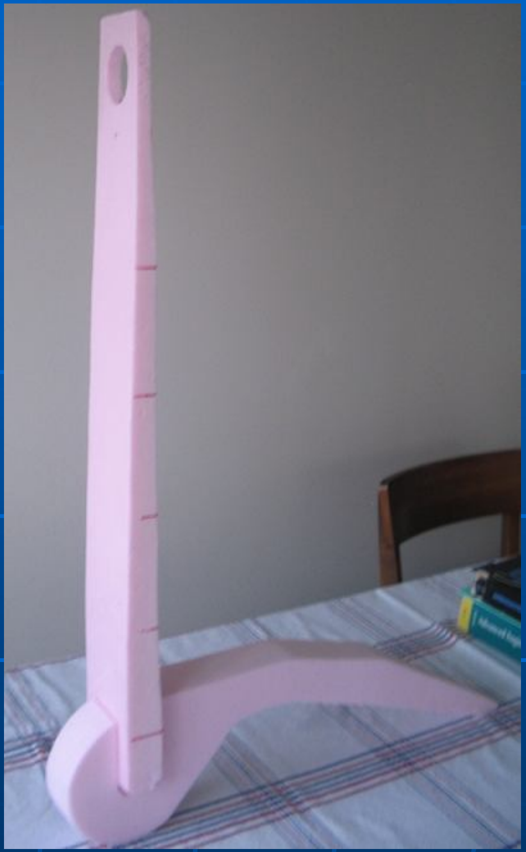
Project 1—Catapult



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Problem Statement

- To launch a standard street hockey ball the longest possible distance using a catapult made of Dow Wallmate extruded polystyrene foam
- The catapult must be assembled from 2 components which must be able to be cut out of a single 23” x 23” x 2” piece of foam.

Problem Statement (cont'd)

- The catapult is initially strained by a string attached to a load.

- Two unmodified pencils can also be used to connect the two components and/or transmit the load from string to the catapult.

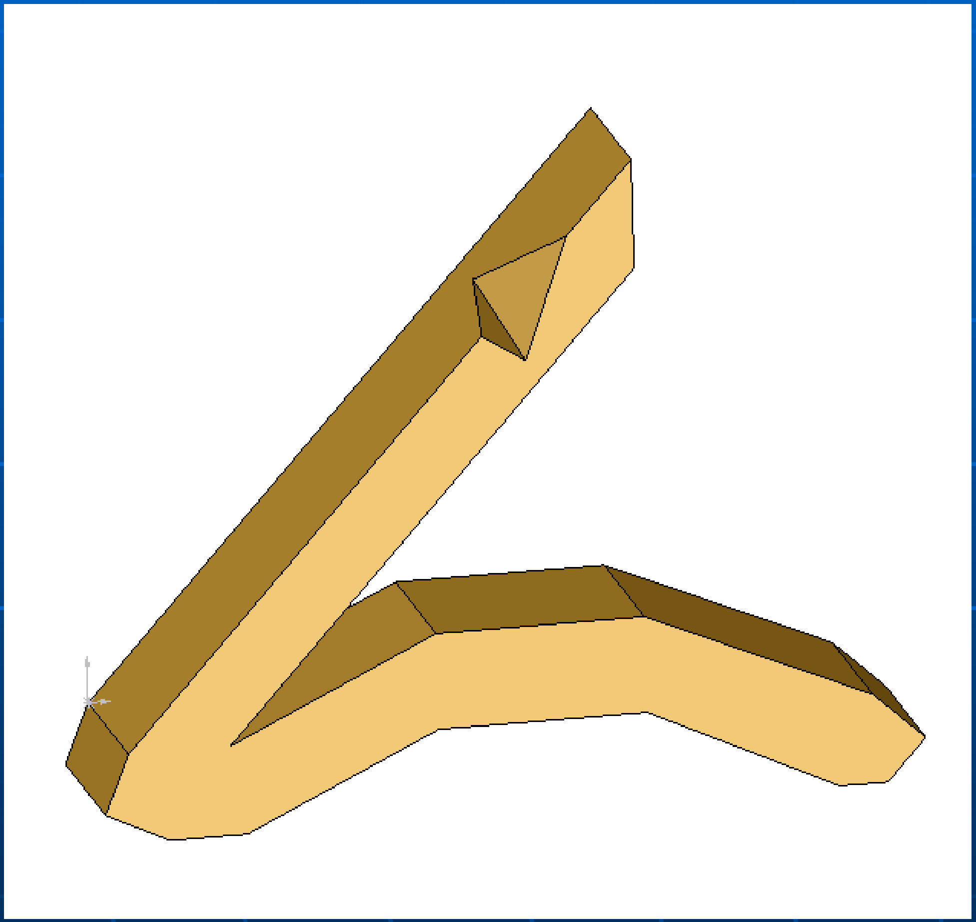
- The hockey ball is launched by cutting the string, which drops the load and allows the catapult to return to its original position.

