Title: Analysis and design of shock absorbing package for an egg drop experiment.

Institution: Ashesi University, Ghana, January 2016

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OBJECTIVE OF THE EXPERIMENT:

The aim of this project is to find the force required to break an egg in order to design a package that can contain and protect the egg from breaking when it is released from a certain height (5m).

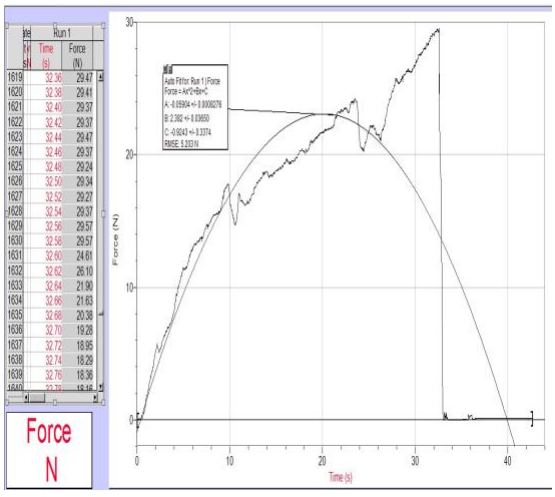
In the process to determine this force, the Newton's laws of motion and theory of Pressure was applied.

ANALYSIS:

Before the analysis, the round tip of the force sensor was gently pressed against the sides of the boiled egg to determine its strength. This helped us to know that the boiled egg will break when the force within a range of 20N to 30N.

According to the results obtained from the experiment, it was seen that the force applied by the force sensor increased gradually until it got broken after 32.58s. It was found that an egg of mass 0.06337kg required a force of 29.57N to break its shell after 32.58s. The graph below represents the actual data taken from the LabQuest2 device.

The graph of force versus time



The effect of Newton' third law is also considered, which states that there is an equal and opposite reaction when an object A acts on another object B. When the egg hits the ground, the ground reacts equally and opposite to the action done with the egg. Due to this, a greater exerted force exerted by the egg can cause the egg to break.

The egg is expected to contain an amount of kinetic energy before it hits the ground. The calculations for the kinetic energy of the egg is below:

Kinetic energy = Potential energy

$$\frac{1}{2}mv^2 = mgh$$

$$v = \sqrt{2gh}$$

where m is the mass of the egg, v is velocity, and h is the height at which the egg was released.

$$v = \sqrt{2x9.8m/s^2x5m}$$

$$v = 9.9m/s^2$$

Hence the Kinetic energy =

$$K.E = \frac{1}{2}x0.06337kg\ x\ (\frac{9.9m}{s^2})^2$$

$$= 3.12J$$

More importantly, looking at Newton's second law which shows that the force depends on the acceleration of an object. The acceleration or velocity at which the egg falls can be reduced by providing a drag in order to prevent a greater force, which can damage the egg. This also helps to increase the time of impact on the ground, thereby reducing the impact force.

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The formula**:**

$$= \boldsymbol{v^2} = \boldsymbol{u^2} + \boldsymbol{2as},$$

$$a = \frac{v^2 - u^2}{2s}$$

$$\boldsymbol{where\ s} = \boldsymbol{1cm} = \boldsymbol{0.01m}, \boldsymbol{v} = \boldsymbol{0}, \boldsymbol{u} = 98.01 \text{m}/s^2$$

$$a = \frac{0 - 98.01}{2(0.01m)} = -4.9x\ 10^3 m/s^2$$

Momentum is conserved for the falling egg because part of the momentum is gained by the shells of the eggs to move apart causing the break. After some time, the momentum gained by the egg is further lost to the earth because the earth is larger than the egg, and it is able to absorb any velocity with which the egg hits the ground**.**

$$\boldsymbol{m_{egg}V_{egg}} = (\boldsymbol{m_{egg}} + \boldsymbol{m_{ground}})\boldsymbol{v}$$

Again, pressure is considered in the process. Pressure is directly proportional to force applied, but inversely proportional to the area where the forced is applied. From the theory of Pressure: =

$$P \propto \frac{Force}{Area}$$

A greater surface like that of the oval face of the egg will require a

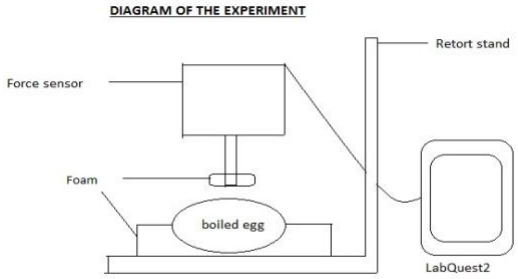
smaller force than the tip of the egg to break.

TEST OR PROCEDURE:

Measure the mass of the boiled egg to be used for the experiment and hold it in a soft board so that it does not slip away.

Connect the force sensor to the labQuest2, Set many samples, and time for the experiment.

Gently apply force using the force sensor.



DESIGNING THE PACKAGE:

Problem or Need: In this project, the problem which needs to be solved is the egg's breakage when released from a height of 5m. From the analysis above, the only parameter that will change is force.

Material Used: masking tape, foam of a thicker density, blade.

- A thick cylindrical Styrofoam of height 14.5cm and a diameter of 9cm is chosen because it is suitable to contain the egg. A spherical hole of the egg's size of depth 8cm is made in the middle of the thick foam to hold the egg in position. The hole is made in such a way to hold the egg tightly because I realized that a little space around the egg in the hole can lead to breakage when released from a height.
- The circular ends of the Styrofoam are sealed with additional foam padding in the form of a cork by the help of a masking tape. This is to prevent the egg from falling out of the package, and also absorb some of the impact force upon hitting the ground.

A graph of force versus extension of the Styrofoam.

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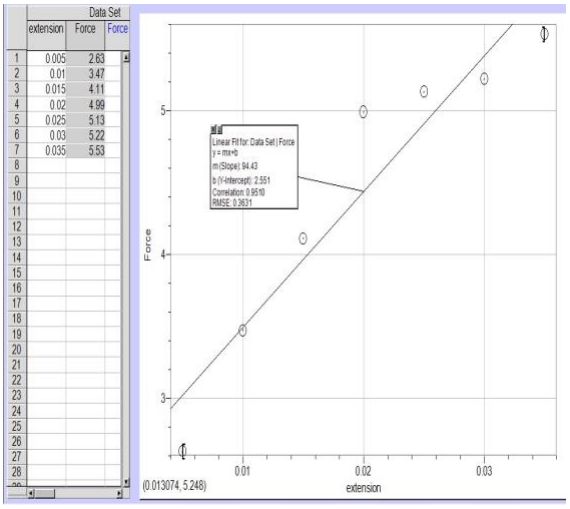
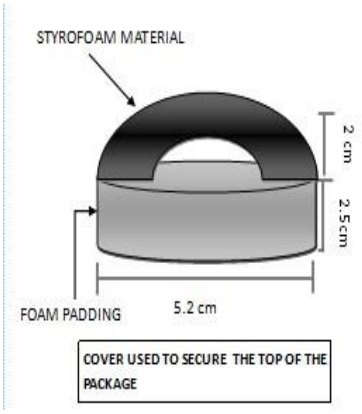
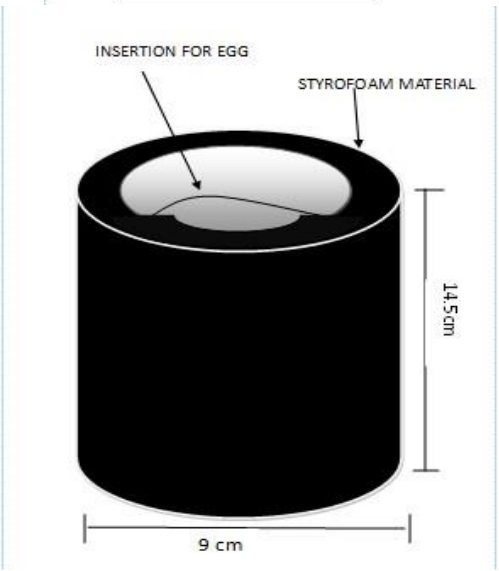


From the graph above, it can be seen that elastic constant of the Styrofoam is 94.43N/m.

Diagram of the package





The weight of the package coupled with that egg is 0.91N and a total mass of 0.091kg.

CONCLUSION AND LESSONS LEARNED:

From the above, it can be deduced that it requires a minimum force of 29N to break a boiled egg when released from a certain height. And to prevent this force or more from breaking the egg, the egg needs to be secured in something that can cushion it; absorb the shock that can break it. By so doing, we change parameters such as force.

All through the test of the force with the force sensor, I learned that the tip of force sensor should be covered with a foam to prevent it from slipping from the egg surface to hit the table, which can damage it. Making hole in the Styrofoam and the exact height to test the efficiency of the package were the only limitations that stood our way in the courses of the experiment. With regard to the designing of our package, I discovered that the package should be able to hold the egg tightly to prevent breakage. When the egg is loosed, a greater amount of the force absorbed by the cushion is transmitted to it which can break it.