2013

Space Pong: Teaching the Principles of Energy Through the Use of Springs

Charles Setterlund

Sam Craft

James Weaver

Andrew Gray

Space Pong: Teaching the Principles of Energy through the use of Springs

Charles Setterlund

The University of Alabama in Hunstville

Dr. Christina L. Carmen

Department of Mechanical and Aerospace Engineering

The University of Alabama in Hunstville

Abstract

In order to meet the goal of demonstrating elastic potential energy and elastic kinetic energy the UAH Space Pong team constructed a ping pong ball shooting gallery. The springs mounted inside the two launchers at the front of the exhibit will function as the central points of science where energy is first stored and then released which propels the balls into the depth of the gallery. The exhibit will feature signage that will engage the users and teach them about the various equations of energy and will also begin to show to the children how mathematics and science are indeed related. Sci-Quest, our customer, will feature the gallery in their large collection of educational exhibits which will first be located at their Huntsville Alabama location and then moved to their new Madison Alabama location.

Key Words: Launcher, Spring, Energy

Introductory Section

Beginning with a request from Sci-Quest Hands-On Science Center, our customer, and Women in Defense, our sponsor, we have constructed an exhibit for the children's science center that will demonstrate elastic potential and kinetic energy through the use of springs and the kinetics of ping pong balls. The project was planned out and constructed over the course of 10 months. Constant updates were given to our customer and sponsor through the use of many presentations that the team had organized to monitor and track progress.

A major goal of the exhibit is to instill an interest of Science and Mathematics into the children and moreover interest them into giving more focus to the natural forces around them in the world and allow them to better understand those same forces both tangibly and mathematically.

As per the requirements for the exhibit, it will provide a safe and educational environment for the users that will teach the principles of energy and work and will also help the children begin to relate the equations or math for energy and work to their corresponding phenomena in Science. The Mission

Statement for the Space Pong team is as follows: “To design a Ping-Pong Ball Launching Gallery for Sci-Quest Hands-On Science Center in Huntsville, AL that will demonstrate elastic kinetic and potential energy using springs. The project is sponsored by Women in Defense (WID).”

Supporting Literature

The basic equations for the two relevant types of Energy will be included with the signage for the exhibit in order to allow the kids to better correlate those relationships between Science and Math. One of the goals for the exhibit is to make the children’s jobs easier in piecing together Science and Mathematics by introducing the correlations between the two at an early age. Although the kids are not expected to be able to understand the equations and definitions for the various phenomena, they are there if the children decide to accept the challenge.

As a whole, the exhibit utilizes kinetic and potential energy in the form of elastic energy released from springs that will propel the Ping Pong Balls into the depth of the gallery. A mathematical analysis of the distances that the springs can reach can be found in the graph of the launcher’s range calculations. (Figure 1) The calculations for the distances come from the various equations for the mechanics of the

