Feeding System - Designing the Funnel Body

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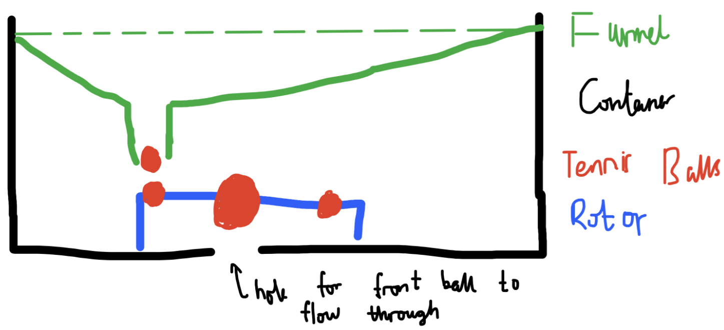
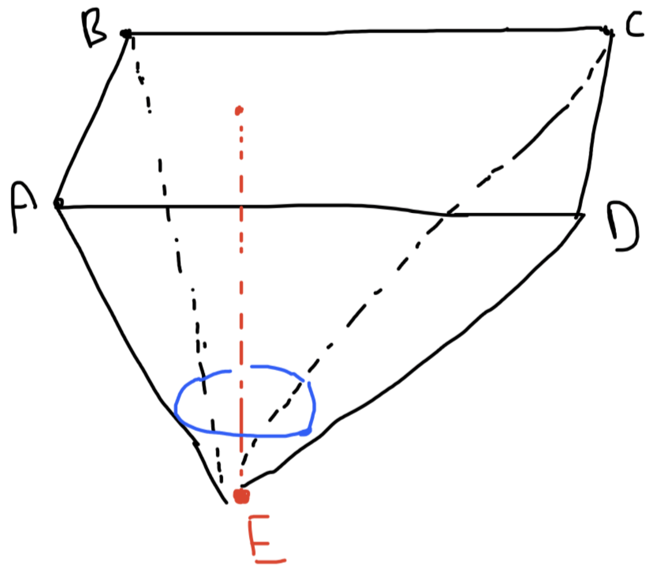
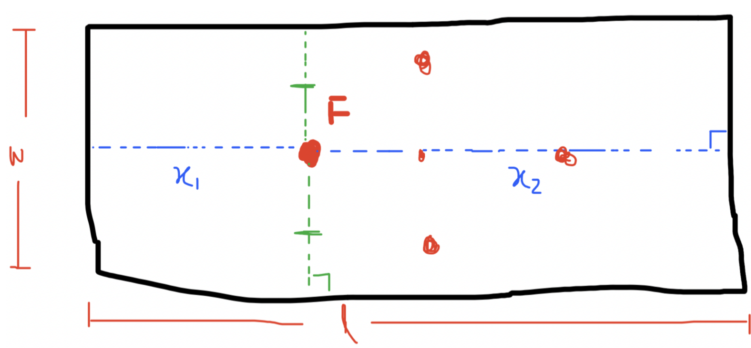
Consider we have a rectangular prism for a container and we want to place our rectangular pyramid funnel body in our container so that we can guide balls towards the rotor. We've seen this idea before but using a bucket (an open cylinder). Recently, I decided to change the bucket to a rectangular prism instead. So overall, the system would look something like this:



For a 3D view we might get something like this



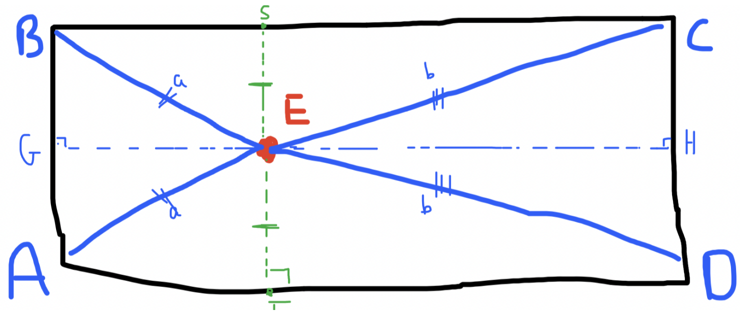
ABCDE is a rectangular pyramid with the apex (at E) off centre. The apex is going to get 'beheaded' (marked in blue), to give us a hole on the bottom where the tube part of the funnel can be attached. Note that point E should hover directly over the centre of the rotor hole that has just passed the container's hole. This centre, from a bird's eye view, will be located here:



Point F refers to the centre of this particular hole. The central red spot in the above diagram corresponds to the centre of the rotor which will be located at the centre of the floor of the container. Note that the point F is located such that it is equidistant from the top and bottom sides of the rectangle but is closer to the left side than to the right side.

The terms l and w refer to the dimensions of the rectangle. Note that it is not necessarily the case that $l > w$.

So in terms of the triangle faces that form the rectangular pyramid, they would look like this:



Note that point E is directly above point F. From a bird's eye view, they are not distinguishable.