Initial Design

- Use both the arm and base to store strain energy

1) Flat base that bends upwards under loading.
2) Curved base that flattens when strained.

Initial Design (cont'd)

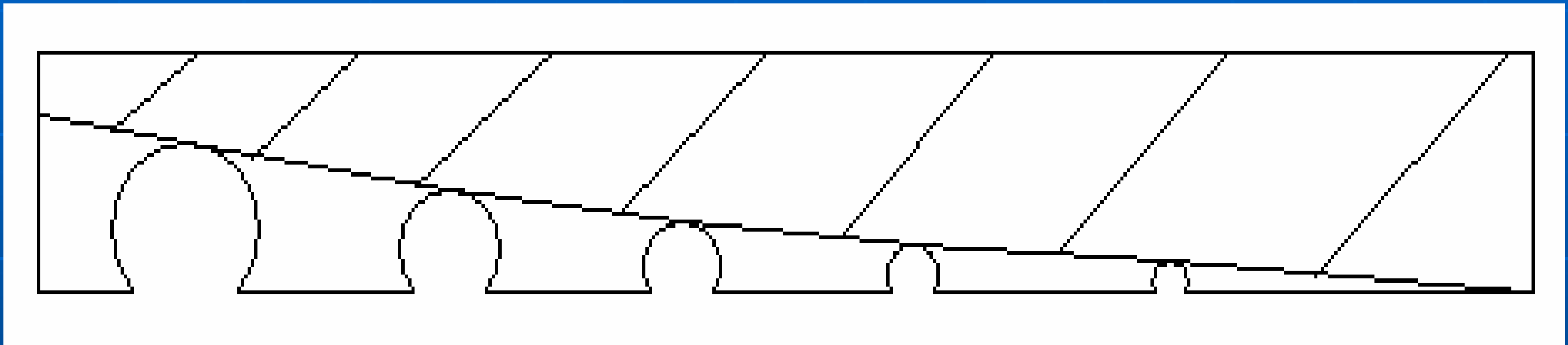


Our first design consisted of two parts like the one shown. The parts were joined by a pencil going through the top of the arm.

Lessons Learned from Competition

- Our initial design was too small and did not take full advantage of the design criteria
- Slot joint is a simpler and more elegant solution to the Clevis joint we used
- An arm designed by a group which used radiuses on the side of compression bent very uniformly

Lessons Learned (cont'd)



