Crash Helmet Design Report

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Question

We encountered a lot of questions before we started to design. What is TBI? Why do we need a helmet? But the most important one is: How do we make our helmet, so when the egg is dropped, it is less likely to get crushed? Base on this, the purpose of this lab is to design a helmet that reduces the impact of force when the egg hits the ground.

Hypothesis

By creating a 3D printed helmet, with foam inside and a parachute on the top, we can prevent our simulated egghead from getting TBI, which is crash and break apart in the experiment.

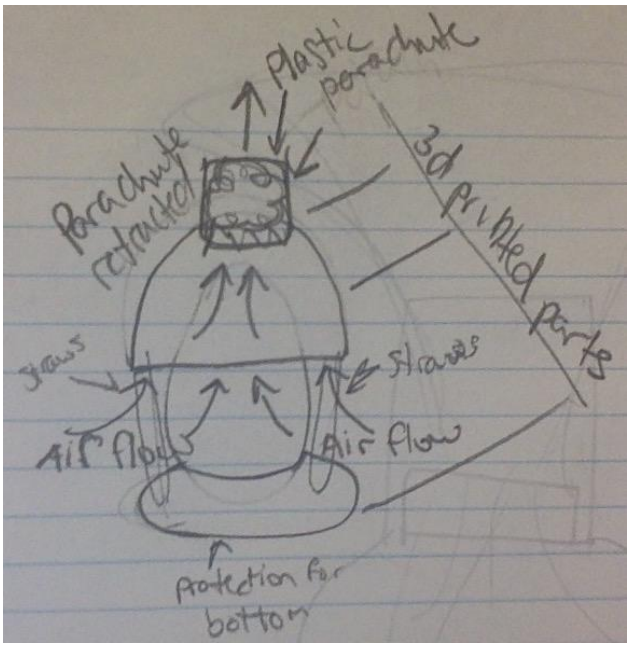
Materials

filament for 3D printer	string straps*3	plastic sheet*1
straws (at least 4)	hot glue,	
packing peanuts*4	wooden dwells*2	

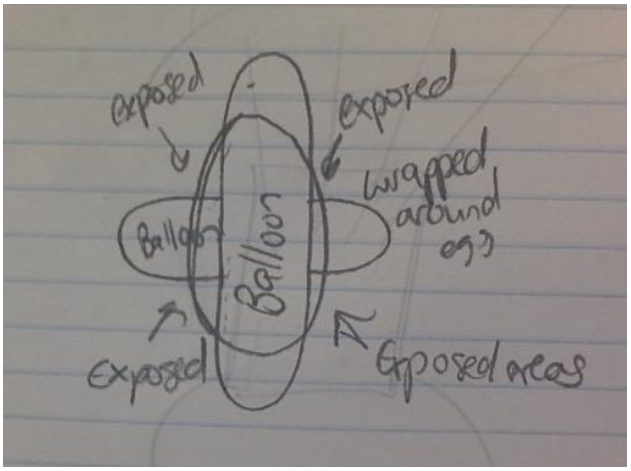
Procedure

Before we decided on our design, we had several different ideas.

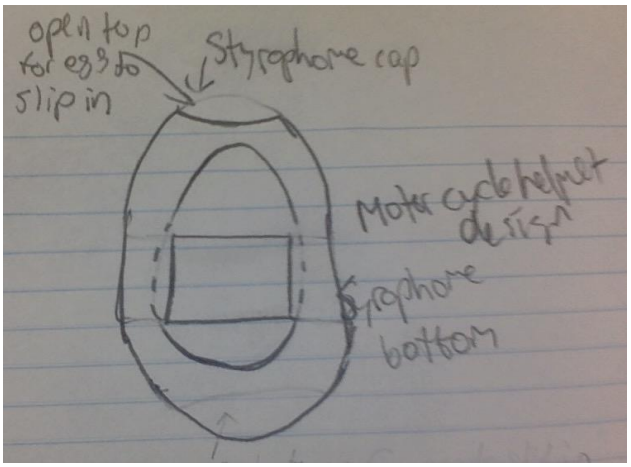
These ideas included the following:



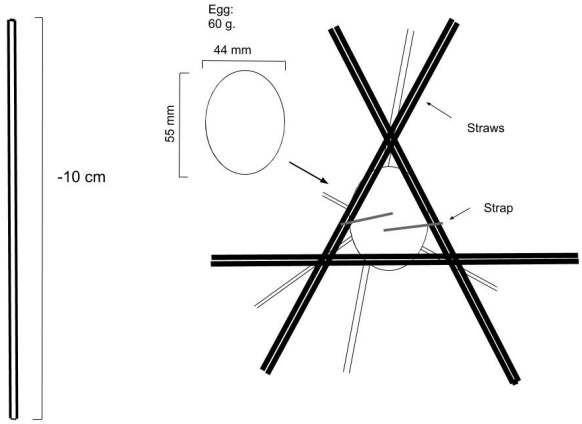
Parachute plus helmet (the one we used)



Balloon

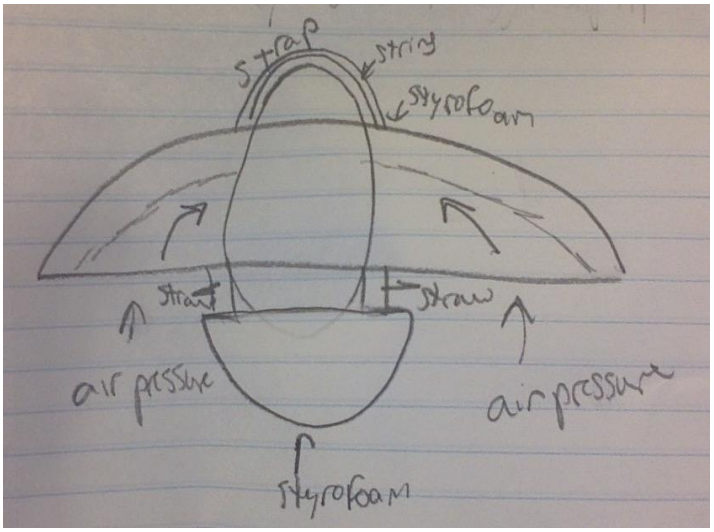


Styrofoam (slime)



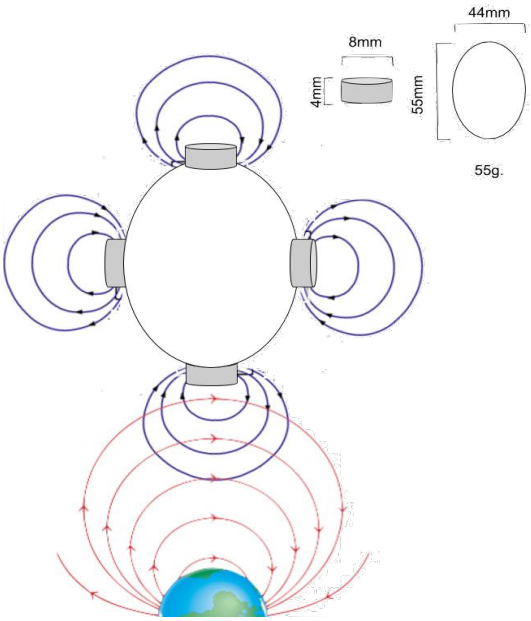
Straw

Egg in bag



Egg tutu

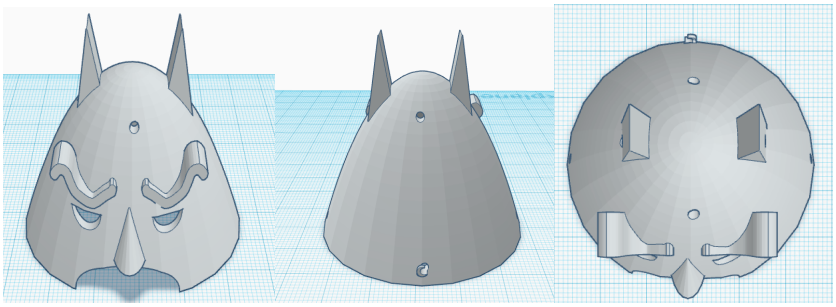
Phone case (edge will pop out when dropped)



