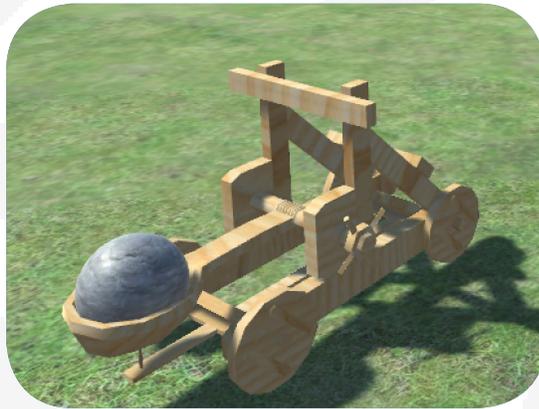


1.2

Investigate the Energy Involved in Launching a Cannonball from a Catapult

Steps:



Your catapult with energy data

Step 1: Open lesson 2 and investigate the relationship between mass, force, and energy [5 minutes]

Step 2: Describe how the law of conservation of energy explains how energy is transferred from the catapult to the cannon ball [5 minutes]

Step 3: Use a kinematic equation to find the acceleration of the cannonball [15 minutes]

Step 4: Open the Boxes Free Play and find the potential energy value you need to knock down all the boxes [10 minutes]

Lesson Length:

60 Minutes

Overview:

You will begin by opening lesson two and looking at how the mass and force sliders you used in the last lesson affect the energy involved in a catapult launching a projectile. When you've used your sliders to change the energy being used in your catapult, you will launch the ball and track the energy associated with the ball through its arc between the catapult and the ground. Using the law of conservation of energy, you will explain how energy is used and transferred by the catapult. Using one of the kinematic equations, you will be calculating the acceleration of your cannonball for two different sets of mass and force values. When you have finished with the lesson, you will move on to the boxes free play activity and track the energy needed to knock down all the boxes.

Project Outcome:

The player will be able to explain the relationship between mass, force, potential energy, and kinetic energy. Players will use kinematic equations to find the acceleration of a cannonball launched from a catapult. Using what they've learned, they will find the optimal mass, force, and energy needed to knock down a stack of blocks.

Note: The law of conservation of energy and the kinematic equations can be found in the Formulas and More document.

Learning Objectives:

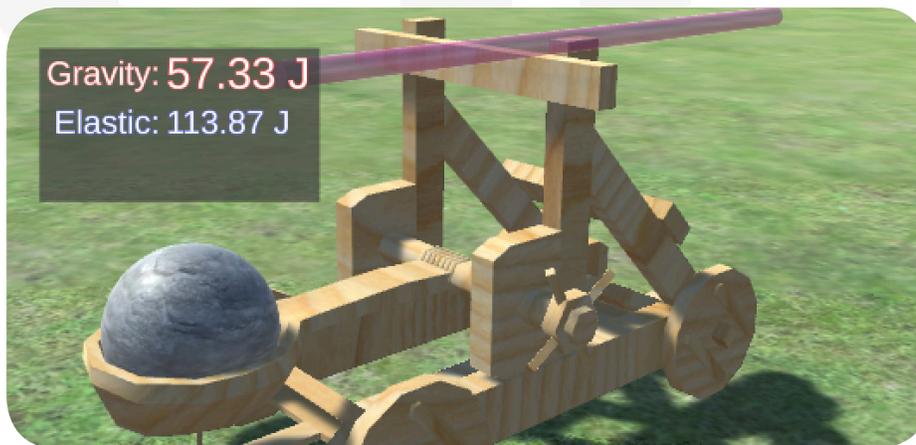
By the end of this lesson, you will be able to:

- Adjust the mass of a cannonball and the force being used to launch it and understand the relationship between mass, force, and energy.
- Understand the relationship between elastic potential energy and kinetic energy.
- Understand the relationship between the kinetic energy involved in the launch of a cannonball and the gravitational potential energy that a cannonball gains as it travels higher.
- Explain the relationship between the law of conservation of energy and the way a catapult launches a cannonball.
- Use kinematic equations to find the acceleration of a ball as it launches from a catapult.