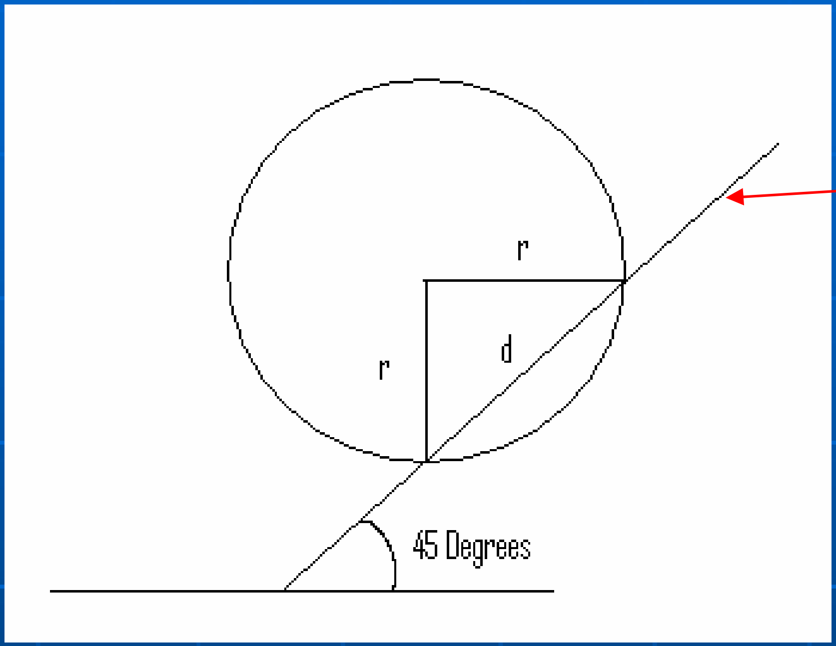
- We came to the conclusion that their performance was not due to the use of radiuses but to the parabolic shape that they approximated.

Approximating a Parabola

- Use straight lines to approximate a parabolic shape
- Substitute in equal increments of x into the following equation to calculate shape of the arm:

$$h_x = h_{\max}\sqrt{\frac{x}{L}}$$

Derivation of Optimal Size of Hole



Surface of the arm

- Once the angle between the arm and the horizontal is > 45°, the centre of gravity of the ball would be outside of the hole.
- Optimal diameter = $\sqrt{2} \times 35mm \cong 50mm$

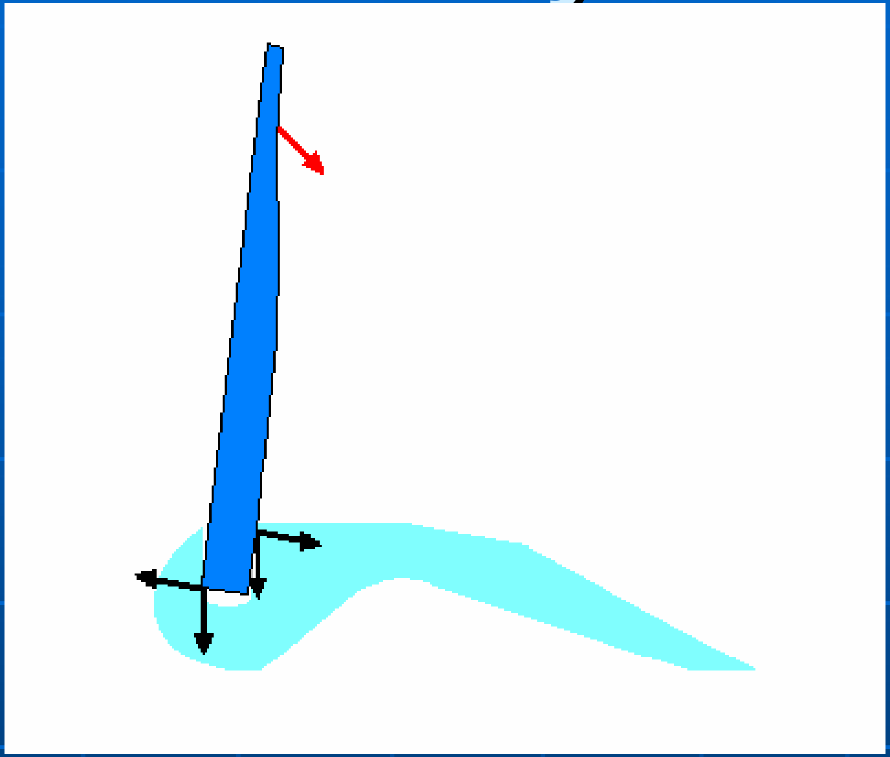
Optimal Angle between Arm and Base

- Used insertion pieces to alter the angle of the arm

Optimal Angle between Arm and Base (cont'd)