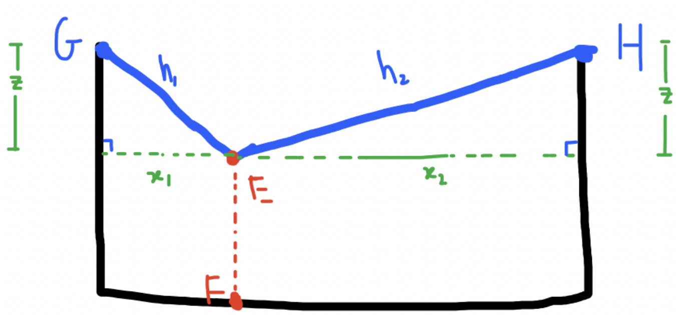
We can draw the conclusion that triangle ABE and DCE are isosceles triangles of different sizes.

Reasoning: By construction, we know AB equals TS and AB is parallel to TS. Therefore we know $ABST$ is a parallelogram as it has a pair of sides that is both equal and parallel. Combining this with knowing that BS is perpendicular to ST, we know $ABST$ is a rectangle as it is a parallelogram that contains at least one right angle. Therefore $BS = AT$ (since opposite sides of a rectangle are equal). We are also given $SE = TE$. We also know $\angle ATS = \angle BST$ as they are both right angles. Therefore, triangles $\triangle BSE$ and $\triangle ATE$ are congruent (SAS). Therefore, $AE = BE$ (matching sides on congruent triangles $\triangle BSE$ and $\triangle ATE$. Therefore, $\triangle ABE$ is isosceles (two out of three sides are equal).

A similar argument can be constructed to show $\triangle DCE$ is isosceles.

Triangles BEC and AED are scalene triangles.

Now to consider a side view, specifically focusing on the line segments GE an HE.



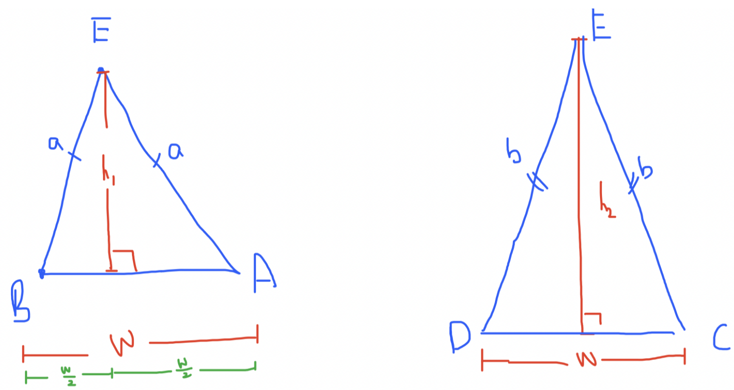
The term z is a hyperparameter, meaning I will choose the value. It represents the perpendicular height of the rectangular pyramid. (In figure 2, it would be the length of the red line.) The term x_1 refers to the horizontal distance from G to the point F (or E). Similarly, x_2 refers to the horizontal distance H to point F.

Note that G and H refer to the midpoints of the bases of the two isosceles triangle (see the previous diagram for further clarification).

Note that h_1 and h_2 refer to the perpendicular heights of the two isosceles triangles.

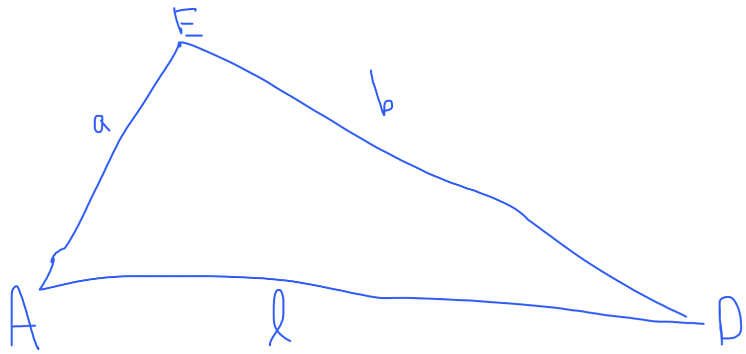
Using Pythagoras' Theorem we can calculate the values for h_1 and h_2; $h_1 = \sqrt{x_1^2 + z^2}$ and $h_2 = \sqrt{x_2^2 + z^2}$.

So now we know the perpendicular heights of the two isosceles triangles. Since we know these heights and we know the base lengths of the isosceles triangles (equal to the appropriate side length of the container), we can determine the lengths of all sides of each isosceles triangle.



Using Pythagoras' Theorem, we know $a = \sqrt{(\frac{w}{2})^2 + h_1^2}$ and $b = \sqrt{(\frac{w}{2})^2 + h_2^2}$.

Notice how in finding a and b, we have now found all of the side lengths of the congruent scalene triangles.



In terms of finding the internal angles of each triangle, since we have all three side lengths, we can apply cosine rule three times for each triangle to find each internal angle.