# TODO

## Mechanical

1. ~~Create PLA materials at different fill densities~~
2. ~~Set correct densities on all relevant moving components to enable simulation~~
3. Order slip ring, check dimensions, adjust model as necessary

### Arm print

1. Bottom face is not smooth, remove raft support
2. Triangular side cutouts require support material – reduce top radius until this is not the case

## Software

1. ~~Figure out how to estimate motor tf from performance curves~~

* , motor torque constant – divide stall torque by the difference between the stall current and free run current
* , motor emf constant – should ideally be equal to the torque constant if in SI units, can be calculated by dividing the rated voltage by the free-run speed without gearbox, but it is best to not rely on a perfect gearbox
* , motor resistance – divide rated voltage by stall current
* , rotor inertia – can be calculated by considering the geometry of the shaft, but can usually be neglected due to the inertia of attached load being much higher than that of the rotor
* , viscous friction coefficient – divide the no-load current by the no-load speed and multiply by the motor torque constant
* , inductance of the motor, if , it can be set to 0 and neglected thus turning the motor into a first-order system

1. ~~Simulate a reduced system (without current state variable) to figure out what torque and speed performance is required of the motor~~
2. ~~Confirm that translational changes to the rotation matrix, R2, don’t matter – cannot be incorporated anyway without homogeneous coordinates~~
3. ~~Try your parameters with existing ss controller~~
4. ~~Build two multibody models to confirm that body dynamics with your values plugged into the paper are the same as the “real” dynamics (or similar enough) – local license expired, you could buy one for yourself~~
5. I don’t understand how a motor can provide negative and positive torque at a given rotational speed. Look at DC motor dynamics to answer this.
6. Implement integrator into the model with parameters from paper.
7. Go back and look at controllability with motor dynamics included. Make sure the system can still be balanced with current parameters. Assume motor properties from the paper.
8. Check observability. Design a full state observer with and without motor dynamics.
9. Outer/inner feedback loop for motor torque control? We’re doing torque, not speed control. You may need to derive different motor equations.

# Fresh look after a lengthy break

Physical system is in a satisfactory state. Response data can be collected.   
Some immediate problems:

1. System is not open loop stable for arm 1 position. Arm 2 position is open loop stable hanging down. This is normal and expected. DC motors in controls lab were open loop stable for voltage to velocity transfer function, not voltage to position transfer function. This problem manifests as the “drift” accompanying any input following by arm 1.

The way this is normally addressed is with a stabilizing controller. I have confirmed that a proportional controller with gain ~1 is sufficient to remove drift. More work is needed to make sure the controller calculates and outputs error with correct signs. Conventions on positive direction need to be established and motor electrical connection to driver finalized.

The next challenge here is to confirm that the system with controller “in the loop” can be compared to the simulation by incorporating the controller into the simulation. It seems that incorporating into the simulation will be easy, however incorporating the controller into the symbolic derivation seems more difficult and needs to be investigated further

1. I don’t have an electromechanical model for my motor. I have made some measurements of its electrical properties, but an experiment is always better and should be conducted to collect frequency response data. Voltage to speed or stabilized voltage to position transfer function will be obtained (need to confirm which function better plugs into the values used by the paper).
2. I don’t have good knowledge of the true masses of some components. A weighing should be performed on the two arms, which involves some significant (and risky) reassembly of the encoder system.