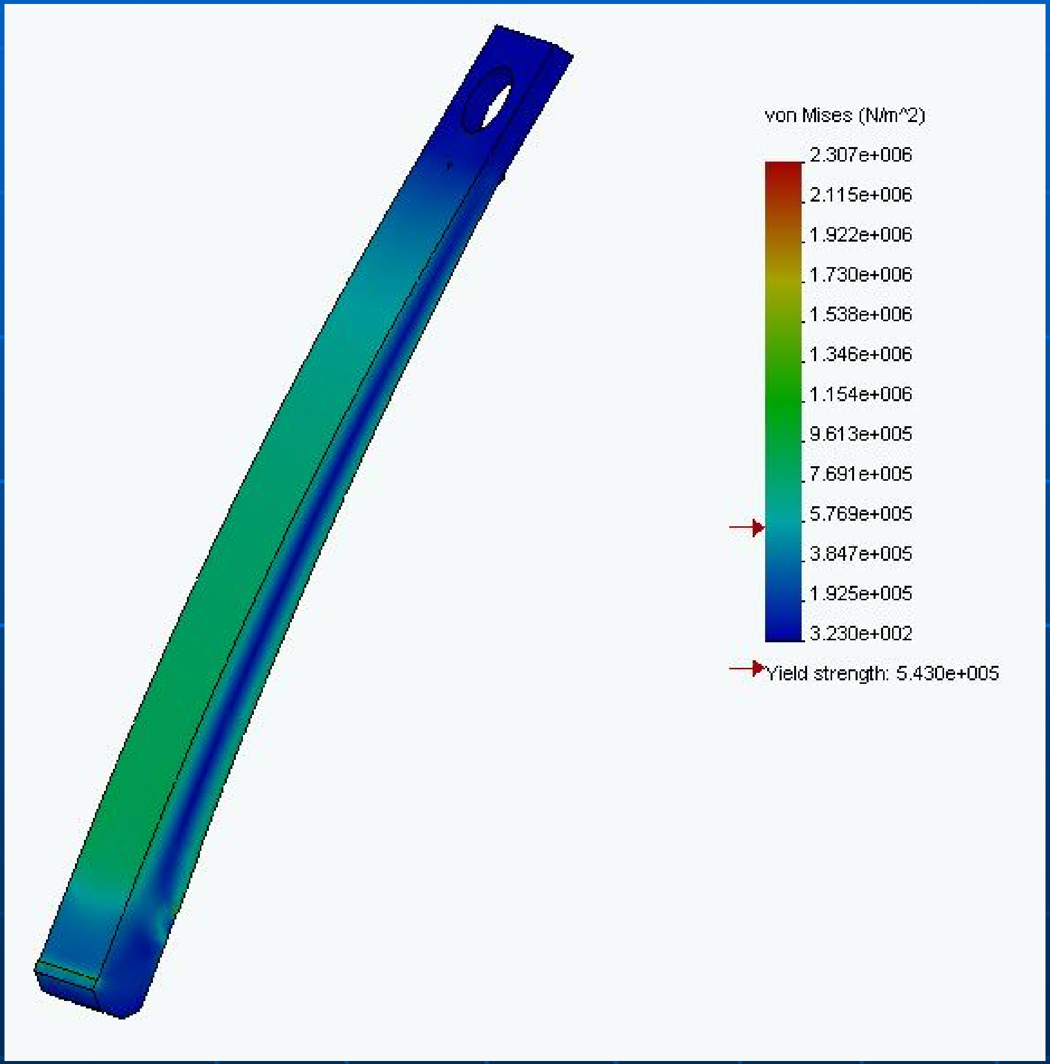
Angle between Arm & Base (degrees)	Distance of Flight (feet)
95	10
90	12
85	9
80	8.5

