Unit 5 (Work & Energy):
Measuring Elasticity

Concept

Forces Cause Change
The distance a rubber band stretched per unit of force is its elasticity.

Content Objective

Student teams determine the elasticity of three different rubber bands and then use one of those rubber bands to find the weight of an object.

Language Objective

Internalize new academic language through meaningful usage.
Explain energy changes using complex sentences and verb phrases based on previous learning.
Discuss projectile motion and energy using different vocabulary and parts of speech: *elastic, elasticity*.

Standards

- **NGSS:**
  - **5-PS1-3:** Observe and measure to identify materials based on their properties.
  - **5-PS1-4:** Investigate whether mixing two or more substances results in new substances.
  - **3-5-ETS1-1:** Define a simple design problem, including criteria for success and constraints on materials, time, or cost.
  - **3-5-ETS1-2:** Generate and compare multiple solutions based on criteria and constraints of the problem.

- **TEKS:**
  - **3A** Students will analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing.
  - **3D** Students will connect grade-level appropriate science concepts with the history of science, science careers, and contributions of scientists.
  - **5A** Students will classify matter based on physical properties, including mass, magnetism, physical state (solid, liquid, and gas), relative density (sinking and floating), solubility in water, and the ability to conduct or insulate thermal energy or electric energy.
  - **6D** Students will design an experiment that tests the effect of force on an object.

- **ELPS:**
    - **1A** Students will use prior knowledge and experiences to understand meanings in English;
    - **1E** Students will internalize new basic and academic language by using and reusing it in meaningful ways in speaking and writing activities that build concept and language attainment.
    - **2G** Students will understand the general meaning, main points, and important details of spoken language
    - **3B** Students will expand and internalize initial English vocabulary by retelling simple stories and basic information represented or supported by pictures.

Materials

Investigation Materials

- A washed and shrunken stocking, tube top, woolen glove, or other clothing item (optional)
- Packages of rubber bands, three different standard sizes (try to get types that are quite different in thickness and length)
- One paper clip (or “S” hook) per apparatus
- Apparatus with ruler to hang rubber bands and weights (see suggestions below)
- Set of prepared weights from 5 ounces to 5 pounds, or use metric weights in grams or kilograms, converting to Newtons using 0.1 kilogram as an approximate equivalent of one Newton
- 1 wood craft stick
- Mystery weight, something you can hook with a paper clip. For example, fill a baggie with pebbles to make a weight of 2.5 pounds
- Scale to confirm weight of unknown in pounds or ounces Safety goggles for each student
- Calculators to compute averages
- Copies of Handout **5.5.1**

Literature Connections

Plastic Man comic book series by Jack Cole

BACKGROUND INFORMATON

What is Potential Energy?

First, what is energy? Energy is defined as the capacity of matter to perform work as a result of its motion, its position, or its internal state. *Kinetic* energy is energy of motion. *Potential* energy, then, is energy of position or internal state. A bucket of water above a well, with its rope wound around an axle, has potential, or *stored* energy that will be released when the rope unwinds. The chemical energy in fuels and batteries is potential energy also.

Forms of Stored Energy

Elasticity Springs, including rubber bands, return to their original shape and dimensions after experiencing a load that changes their shape. This is elasticity. Within their intended range of performance springs continue to be elastic. If too much of a load is put upon springs, they deform and are no longer elastic.

Gravitation A body on the earth's surface works against the gravitational field to stay upright. Moving the body to a higher height causes an increase in potential energy.

Chemical Energy Fuels and food are forms of chemical energy. Calories, for example, are units of energy, specifically the amount of energy needed to change the temperature of one gram of water by one degree Celsius. The calories in your apple are potential energy that is released when the apple is consumed.

Children's Ideas About Energy

Keep in mind that most students—even through high school—do not understand that energy is conserved. For example, in an electrical circuit, energy is not "lost" as a light bulb burns; the energy simply changes to heat and light and then dissipates. It only is "used up" in the sense that WE can't further use the heat or light, but the energy is not consumed. It is difficult to prove this also when potential energy is changing into kinetic energy, because you cannot see it. The big idea that you CAN help children understand while they are still learning concretely is that potential energy is stored energy, then go on with some interesting ways to study and use it.

