PHYSICS OF THE CATAPULT

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The Physics and Human Affairs (PHA) course requires a capstone project where learners work collaboratively to investigate and learn about physics concepts. We also served the community by providing educational outreach opportunities.

Our team chose the “Physics of Catapults” as our project.
History of Catapults

The first catapults were early attempts to increase the range and power of a crossbow. Diodorus Siculus, a Greek historian, was the first to document the use of a mechanical arrow firing catapult (early Ballista) in 399 BC.
• The Ballista is a giant crossbow.

• The Ballista was created to amplify the range and power of the crossbow and was the earliest catapult. Two wood arms that are attached to a piece of rope. The rope was attached to a winch and pulled back, bending the arm back.

• When released the Ballista would shoot large arrows, or darts toward the enemy with more accuracy.
The Mangonel was invented by the Romans in 400 BC.

The Mangonel was capable of firing 1,300 ft. Easy to construct, wheels were added to increase mobility.

The arm stopped earlier than a 90° angle, this would result in a path angle (above the horizontal)

The Mangonel consists of a long wooden arm with a bucket. Energy was stored in the tension of the rope and the arm. The bucket was then loaded and released. The arm would return to its equilibrium position, when it came in contact with the beam.

The Mangonel fired projectiles in an overhead arc, the angle of the path of the projectile could be determined by a block placed on the beam that stopped the arm.
PHYSICS AT PLAY

• Catapult physics is basically the use of stored energy to hurl a projectile, without the use of an explosive.

• Main Energy Storage Uses at Work:
  - Tension and Gravity.

• Uses Elastic and Gravitational Potential Energy

• A catapult makes use of elastic potential energy and the elastic object that is deformed under tension transforms into kinetic energy.
NEWTON’S 2ND LAW

• The second law is shown by the projectile. A rock with more mass has less acceleration, and a rock with less mass has more acceleration.

• The bungees cause the force to move the throwing arm and projectile.

• The amount of force is directly related to the amount of mass. As the mass of the projectile increased it required more bungees to provide a higher force in order to transfer more potential energy to kinetic energy to throw the projectile the same distance.
\[ t = \frac{V_{\text{oy}} + \sqrt{V_{\text{oy}}^2 + 2gh}}{g} \]
Teamwork
WHAT WENT WRONG

- Tried to add a longer neck, because it wasn’t shooting as far as we wanted.

- Added a huge rock to counterweight the neck. Didn’t work because more energy is wasted with more weight because it can’t accelerate quickly.

(The arm and bucket needed to be as light as possible)
We found that with the shorter neck and no weight at the bottom that the Ball would shoot farther.

This is because the stored energy went into the arm which made it more efficient.

The bungee cords gave Elastic Energy.
COMMUNITY EVENT
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• We allowed the children to help shoot off the catapult to see if they could shoot the baseball into one of the three buckets.

• The kids received candy for shooting it off.

• We had a lot of fun teaching kids about the catapult.
CURRICULUM LEARNED

• Newton’s Laws of Motion
• Energy Transformations
• Stored, Potential Energy
• Energy of Motion, Kinetic Energy
• Conservation of Energy
• Mechanical devices
TECHNOLOGY USED

• Smart phone apps, cameras, video capture
• Microsoft Office, Word, Power Point
• Internet tools - Google docs
• Power Tools – saw, drill
• Other tools for construction include: sander, hammer, screw drivers, bungee cord
WHAT SKILLS DID WE DEVELOP?

- Communication
  - Oral
  - Interpersonal
  - Written
- Leadership – Melissa Cooper – “I learned how to delegate tasks and facilitate in communication.”
- Team
  - Working together, but not at the same time….this was a challenge for nine people
  - Collaboration led to lasting friendships
- Honed skills that many of us already had.
- Construction tools
  - Melissa, Aubrie…learned how to use power tools
- Critical Thinking - we failed more than once and learned from our failures how to reach success
WORKS CITED


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