Mechanics Analysis of Arm



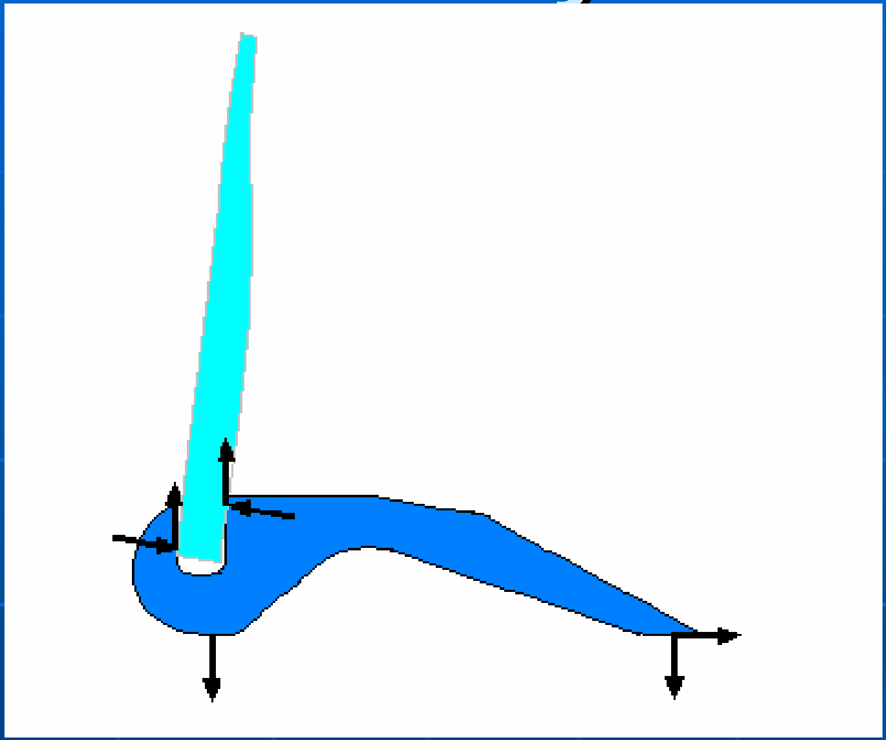
- The force applied by the string (red arrow) can be replaced by two forces located in the contact points shown.
- The torque caused by the string can also be replaced with two forces at the contact points forming a couple.