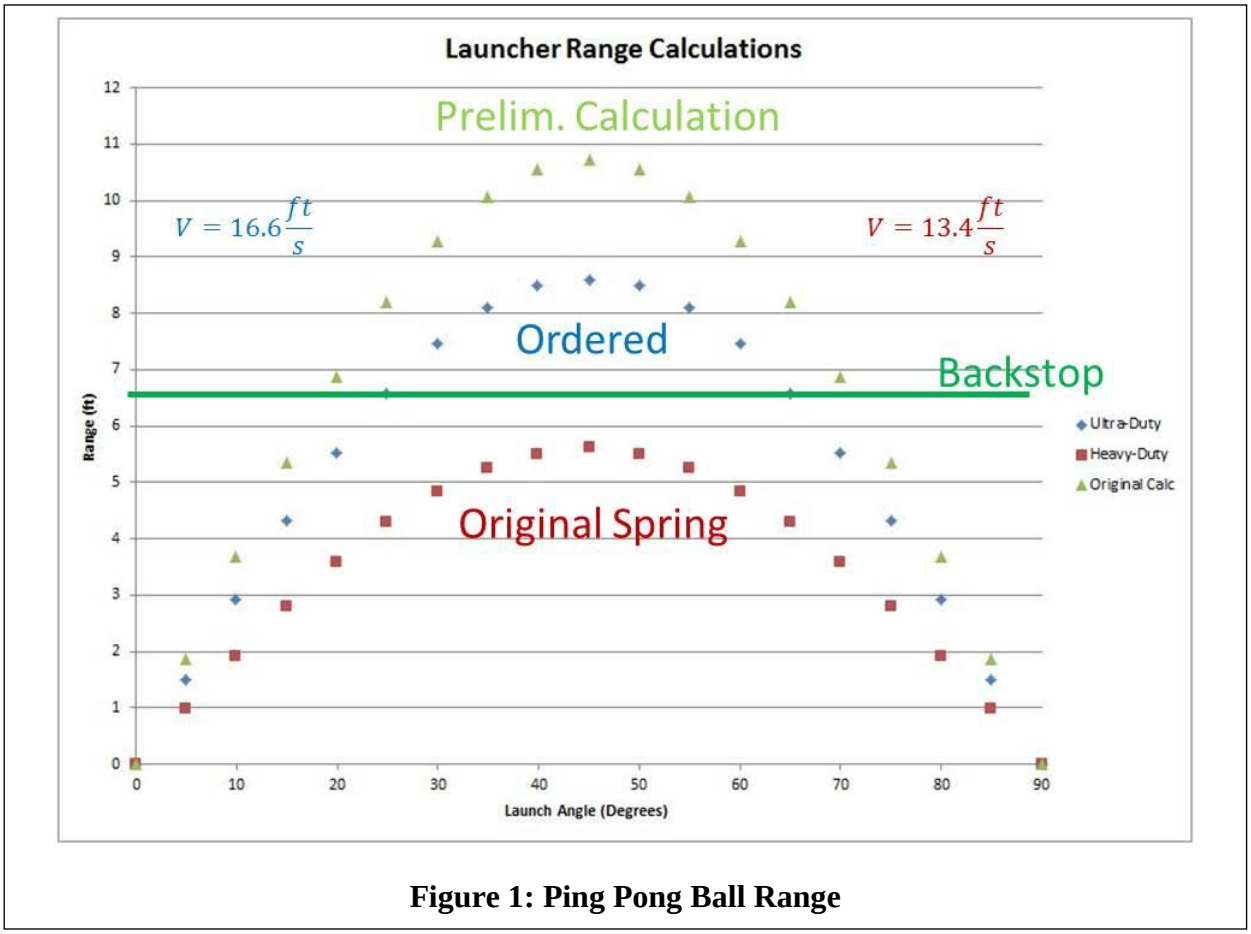

Figure 1: Ping Pong Ball Range

springs (shown in Equations 1 and 2) and Newton’s laws of motion for objects.

These calculations are based on the principle of Hooke's law which states that for a given deformation of the spring to a certain distance those change in position will provide a linear change in the amount of force that must be applied in order to stretch the spring to that length. (Equation 1)

$$Force = -(Spring\ Constant) * (Distance\ from\ the\ free\ length)$$

$$F = -kx$$

Equation 1: Force of the Spring

The energy that the spring stores can be found by taking the derivative of the pervious equation as a function of distance. This gives an equation for the potential energy of the spring system that is experiencing the deformation. (Equation 2)

$$Work = \frac{1}{2}(Spring\ Constant) * (Distance\ from\ the\ free\ length)$$

$$PE = \frac{1}{2}kx^2$$

Equation 2: Potential Energy of the Spring

A diagram of how the elastic potential energy of the spring system correlates to the spatial changes in the physical experiment can be found in Figure 2.

