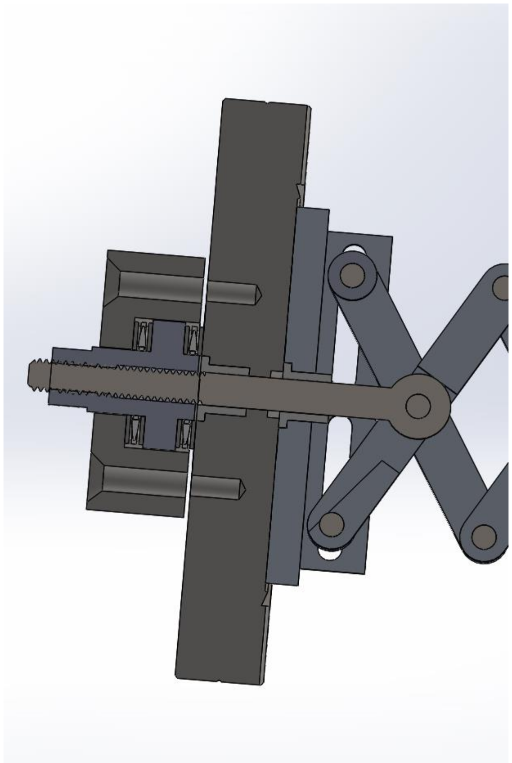
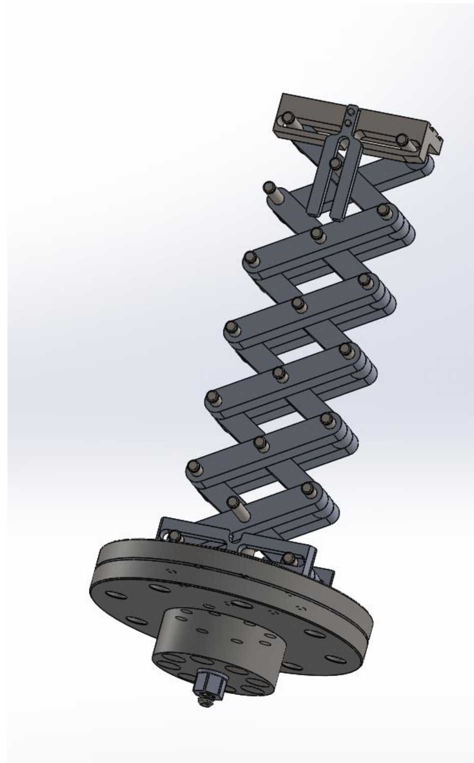
1. **After having had the chance to ruminate on your design for a week, make any changes needed to update the FRDPARRC table, Error Budget, solid model and drawings.**

   See updated Solidworks model ("Gould_Scissor_Actuator.SLDASM") and renderings below.

2. **Create a Bill of Materials, and make sure you have all you need to build. (1 pt)**

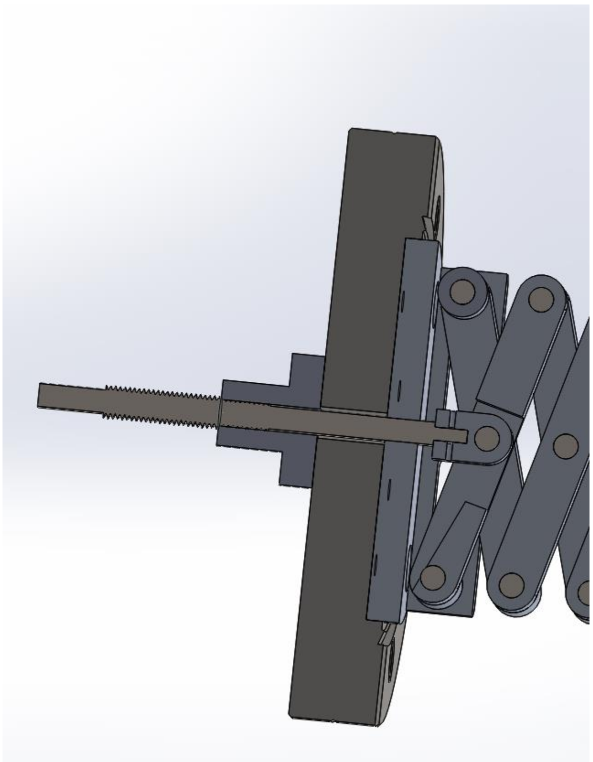
   See ("Gould_PUPS_8_BoM.xlsx") for the Bill of Materials.

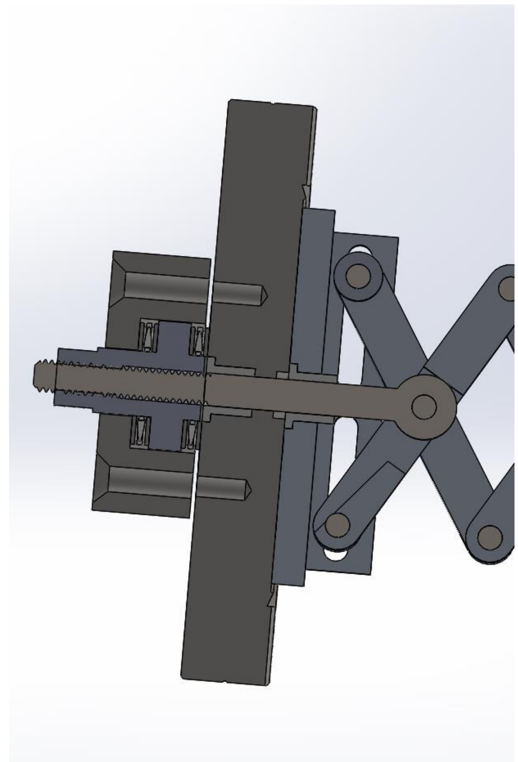
3. **Make the parts and measure and compare to the drawings. Did you achieve the desired tolerances? (4 pts)**

