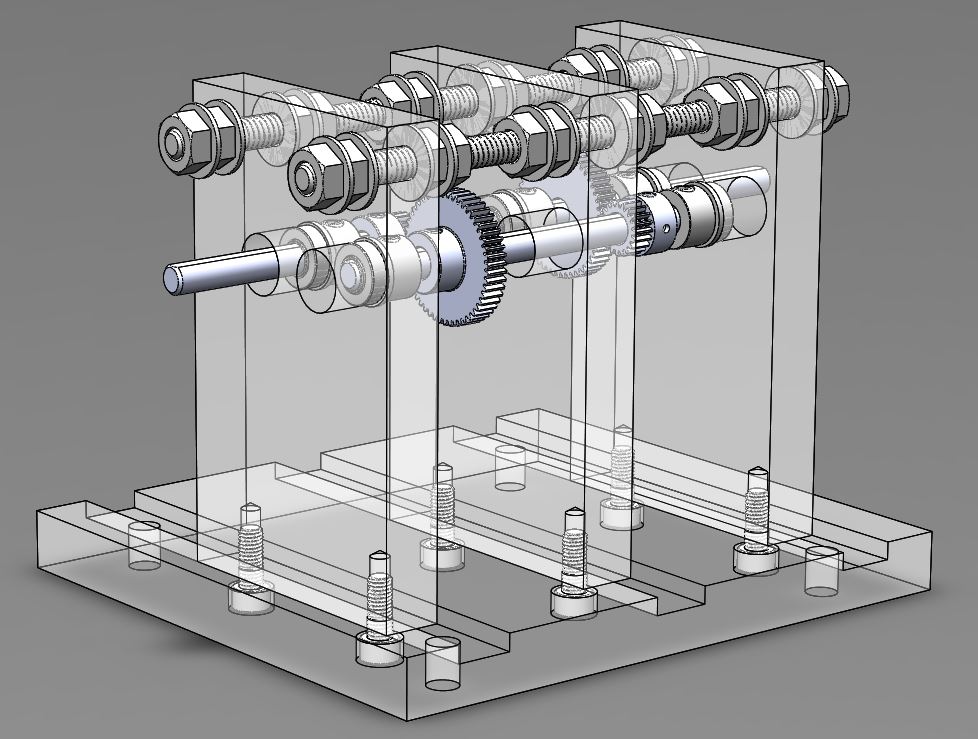
# Detailed Summary of Design, Fabrication, and Test Plan

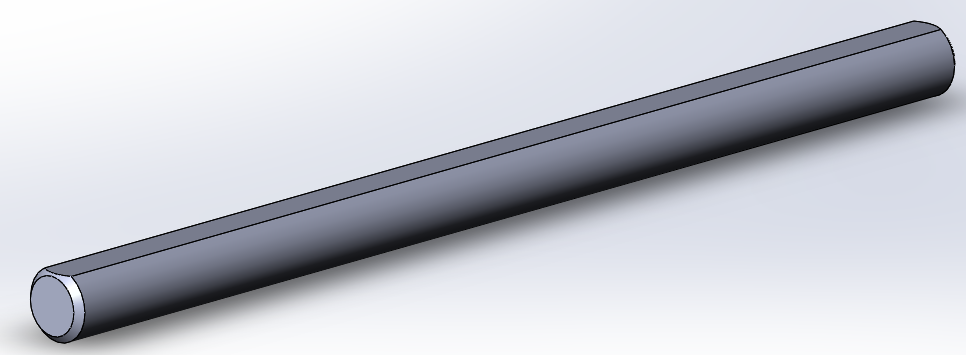
## Design:

For our overall design, we decided on a two-stage inline drive. The two-stage inline drive is a simple configuration that satisfies the requirement of having the input and output shafts lie along the same axis. We tried to minimize the total number of moving parts so that friction is minimized – this setup has only three rotating axles. We also kept the size of this transmission to a minimum – this is to reduce deflections and stresses on the material. We decided on gears as they are simple, don’t slip and are very efficient at transmitting large amounts of power over small distances.



