TruBalance Stand Design Process

Goal: Define a rigid tablet stand that is defined by a continuous curve to have each possible point of contact be a point of static equilibrium.

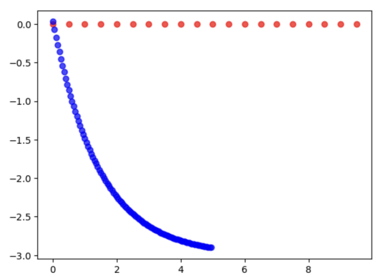
Initial Design Constraints

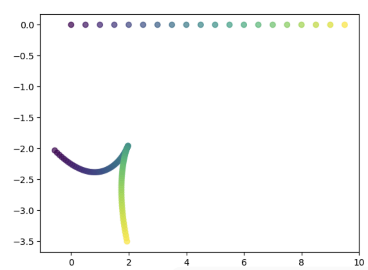
- Rigid bodied (no moving parts)
- High range of freedom (~90°)
- Each continuous point must be at a resting equilibrium (balanced).
- It will need to be discretized to increase the stability of the system.

Possible design Ideation

Numerical Simulation Method

One Idea I had was to define discrete points as the tablet and stand, and use simulations to define a curve where each point is at resting equilibrium.





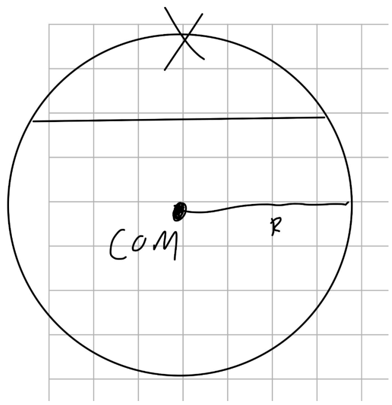
Methodology:

1. Define discrete points with densities that correspond to the tablet and material
2. Divide the range of freedom (90 degrees) into the number of points
3. Rotate the system so that each point has a chance to be on the “bottom”.
4. Calculate the COM (center of mass).
5. Move the target point laterally slightly towards the support line of the COM.
6. Repeat until points stabilize

This method did converge, but unfortunately, it had the issues seen in the image above, with the solutions being geometrically infeasible for a real design.

Partial Circle Method

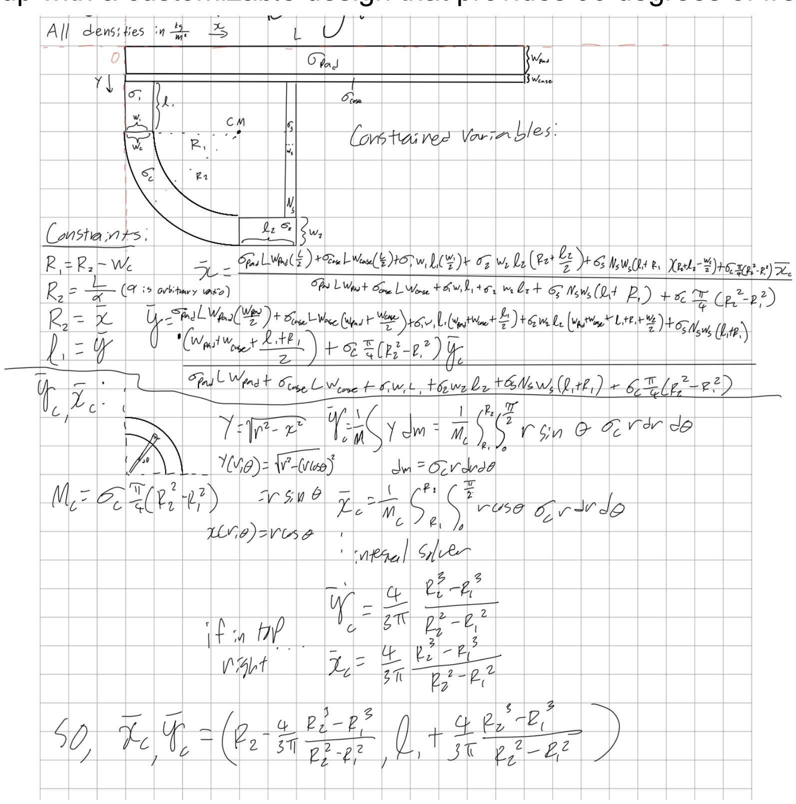
One thing I realized is that the best design would likely take advantage of the fact that a circle has high symmetry. Specifically, the normal line to the curvature of a circle always points towards the center of a circle, giving a consistent “focal point”. Therefore, if we can match the center of mass to the center of our circle we have a working solution.