   For the most part, I've hit all my tolerance goals. The three reamed holes in each of the scissor segments are very close to one another (within 0.001"), but not 100% consistent. Some occasional hand reaming was necessary during assembly. My goal was to achieve something between a transitional and an interference fit (what I've been calling a "wear fit", since it was very tight upon initial assembly, but loosened slightly after one revolution cycle). With this fit, the dowel pins basically retain themselves, but retaining rings and springs (currently coiled springs, but potentially disc springs if higher forces are needed) are still needed to keep the three levels of segments pressed together (which minimizes the sag (re: error budget calculations)).

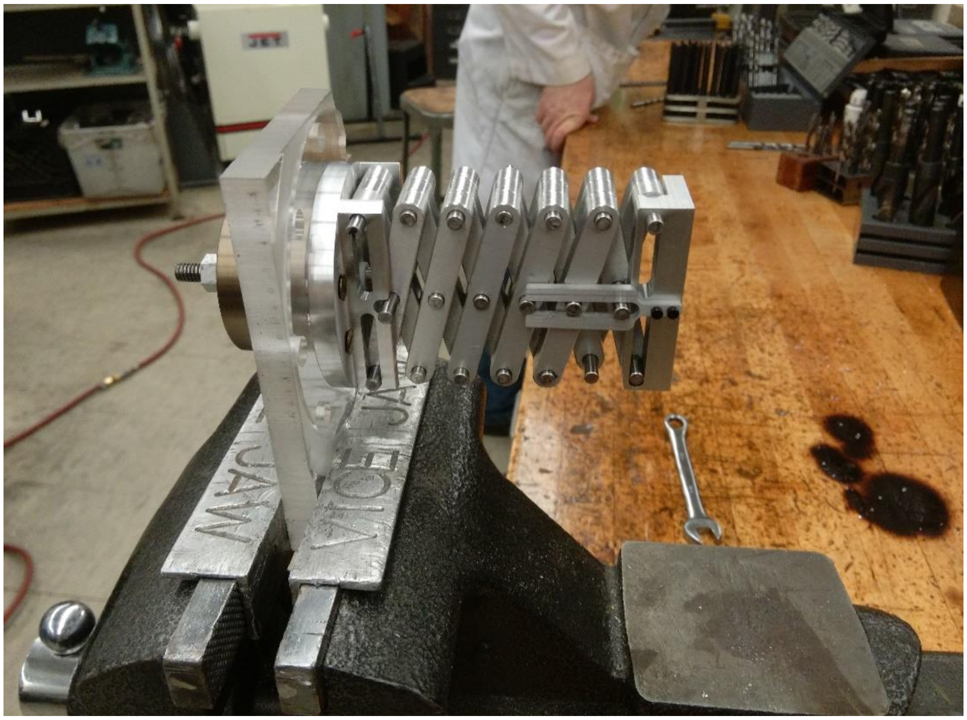
4. **Assemble the axis, and comment on did it go together the way you expected? (1 pt)**

   Somewhat. The actual external force has changed from just a linear sliding motion to a screw motion to both gain extra force and for better control of the extension length. The screw motion idea is in its second incarnation. The first idea (left picture below) relied on a rotating joint that also transmitted the force, which, given its small cross-sectional area, was not a very good choice. The second idea (current idea, right picture), uses a plain rod end and a captive flanged nut for actuation. The captive nut has thrust bearings on both sides to take the extension and retraction loads. Bushings are included to take up any radial loads. The hex head on the end of the captive nut means basically anything (wrench/gear/pulley) can be used to extend/retract the actuator, and also fulfills the functional requirement of both manual and motorized operation.





Below are some pictures of the actual actuator. A video of it moving has been uploaded as well (https://youtu.be/2qJ83pd7X8w).



5. **Measure performance and compare to that predicted (e.g., attach a laser pointed taped to "on" to the carriage and measure motion of the spot far down the hall…) (4 pts)**
    a. **Accuracy**
    b. **Repeatability**
    c. **Resolution**
    d. **Stiffness**
    e. **Update your predictive model accordingly**

To test the performance of my scissor actuator, I performed a semi-scientific test of the z-axis sag using a mill vise and a dial indicator mounted on a height gauge. I first clamped the scissor assembly perpendicular to the vise jaws (using squares and taking care to make sure the actuator was not extending at an angle), and then used the dial indicator to measure several points on the actuator. I then extended the actuator to its full extension and re-measured at the same points. The measured sag was between ~0.041" (1.04mm). I am happy with this result, as my functional requirement was <1mm of sag, and I haven't even added the springs and retaining rings to keep the 3 levels of segments together (which should improve the stiffness). Once I add the springs and retaining rings (which will probably be as soon as the quick-change lathe comes back on-line, since it makes the process much, much easier and faster) I will set up a more sophisticated test system with something like a laser pointer and run repeatability and sag tests.