FEM of Arm



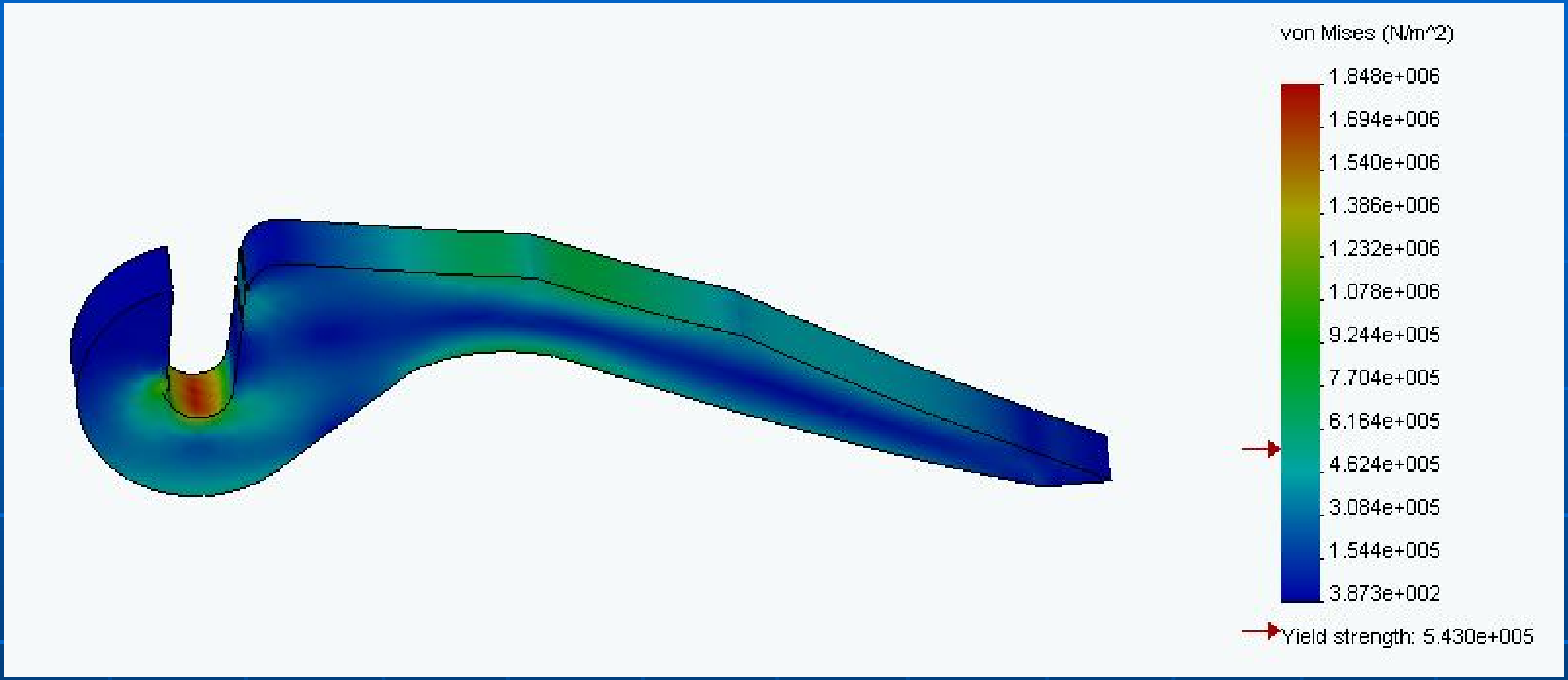
The finite element model was fixed at the contact points. A 50N force was applied at the location of the red arrow in the previous figure.

Mechanics Analysis of Base



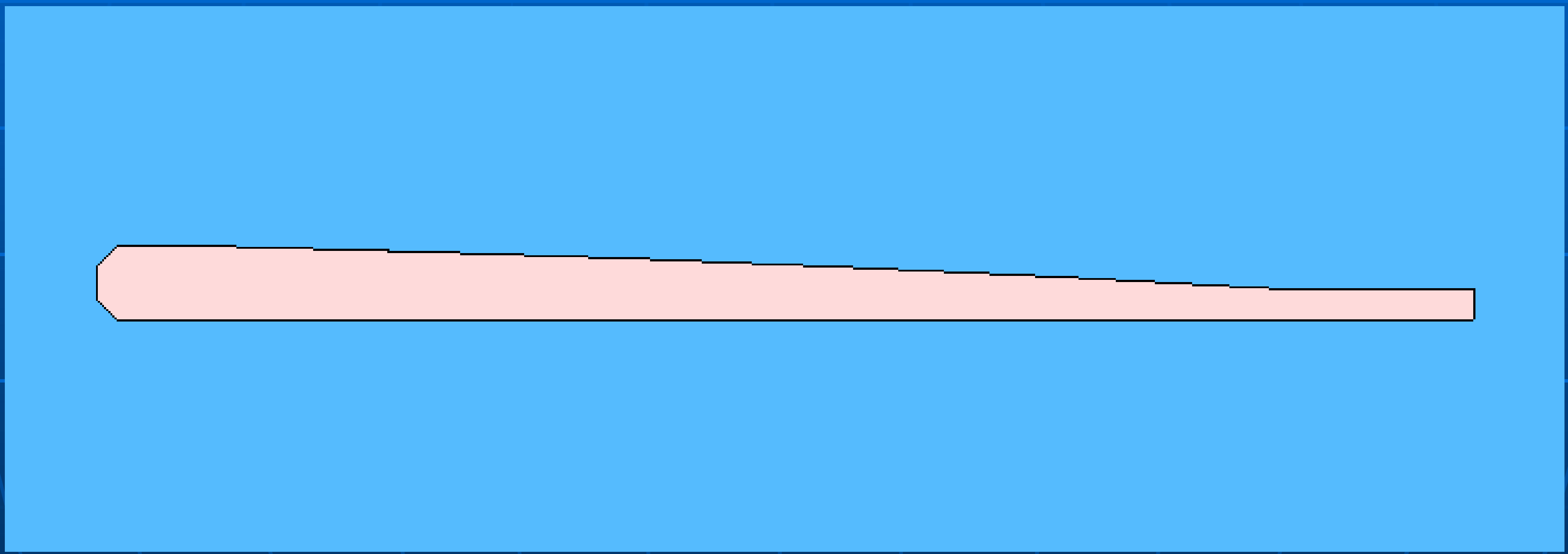
- The black arrows are all the reaction forces to the floor and the arm from the base.
- We assumed that the front of the base (where the arm is connected) could slide forward; this only leaves a reaction force in the vertical direction.