This is the initialize design I came up with, where we chop off the top of a circle and place the iPad there. As long as the system of the partial circle and tablet matches the center of the circle, this design would work. However, this design presents its own issues. Because the radius of the circle is the only tunable feature, we do not have much customizability in terms of stand shape. Additionally, this design is clunky, and the angles where the tablet is near flat would be extremely tall, making the use awkward. Thus, I moved on to the following design:

<u>Segment and Quarter Circle Method</u>

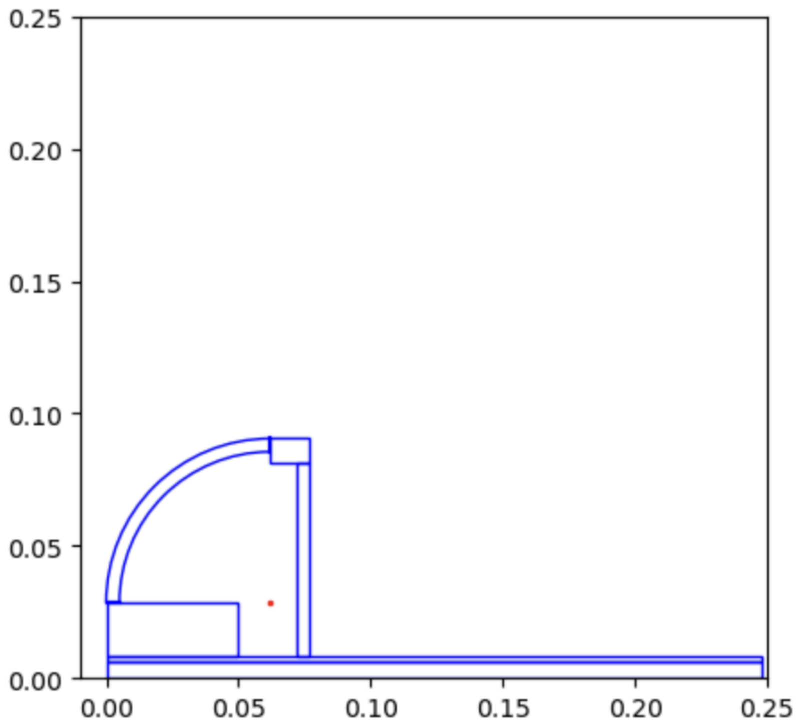
One thing I recognized is that if we have a stand in the lower left quadrant only, the center of mass must be down and left from the COM of the tablet. This can be seen in the figure below. Therefore, by constructing the stand this way and using the symmetry of a circle, we can come up with a customizable design that provides 90 degrees of freedom:



This idea includes two segments on the top and bottom of a quarter circle, where parameters are tuned to ensure the center of the circle lines up with the center of mass of the system. This design generated two constraint equations: $l_1 + w_{case} + w_{pad} = \overline{y}$ and $R_2 = \overline{x}$. These essentially just define where the center of mass should lie in relation to the dimensions of the system. This allowed me to generate full constraint equations based solely on the dimensions of the stand, as well as material densities. Additionally, by only having two constraint equations, we can customize every dimension and pick 2 dimensions to be constrained. This allows for significant customizability.

Numerically Solving Constraint Equations

I then solved the constraint equations numerically, picking two inconsequential parameters (widths of the top and bottom segments) and solving for the final parameters based on this. Significant iteration was necessary, as most parameter combinations did not have well-behaved solutions. One set resulted in this design:



Using these design parameters, I can begin CADing the model for prototyping.