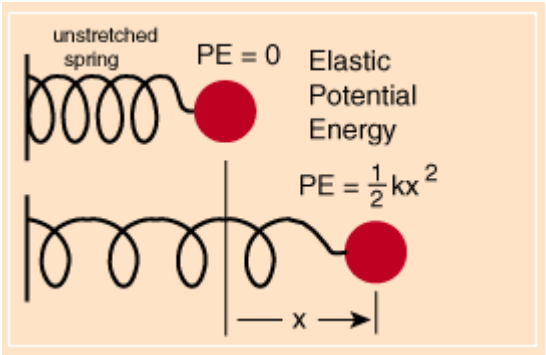

Figure 2: Spring Diagram

Description of Innovation:

The exhibit's dimensions are 5 feet across, 6 feet tall, and 8 feet in depth from the front of the gallery where the ping pong balls will be launched. Using springs mounted within the two launchers, the exhibit will demonstrate the principles of elastic potential energy, when the springs are storing energy from being pulled back, and elastic kinetic energy, when the energy stored inside the spring is translated into the motion of the ping pong balls. A Computer Aided Drawing of the exhibit can be seen in Figure 3.

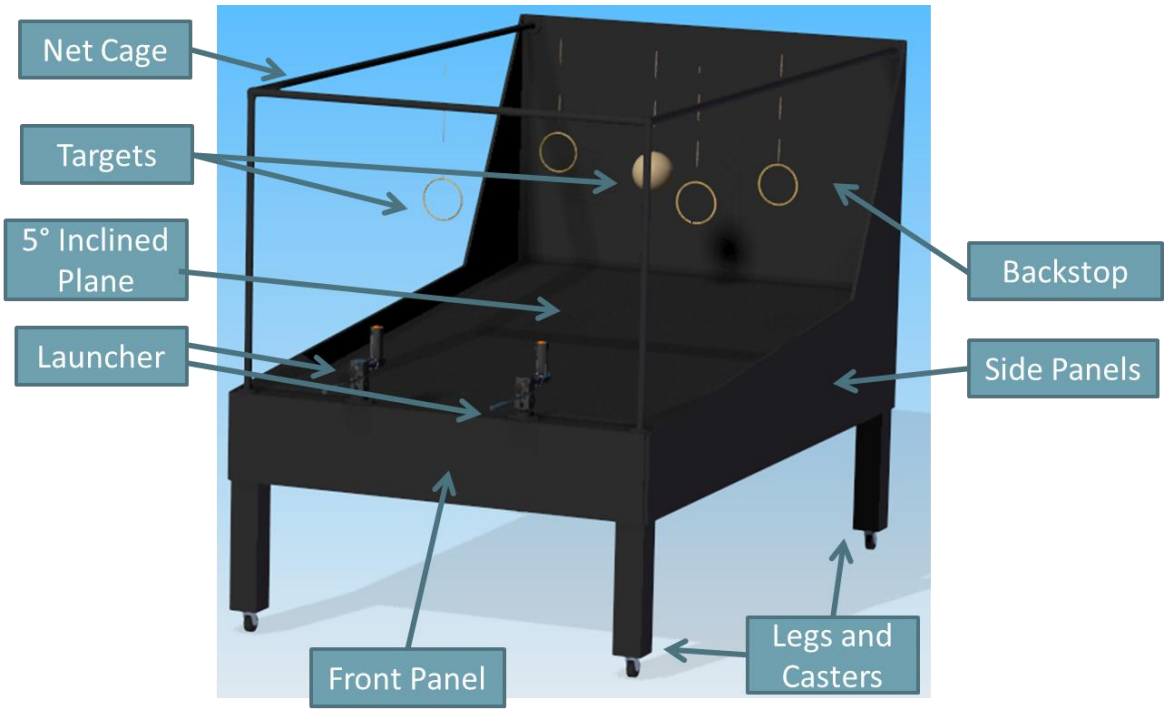

Figure 3: Rendered Launcher Gallery

The children will see the springs become compressed due to the forces applied from their hands which will later be translated to motion that will send the ping pong balls into the various rings and targets that are hung throughout the gallery area of the exhibit.

