The Alarm Clock Turner Off-er

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*All team members have seen and agree to the following report
Abstract:
The goal of this team project was to create a Rube Goldberg device that turned off an alarm clock. A Rube Goldberg device is one that goes through an inefficient and complex process to perform a simple task. Our device begins with a small marble rolling down a tube that is wrapped around a cardboard box. At the end of the tube there is a long piece of wood that acts as a lever. The lever is hit by the small marble then hits a large marble sitting on top of a ramp. The large marble shoots down the ramp and jumps into a tube. The tube takes it to a small ramp in order for the marble to hit the center of a book. The book hits another book creating a domino effect. The last book has a knife on the top and cuts a string that is holding a weight. The weight falls and lands on the alarm clock’s snooze button and turning it off.
Introduction:

The objective of the project was to create a Rube Goldberg device that turns off an alarm clock. We needed to create a device that had at least five steps to turn the alarm clock off and included four concepts that we learned about in Engineering Fundamentals 151, which included projectile motion, conservation of energy, conservation of linear momentum, conservation of angular momentum, torque, and center of mass. It was required to perform calculations for our primary steps in the device. A PowerPoint presentation was required before we showed our project to the class.

Design Process:

The final design of our machine came a long way from the original ideas. When the project was assigned, our group was completely unsure of what to do. Our group's first meeting for the project was during the first recitation work day. Caleb, Sasha, and Corey brought different items, which consisted of cups, threads, needles, strings, a box, a mail tube, and a ball. We tried playing around with these items trying to produce ideas. We thought about using pulleys, making a ball go through a loop, and shooting a ball over a gap. In the first meeting, we didn't stick with any permanent design ideas, but we did get the materials we would use for the machine. Our second meeting was at the library on a Wednesday evening, one week before the project was due. During this meeting, we discussed what our machine was going to do. Corey came up with the idea to turn a stereo off that was playing a song, and Caleb came up with turning off an alarm clock. Francisco took Caleb's idea and added that the machine should turn it off by dropping a weight on it. This was the final plan for what our machine was going to perform. Our group decided to meet on the following Saturday to finalize the steps and list the materials we were going to need. That Saturday, our group decided to make a ball go around the
box and hit a lever that was going to hit the ball and make it go down the box. For this design to work, we were going to need a tube, a small ball, and a lot of duct tape. Since we didn't have the items on hand, our group went to buy these items. After we bought the items, we scheduled to meet again the next day. On the next meeting, we finalized the designs on our machine by building the frame that was going to hold the weight and making the ball that went down the box hit a book, which hits another book that has a knife attached to it, that cuts the rope which holds the weight. We met for the final time on Monday to fine-tune our machine. The final adjustments were to use a large marble instead of a ball and make it go through a mail tube before it hits the book. Overall, a lot of time was spent coming up with the final idea of the machine.

Device:

Our machine uses five steps to “turn off” the alarm clock. The first step is that a marble is released inside a plastic tube, which starts at the top of the box, goes around the box once, goes inside the box through a hole, and hits a lever inside the box. As the marble is traveling inside the plastic tube, it is gaining velocity. To calculate the final velocity of the marble right before it hits the lever, you will use the following equation:

\[ V = \frac{\Delta d}{\Delta t} \]  

Eq. 1.1

Where \( V \) the velocity in feet per second, \( d \) is the distance in feet, and \( t \) is the time in seconds. The marble travels 8 feet in the plastic tube in 2 seconds. Using Eq. 1.1., the marble has a velocity of 4 ft/s when it this the lever.

The second step is the marble hits the lever at the bottom, which makes the lever hit a large marble at the top and the marble travels down the box and jumps a small gap. Right
before the marble jumps the gap, it has a velocity which can be calculated using the Conservation of Energy equation.

\[ mgh = \frac{1}{2}mv^2 \quad \text{Eq. 1.2} \]

Where \( m \) is the mass of the marble, \( g \) is the acceleration of gravity (32.2 ft/s\(^2\)), \( h \) is the height where the marble starts, and \( v \) is the final velocity. The marble starts at .875 feet above the datum, which is set where the marble leaves the box. The mass cancels out on both sides. Solving for \( V \) in Eq. 1.2, you get 7.51 ft/sec, which is the velocity the marble leaves the box.

For the third step, the marbles jumps over a small 3.5 inch gap. However, we can determine the maximum size the gap could have been using the x-motion trajectory equation.

\[ X = x_0 + (v_0 \cdot \cos \theta) t \quad \text{Eq. 1.3} \]

Using Eq. 1.3, we can figure out the maximum distance by taking the initial position \( (x_0) \), which we'll use 0, adding it to the product of the initial velocity \( (v_0) \), which we found using Eq. 1.2 to be 7.51 ft/s, and the cosine of the launch angle (we'll assume for this problem to be 30 degrees) and multiplying that answer by the time it takes to jump the gap (we'll assume it can do it in .5 seconds). Plugging in the numbers, the maximum gap it can jump is 3.25 feet.

The fourth step in our machine is that the marble travels through a mail tube, goes up a small incline, hits a book which hits another book, and hits the last book that has a knife
attached to it. The marble hitting the book, which makes the book fall is an example of a perfectly elastic collision because the marble transfers some kinetic energy to the book. To calculate the velocity of the book after the marble hits it, we will use the perfectly elastic equation.

\[ m_1v_1 + m_2v_2 = m_1v_{1'} + m_2v_{2'} \]  \hspace{1cm} \text{Eq. 1.4}

The marble has a mass \(1.57 \times 10^3\) slugs, the book has a mass of \(1.94 \times 10^2\) slugs, the book is at rest, and for this example, we'll assume that the marble still has the velocity of 7.51 ft/s and has a final velocity of -1.5 ft/s. Plugging in the numbers, the velocity of the book is .729 ft/s.

The final step is the book with the knife attached to it falls to the rope, which cuts the rope, releasing the 25 lb weight to the alarm clock, thereby turning it off for good. When the weight hits the alarm clock, it applies a certain amount of work on the alarm clock. To determine the amount of work, or energy, applied to the alarm clock. You would use the work equation.

\[ \text{Work}=\text{Force} \times \text{Distance} \]  \hspace{1cm} \text{Eq. 1.5}

The weight has a force of 25 lbs and drops a distance of 1.23 feet. Plugging in the number, the amount of work the alarm clock experiences is 30.7 ft-lbs of energy, more than enough energy to leave an alarm clock destroyed.

**Conclusions:**

Our original design looked nothing like our final design. The thought of making a Rube Goldberg device seemed very easy, but when put into action it was actually much harder than
expected. We began drawing up designs before we had materials, and when we finally got materials our design completely changed. When we had a design we discovered many problems with that design, so we needed to change certain aspects of the design to make it work with as little misses as possible. This project took a few hours and countless mistakes to make it work properly. In the end it was a successful device and our team learned a lot from it.

References:

University of Tennessee Engineering Website: http://ef.engr.utk.edu/ef151-2009-01/