Step 1: Open Lesson 2 and experiment with force and mass

Use the Cannonball Mass and Spring Force sliders to adjust the energy being used by your catapult:

1. Click on the *Lesson 2* button and then proceed to the *Step 1* button.
2. Use the two available sliders to configure the mass and force settings of your catapult and observe how the elastic and gravitational energy values change.
3. Click on the *Proceed to Step 2* button and observe how gravitational potential energy changes as the arm on your catapult rises.
4. Click on the *Proceed to Step 3* button and observe the energy involved in launching your catapult.
5. As you continue, watch as the gravitational potential energy changes as the cannonball progresses through its arc.



Step 2: Add the Player, Animals, and Food

As you repeat the three steps in the lesson, look at the way energy is being transferred and used:

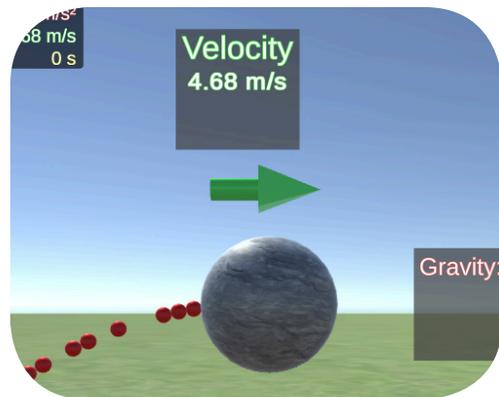
1. Click on the *Lesson 2* button and proceed through the first two steps. Pay attention to the energy values as the arm starts moving.
2. Note the difference between the elastic energy being used to lift the arm and the kinetic energy that is put into the cannonball.
3. On your worksheet, explain how the law of conservation of energy explains the energy values through the launch of your ball. Adjust the XYZ scale of the food so you can easily see it from above.



Step 3: Get the user's horizontal input

Pick two sets of values for your cannonball mass and spring force:

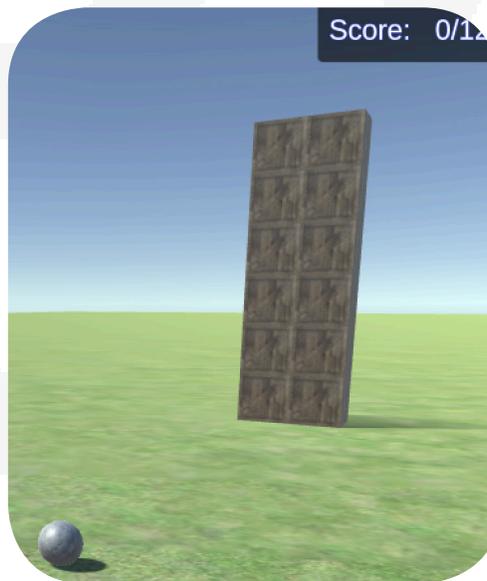
1. After you've picked your first set of values, record the distance your ball travels and the velocity of the ball at the top of its arc.
2. Using the distance and velocity you recorded and the kinematic equations, calculate the acceleration of your ball from its resting position to the top of its arc.
3. Using the distance and velocity you recorded and the kinematic equations, calculate the acceleration of your ball from the top of its arc to the ground.
4. Repeat the process using a different set of values for your cannonball's mass and spring force.



Step 4: Open the Boxes Free Play and knock

Find the energy values you need to knock down all 12 boxes:

1. Click on the *Free Play [Boxes]* button.
2. Experiment with the *Cannonball Mass* and *Spring Force* sliders until you can knock down all the boxes.
3. Find a way to knock down all 12 boxes with the lowest possible cannonball mass.
4. Find a way to knock down all 12 boxes with the lowest possible spring force.



End of Lesson

Recap Key Concepts :

- Potential energy, kinetic energy, gravitational energy, kinematic equations, law of conservation of energy

Key Skills

- Using sliders in Unity to manipulate mass and force variables
- Applying the law of conservation of energy to a catapult
- Using datapoints collected from Unity and kinematic equations to calculate acceleration

Extension Challenge ideas:

- Explain how Newton's three laws of motion apply to the catapult through each stage of the cannonball's launch
- Explain the forces acting on the cannonball after its launch
- Using Hook's Law, calculate the extension of the catapult's spring based on the Spring Force value when the cannonball launches at the end of step 2