The amount of energy that can be stored will depend on the spring constant of the spring that is being used. This is the reason that the two launchers each have a different spring with different spring constant stored within them.

The distance and force of the ping pong balls will vary depending on the angle of fire from the launcher and the amount of force applied to the plungers just before they are released. A universal joint holding the launchers at their very bottom allows for the launchers to rotate 180 degrees from left to right and also allows them to rotate a little over 45 degrees up and down so that a variety of angled shots can be taken. The children will be able to experiment for which conditions allow for the farthest

and best shots of the ping pong balls. A Computer Aided Drawing of the launchers can be seen in Figure 4.

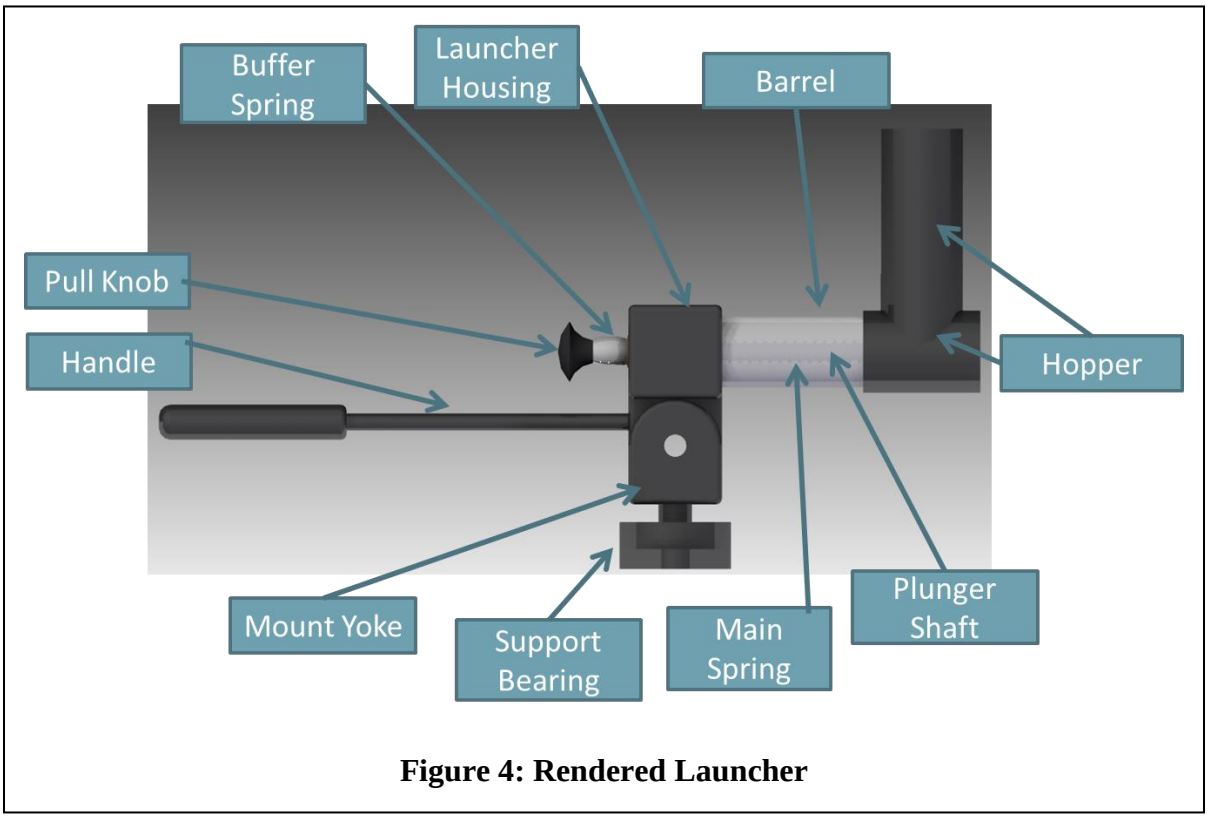

Figure 4: Rendered Launcher

The trial and error type approach will allow the children to gauge how much stored energy is required to move the balls a certain distance. They will learn to understand that differences in the set-up before the shot is taken can and will affect the results of each launch.