Magnets

These designs are not selected eventually because either they're too hard to make, or they cost too much money. For example, the egg slime one restrict the mobility and the visibility of the egg, and it takes a long time for us to put it on the egg. The straw is another good idea, and it's easier for us to put the egg in the device. However it doesn't look nice, and it takes more space than just a helmet. Eventually we stick with the idea of the combination of the helmet with the parachute because it is the most doable on and it doesn't cost a lot of money.

We refined our first sketch and made the final design on TinkerCad. It looks like this:

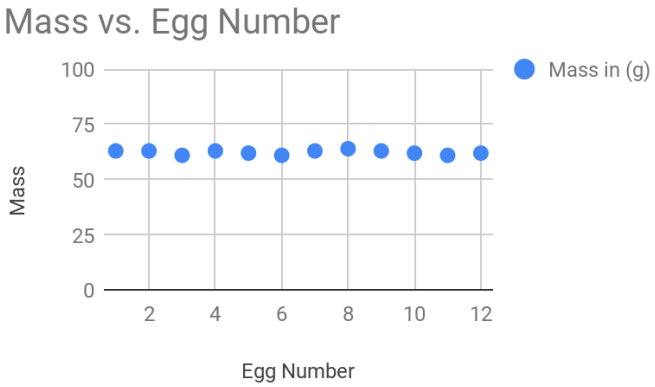

TinkerCad finished design

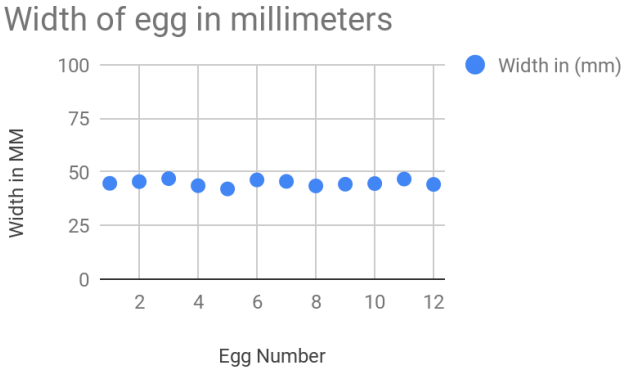

Final design

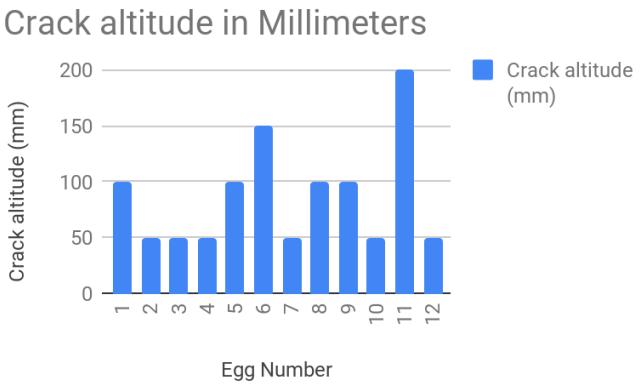
The ‘mouth’ of the cat provides a place for the egg to ‘see’, and the ears provide a slow-down effect when it is hit on the ground. There are holes on the helmet so the string can hang on it. After the helmet is printed, we then use straws to make a chin cushion by sticking 4 cutting straws to some packing peanuts. We also put packing peanuts inside the helmet for cushion. For the parachute we went on website to calculate the size of it based on the weight of the egg. We

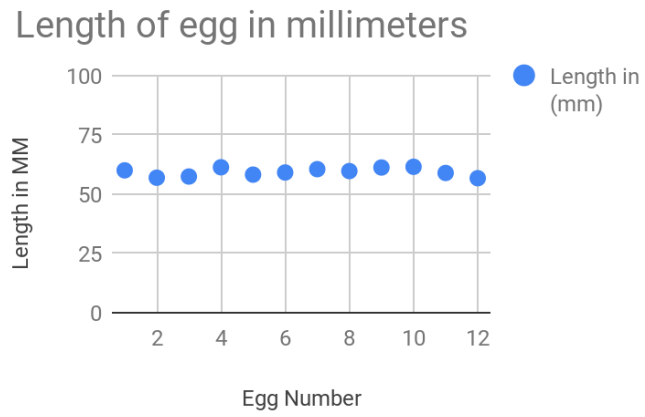
use strings to connect the parachute, the helmet and the chin protection. To strengthen the side string between helmet and the chin protection, we use cutting straws and pull the strings through the straw. There is a middle string between the helmet and the chin, and it can be moved up and down, so it's adjustable and can fit different sizes eggs. The parachute is a circle with the ratio of 10.5 inches, and with two wooden dwellings to open it. We use hot glue at the top of the helmet to strengthen the string there. Overall it is not too hard to make, but it took a long time to refine our design.

Data/Observations and Results









Without the helmet, most of the eggs crack before a height of 80 mm. The first test is with helmet plus the parachute without the wooden dwell, and the egg cracked. After that we add the dwellings it survived multiple droppings from 6 feet height.

Analysis/Discussion

Our result shows and indicates that with the protection of the helmet, the egg can easily survive higher than their average cracking height. To know how good the protection is, we have to calculate the net and the impact force of the unprotected and protected egg. The equation that we are using is F = m*a and Fn = Fi*t(sec). To find the velocity we need d = v*t and the plugged it in v=vi+a*t to find the acceleration. The net force of an unprotected egg is 55g, about 0.539 N. The impact of it in 0.01 second is 53.9 N, which is way bigger than the egg shell could handle. The device have the parachute that decrease the acceleration using air friction. The new acceleration is approximately 6.4 m/s^2, resulting in the new impact time of 0.1 second. The new net force for the egg is now 0.352 N, so the new impact force will be 3.52N after 0.1 second. Our hypothesis is that if we make a helmet with parachute, this will help with decreasing of the impact when the egg hits the ground. The data support the hypothesis because the impact force of the protected egg is less than the impact of the unprotected egg. Therefore, this helmet helps solving the problem that we brought out in the beginning.

Conclusion

After this experiment, we learned that making a helmet can significantly reduce the possibility of the crash, which in reality means it can help reducing the possibility of getting TBI. Our helmet

was very successful, as the design looks good, it is reusable, and the protection device itself hard to break. Most of the grade AA eggs are protected at most of the time throughout our experiment. If we can redo this experiment, however, I'll consider to make more support for the chin, as it is not very strong protection comparing to other parts of the protection device. We might choose to use different materials for the dwellings, as it eventually broke at the end of the class. We can also make the hole bigger so the strings can go through, instead of us using hot glue which doesn't look good and increase the mass. We face a lot of difficulties, including how the whole group can meet for the experiment, how we should utilize the materials, and several calculation errors while printing the helmet. We are happy that overall the device is successful in the testing state, and the egg didn't crash during the testing in class. I really like this experiment because it helps us to learn about something beyond just physics. We learned a new medical term, we practiced our crafting skills, we improved our team work, and so on. I hope that next year we can also make some experiment based on these elements, especially crafting, because that makes a concept more interesting, and we can therefore remember it better.