More About Springs

The shape, material, and elasticity of a spring depend upon its intended use. Springs to close doors are *extension springs*: they stretch open and their elasticity pulls them closed (and the door with them); springs to push staples along in your stapler are *compression springs*: they are squashed, then they apply a force along the staple row. Springs are made in many other shapes for a variety of uses. When engineers need a machine component that will push or pull and then return to its shape, they get the precise measurements of the distance to be covered and the force to be applied, then they use a standardized table to find the spring they need.

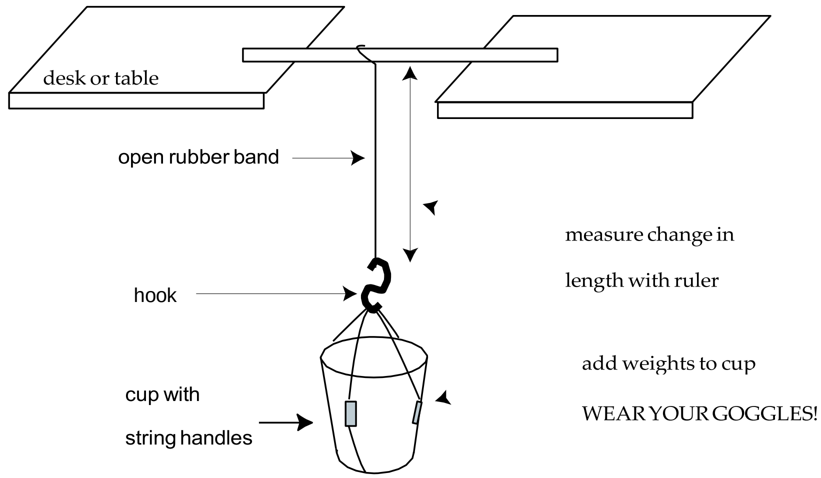
Measuring Elasticity

We determine elasticity or *stiffness* by measuring the change in length of a spring or rubber band as force is applied. The elasticity is expressed as force divided by masses in Newtons (metric force units) you express the elasticity in Newton-meters. The stiffness in the spring, then, is tied to the potential energy in the spring. If you utilize that stiffness to launch a projectile, the distance traveled depends on the stiffness and, therefore, potential energy of the spring.

Children can carry out an investigation with rubber bands to determine elasticity. Since rubber bands are not designed to stretch with precision, and they can lose elasticity, you will need to find packages of rubber bands that are fairly uniform and then, if you are

a stickler for accuracy, change out the rubber band every time a new weight is applied.
Ideally, children will see a proportional relationship between force and distance. In other words, if a one-pound weight stretches the rubber band one inch, then a 2-pound weight will stretch the rubber band two inches distance. For example, if a spring stretches from 9 to 9.5 inches when a force of 10 pounds is applied, we say the elasticity is 20 pound-inches (10 pounds force divided by the 0.5 inch stretch). If you are using

Preparation If necessary, prepare a set of weights to use in the investigation; also, set up one or more sets of elasticity measuring equipment. Here is an example:



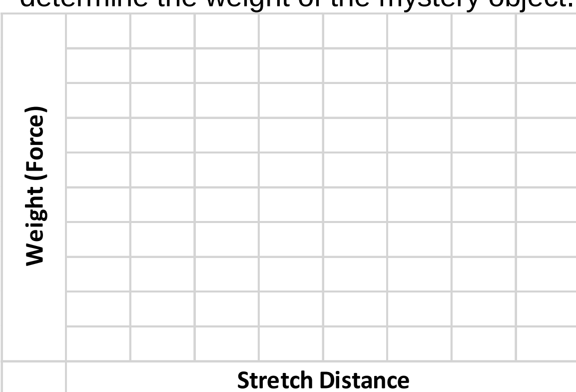
Day 1: Engage *Work & Energy- Measuring Elasticity*