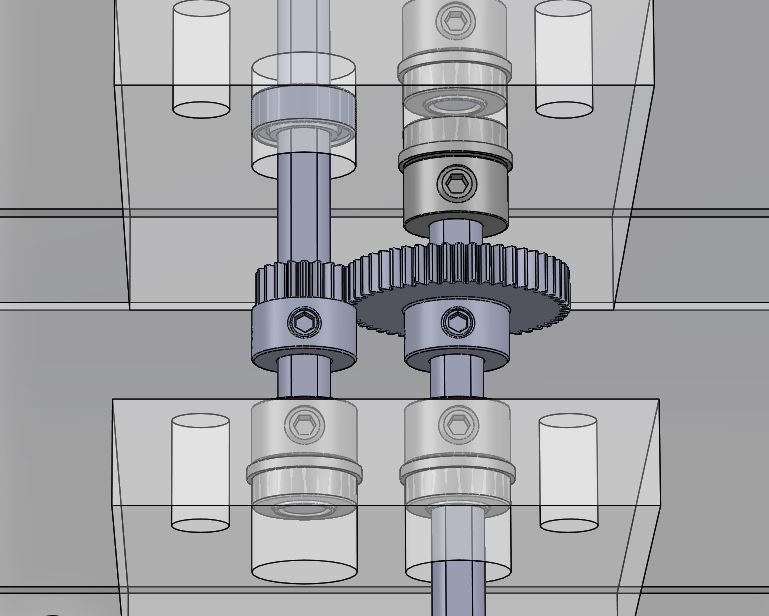
*Overall design, taken from Solidworks*

The transmission shafts will be ¼ inch steel D-Shafts. We chose ¼ inch as it is a very popular size for the gears, collars and bearings, so it would be easy to find suitable components. ¼ inch steel is also strong enough to keep deflections to a minimum. The D-profile makes it easy to secure components on using set-screw fasteners. Each shaft will be constrained the two ends by bearings.



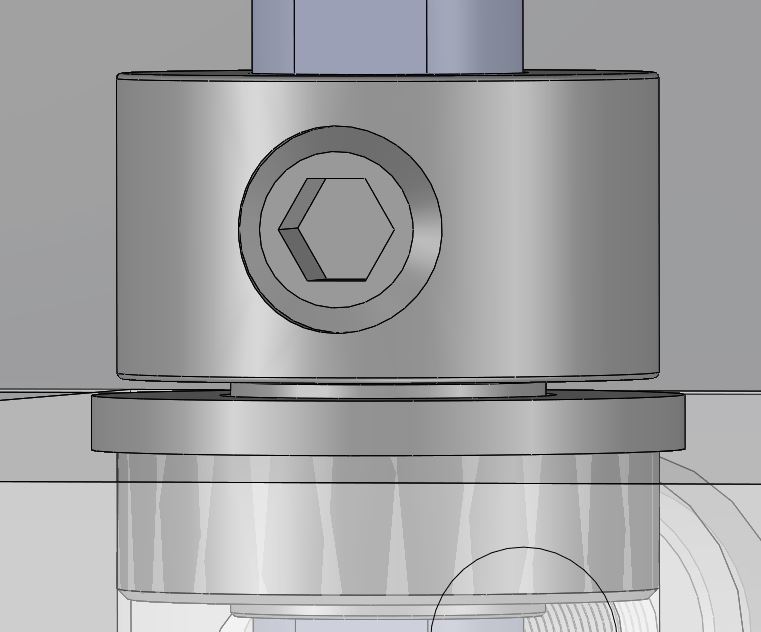
*D-profile shaft*

The aluminium gears we decided on have a diametral pitch of 48 and a pressure angle of 20 degrees. The higher diametral pitch of 48 (compared to lower options of 32 and 24) means that the gears have more teeth per unit diameter, allowing better meshing of gears and thus more efficient force transmission. Aluminium gears are stronger than plastic gears, whilst being lighter and more machinable than steel. In class discussion it was theorized that the optimal gear ratio for the testing setup is in the range of 6 to 6.5, so we decided to go for a gear ratio of 6.25 overall. This means that each gear reduction has to be at a ratio of 2.5, so that the two gear reductions give the correct total ratio. We chose gears with 50 teeth and 20 teeth for this purpose. These gears are on the smaller side, reducing mass moment of inertia of the system and thus allowing for greater acceleration. A wide face width of 0.1875 inches allows for more contact area between the gears - this reduces pressure forces on the gear teeth. Finally, the gears come with build-in set screw hub caps for easy and adjustable fastening onto the D-shafts.