Signs and artwork will illustrate the basic phenomenon of the work and energy of the motion of the ping pong balls for the children and will help instill a tangible understanding of both potential and kinetic energy. The exhibit will feature this signage all along its body that will both attract users and provide education insight about the functions of the gallery. The level of language will be broken down into two levels with each of which serving the goals of engaging the users and teaching the principles of energy.

The children's section will be readable by users starting at the first grade level and will direct them in operating the exhibit. The signage will highlight keywords such as springs and energy which can then be demonstrated directly by the children interacting with the launchers. This section of the signage will also be written to be understood even by those who may not be fluent in English by keep the threshold of vocabulary and education within limits.

The parent's section of the signage will feature more in depth and precise explanations of the principles at work and will include the various equations that are related to the physics of springs. Because math can be a hurdle for some children, it is important to simplify the math as much as possible, while simultaneously introducing these aspects of science to children early on. The team hopes that the parents will be able take these lessons outside of Sci-Quest and instill an interest of the science and mathematics behind these principles into their children.

Example Applications:

The exhibit was constructed specifically to Sci-Quest's specifications and only one gallery has been constructed and that gallery has been deployed to the Sci-Quest Hands-On Science Center in Huntsville, AL. This is the location where it has begun its life and will later be moved to Madison, AL at the new Sci-Quest location where it will stay with the rest of Sci-Quest's lineup for the remainder of its life. The Space Pong team hopes that our exhibit will prove to be an excellent addition to the educational tools that Sci-Quest uses to teach and education the next generations.

Assessment:

The exhibit has fulfilled its requirements of providing a safe and educational atmosphere for its users while teaching the principles of elastic potential and kinetic energy. All of the components have been tested for safety and functionality and each of which have passed all of assessments. Even in the early days of the exhibits life, there had already been great interest to interact with the gallery even before it had been fully deployed at the Science Center. The children enjoyed learning about the mechanics of the springs and the ping pong balls even before the signage was used to complete the exhibit.

Conclusion/Summary:

The Space Pong exhibit will provide an atmosphere of fun and education for the users at Sci-Quest for the remainder of its life. The Space Pong team has constructed an educational tool where the science has become an inherent and tangible part of the experience and has ultimately allowed fun and education to become one in the same.

Acknowledgements:

Our team would like to thank our customer Sci-Quest for giving us this wonderful opportunity to apply what we have learned in our engineering studies to help reach out to and educate the children in our community about science. Our team would also like to thank our sponsor Deborah Fraley with Women in Defense who made this whole project possible and helped us organize and improve our efforts along the way. Mr. White's generous donations for his metalworking services and also for donating the whole of the launchers for the exhibit; it goes without saying that without his generous support this project would not have come together. Finally we would like to thank Keith Jones for providing all of the signage which has allowed this exhibit to become complete.

Authors

Charles Setterlund is a Mechanical and Aerospace Engineering Senior at the University of Alabama in Huntsville. He has an interest in Chemistry and Physics and works with computer hardware during his free time. He is a part of the Honors Program at the University of Alabama in Huntsville.

Co-Authors

Sam Craft is a Mechanical Engineering Senior at the University of Alabama in Huntsville. He is an experienced woodworker with an interest in recreational shop projects and carpentry.

James Weaver is a Mechanical Engineering Senior at the University of Alabama in Huntsville. He has an interest in all kinds of aircraft and hopes to one day obtain his recreational pilot's license.

Andrew Gray is a Mechanical Engineering Senior at the University of Alabama in Huntsville. He is an experienced metalworker with a variety of projects that he has constructed during his free time.