FEM of Base

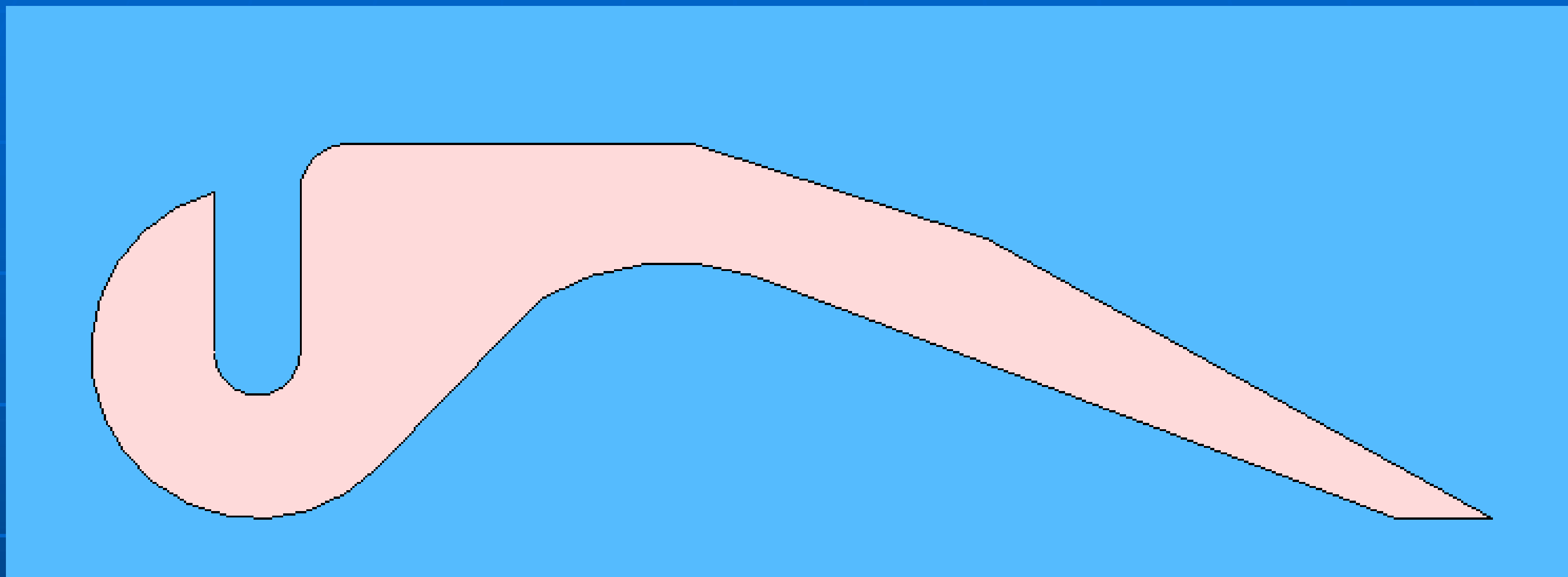


We fixed the trailing end of the catapult and applied a couple at the contact points. The forces used to produce the couple were calculated to be 473.5N.