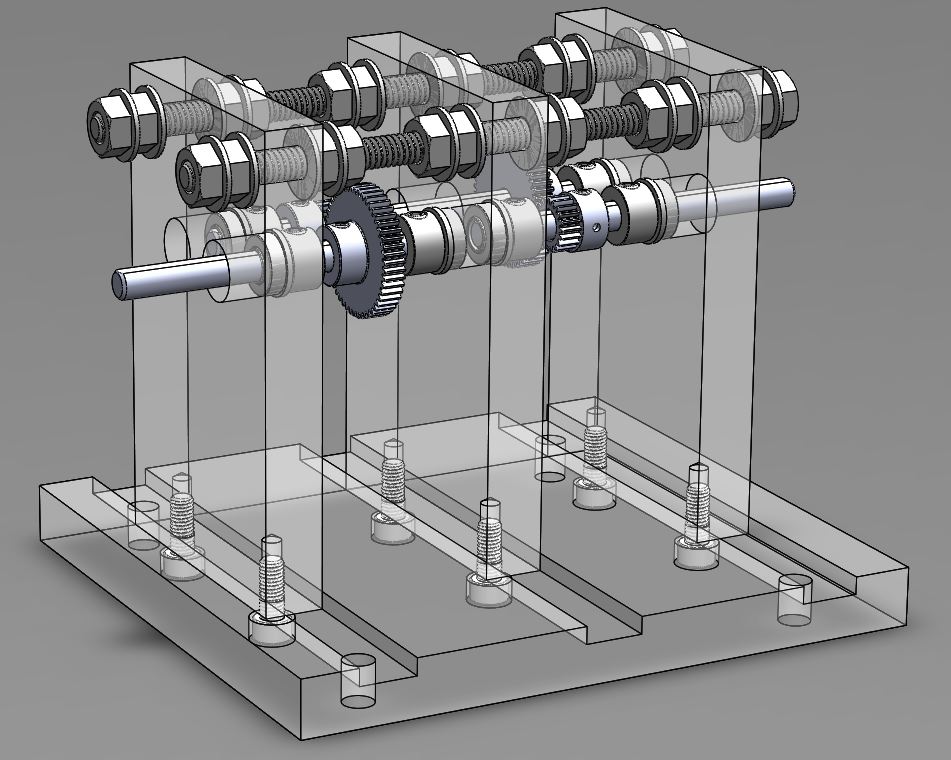
*50 tooth gear (right) and 20 tooth gear (left) attached to shafts.*

For the bearings, we decided on steel ball bearings as they tend to have lower friction than bushings – this improves our efficiency. The flanges on the bearings help with constraining after they have been press-fit into the plates. We chose shielded bearings to reduce the amount of dust and debris that gets inside the bearings – as the transmission will not be running for significant periods of time, we don’t require the head dissipation capabilities of open bearings. We also chose bearings with the smallest outer diameter available (½ inch) as drilling larger holes into the acrylic plates results large stresses and possible cracking. To constrain the shaft against these bearings, we chose set screw collars as they are easily adjustable and compatible with our D-profile shaft. Our ball bearings have extended inner rings – this is where the collars will push up against so that they do not make frictional contact with the face of the bearings.



*Close-up of bearing and collar contact*

For the supporting structures, we will be using the ½ inch acrylic to cut out the appropriate base plate and vertical plates. This material is thick and rigid enough for our purposes. The base plate will have slots for a close, tight fit with the vertical support plates, which will be secured using 10-32 cap screws. For the top constraints, we chose to use a threaded rod with nuts to allow for more flexible constraining. We will use additional lock nuts for this as a single nut could loosen with vibrations.



*Overall assembly*

## Analysis:

For our design, we performed a stress analysis on the various shafts. Shaft 1 is the shaft that connects to the external motor and receives the input torque. Shaft 2 connects to Shaft 1 through a gear to gear contact with a gear ratio of 2.5. The last shaft (Shaft III) is connected to Shaft II also by a gear to gear contact with a 2.5 gear ratio. The analysis of these shafts are as follows:

