SUMMER INSTITUTE FOR ENGINEERING AND TECHNOLOGY EDUCATION

MECHANICAL ENGINEERING -- GRADES 9-12: MODULE 3

EGG DROP

CONCEPT

This experiment is designed to demonstrate the concepts of Newton's second law, acceleration, collision, and resilience.

OBJECTIVES

Students will apply the principles of Newton's second law, concepts of force and acceleration due to gravity, collision, and resilience to build a housing for an egg so that it will survive being dropped from the maximum height possible. The teacher may also require material cost to be a factor in the design.

MATERIALS REQUIRED

1) Eggs
2) Shoe Box or any other cardboard box
3) Filler materials like newspaper, sponges, marsh mellows, styrofoam blocks, styrofoam peanuts, rubber, popcorn, cotton, rags, plastic, etc.
4) Fastening materials like tape (duct, masking, scotch), paper clips, strings, rubber bands.
5) Tools like scissors, pliers, knives.

THE JOB

The job of a Mechanical Engineer does not end at the workshop or at the manufacturing plant. Once the parts are manufactured according to the specifications, proper care should be taken in packing the products for transportation. Poorly packed products lead to breakage, distortion, or improper functioning of the part. There is a strong need to pack these products properly to survive transportation, stacking etc. A well packed product also enhances the image. Keeping these points in mind, your job is to design a housing for your egg. The housing should be designed in such a way that the egg will survive being dropped from the maximum height possible. Build this housing by making use of the materials provided. Your are also advised to team up with 3 or more students to work on the experiment. When the designs are complete each group's housing will be tested by dropping the housing along with the egg inside from incremental distances until the egg breaks. Remember, if cost of material is a factor, then you will be attempting to design the best egg drop apparatus at the lowest cost.

EGG DROP FUNDAMENTALS

The objective, of course, in this exercise is to keep the egg from breaking. To accomplish this objective, we desire to minimize the force that the egg experiences upon impact. We can begin to quantify this force by examining some fundamental laws of gravity and momentum as laid out by Issac Newton. Newton's Second Law of Motion relates force, acceleration, and the rate of change of momentum as follows:

$$F = ma = \frac{d(mv)}{dt}$$

where F represents force, m represents mass, a represents acceleration, v represents velocity, and t represents time. The product of mass and velocity is momentum. Thus, Newton's Second Law states that force is directly related to an object's rate of change of momentum. We have all experienced this force when we decelerate (or accelerate) while driving. Further, the more quickly we decelerate, the larger the force we experience. Assuming that the mass of the object does not change, we can divide through by the mass to show that the acceleration is equal to the time rate of change of the velocity. Typically, this acceleration is expressed in g's where 1g is the acceleration (or gravity, 9.8 m/s^2) on Earth.

As a specific example, consider a car uniformly decelerating from 60 mph to rest. The change of momentum would simply be the mass of the car multiplied by the change in velocity -- 60 mph. Note that the change in momentum is constant independent of the time required to bring the car to rest. However, the above equation shows that the force increases as the time required decreases. Since the mass of the car remains unchanged, we can evaluate the acceleration. Converting from miles per hour to meters per second, the change in velocity is 26.8 m/s. If the car is brought to rest in 2.7s, then the acceleration is 9.8 m/s^2, or 1g. During this time, the car would travel 36m or about 120 feet. If the car is brought to rest in 0.54s, the acceleration is 5gs and the distance traveled is only 7.2m or about 24 feet. This acceleration is about what astronauts experience upon liftoff but below the limit for human survival (around 10 gs). Astronauts wear gravity suits which enable them to survive these high accelerations.

Thus, we see that for the egg to survive, we must try to minimize the egg's velocity upon impact, and/or maximize the time (distance) over which the egg is brought to rest (meaning provide some sort of cushion around the egg to absorb the force when the egg hits the ground). When dropped, the egg is accelerated by gravity. When the air resistance (the force experienced when placing one's hand out in a strong wind), which increases with increasing velocity, equals gravity, the egg's velocity will remain constant. This velocity is known as terminal velocity. Parachutists depend on this phenomenon to survive when jumping out of airplanes.

With these principles in mind, let's drop some eggs!

ASSESSMENT

Prepare an informal lab report based on the construction and performance of your egg drop apparatus. Consult with your teacher for lab report format. If time allows, redesign the apparatus for better performance!

BIBLIOGRAPHY AND REFERENCES

PETROSKI HENRY, *To Engineer is Human: The role of Failure in successful* Design, St. Martin's Press, New York, 1985.

PETROSKI HENRY, Beyond Engineering: Essays and other Attempts to Figure without Equations, St. Martin's Press, New York, 1986.

GLORIOSO, R.M. AND HILL, F.S, *Introduction to Engineering,* New Jersey, 1975.

BLOTTER, P.T, *Introduction to Engineering,* New York, 1981.