Teacher Says/Does	Student Says/Does	Language requirements
1. Hold up the shrunken article of clothing (see materials list). Ask the students if they think you can use the article again. If they have had some experience with elasticity, they may know you can stretch the clothing back out to its proper shape. Use the word *elastic* to talk about things that stretch or shrink but then return to shape. Write the words *elastic, elasticity* and *stored energy* on the board. 2. Ask the children if they think the sweater (or other) has energy stored in it. Can they think of other stretchy things that store energy till it's needed? Think about cars or propellers driven by rubber bands. Demonstrate the following: Have a child hold up two fingers, one from each hand. Stretch a rubber band between the fingers. Weave a wood craft stick in the center of the rubber band and wind it up. Let it go and the stick will spin. The rubber band stored energy until you released it. 3. Look around the room for other types of stored energy, such as things that stretch, objects in raised positions (coat on a coat hook) or objects with chemical energy such as batteries. 4. Ask students if they think it is important for engineers and other designers to know exactly how much something stretches? Tell students to listen as you read them a story and that their job is to help you finish the story. Say "**For her birthday, *Jessica* wanted to do something crazy. She had been learning about elasticity in class and she wanted to go bungee jumping! (Project an image of a person preparing to bungee jump.) She was worried though. If the designer was wrong about the length of the stretched cord, what might happen?"** Have students share possible outcomes if the cord stretched longer or shorter than	Students share their ideas with the whole group. Students discuss their ideas. One student helps with the teacher demonstration. Students share their ideas with a partner.	Vocabulary terms ***Brick words:*** *elastic, elasticity, stored energy, bungee cord, spring scale* ***Mortar words:*** *apparatus, graph, plot*

predicted. Ask if there is a way to measure the amount of elasticity in the rubber bands and have students share ideas with a partner		

Day 2: Explore/Explain *Work & Energy- Measuring Elasticity*

Teacher Says/Does	Student Says/Does	Language requirements
1. Explain that students will be testing elasticity of three different rubber bands, much like the designer of the bungee cord. Have the students help set up the apparatus they will use to measure the elasticity of the three rubber band types. 2. Give each team of students a copy of "*Rating Rubber Bands"* (**5.5.1**) handout so they can begin their investigation. Please be sure students wear safety goggles to protect their eyes from flying hooks or weights if rubber bands snap! 3. While the students are working, use the **Collaborative Dialogue Template** (p. 32 Teacher Handbook) to guide conversations and take a running record of students' progress on content and language objectives. 4. If your class has experience with line graphs, help them set up graphs such as this and plot the points. When teams have completed their measurements, they are to use a rubber band to determine the weight of the mystery object.	Student teams test the elasticity of the three rubber bands. While they conduct the tests, they plot the elasticity measures on a line graph.	



Day 3: Elaborate/Evaluate *Work & Energy- Measuring Elasticity*

Teacher Says/Does	Student Says/Does	Language requirements
1. After the students have plotted the results of the three rubber bands, ask the following questions: • How were the results from the three trials different? • Would they say their rubber bands make dependable weighing devices? Why or why not?	Students discuss their ideas in small groups and then share with the whole group.	
2. Show students a spring scale. Ask: How does it work? After giving students think time, have them sketch their understanding of how the spring scale works.	Students draw their ideas of how the spring scale works.	
3. Have students share their ideas in a whole group discussion until arriving at the following conclusion: The spring in the spring scale has a known elasticity, or *spring value* that can reliably determine weight.	Students discuss their ideas in the whole group.	
4. Students write questions and answers for a test. The questions should reflect an in-depth understanding of the vocabulary for the unit.	Student pairs write questions and answers for a test of the information from the unit.	Complex sentences: Based on your different trials, The line graph demonstrated ______, which helped illustrate ________________.

Rating Rubber Bands

Find out how much *elasticity* the three types of rubber bands have.

1. Cut each rubber band to be tested. Tie one end on the support and tie a hook on the other end.
2. Measure how much the rubber band stretches when you add a series of weights.
3. Repeat each measurement for a total of three times to be sure you are correct. Take the average of the three measurements (add them up and divide by three). Use the same weights for each rubber band type.
4. Write your data in the chart below.

Weights tested	Average stretch of Rubber Band Type A	Average stretch of Rubber Band Type B	Average stretch of Rubber Band Type C

- To find the elasticity rating of each rubber band, divide the weight by the stretch.
- For example, if three pounds of weight stretches the rubber band 2 inches, the elasticity is **3 divided by 2**, or 1-1/2 **pound-inches**. (If you are using metric measurement, divide Newtons by meters).

5. Now, select a rubber band (A, B, or C) and hang the mystery weight on it. Using your data to help you, predict the weight! Then check with the teacher to find out how close you are