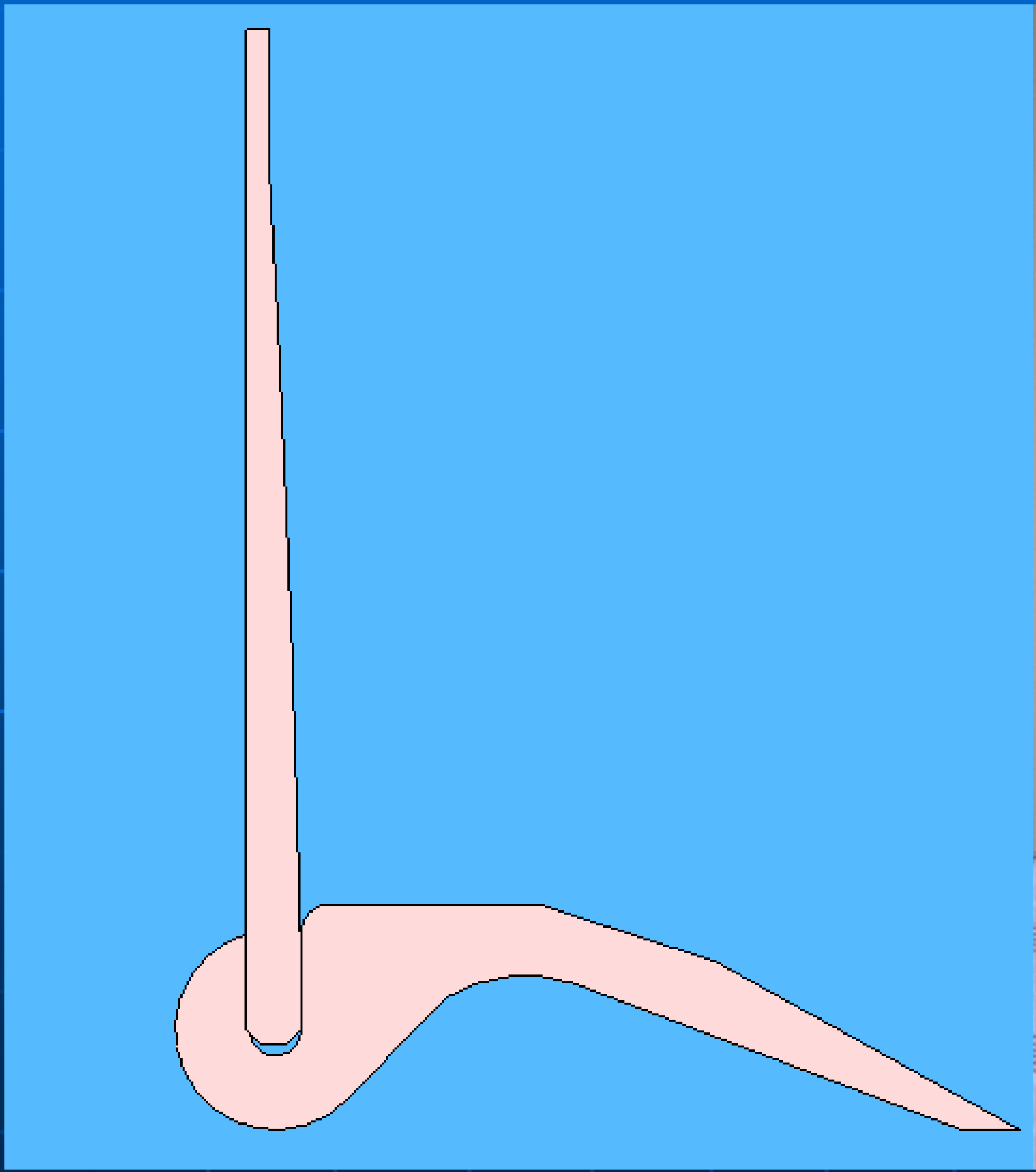
Arm



Base



Assembled Model



Questions?