What is a Newton (N)?
Or Neil Armstrong Shoots a Bow and Arrow on the Moon

Grade Level: 8
Subject Areas: Physical Science
Duration: 30-45 minutes plus a homework assignment of 10-15 minutes
Group Size: Any
Setting: Classroom
Standards Connections: Physical Science, Forces, 2 a, b, c, d

Objectives

Students will be able to:

- Describe the difference between mass and force
- Identify a tool which measures mass and a tool which measures force
- Identify two forces (gravitational force and elastic force) which can act on an object, and whether these forces do or do not change in different places

Summary

- Students hear a funny story about measuring mass and force on the moon.
- Students build their own basic bows, or use a manufactured bow.
- Students measure both the forces of gravity and elastic due to tension and compression using their bow and a spring scale

Materials

- Mechanical balance scale or triple-beam balance scale, grams (one for the class) (Possible Source/Reference: www.northshorecare.com, Ohaus Triple Beam Balance).

- Pull-spring scales, grams and newtons, 5,000 gram/50N (One scale per three students). (Possible Source/Reference: Carolina Science catalogue or www.carolina.com, Ohaus Spring Scale, grams/newtons. Item #: FA-70-2062 Range: 5,000 x 100g and 50 x1N)

- 12" / 30cm ruler

- NASP (National Archery in Schools Program) archery equipment, (One bow per three students).

- Or Make your own simple bows, using the Make Your Own Bow Activity. See CalNASP coordinator for a copy of this activity.

- Take Home Quiz

- Story: "Neil Armstrong Shoots a Bow and Arrow on the Moon", one copy per student

Background

What is a newton (N)?

Answer: The SI (International System of Units) unit of force. A force of one newton will accelerate a mass of one kilogram at the rate of one meter per second per second. The corresponding unit in the CGS system is the dyne; there are 105 dynes in one newton.

In traditional English terms, one newton is about 0.224809 pounds of force (lbf) or 7.23301 poundals. The newton is also equal to about 0.101 972 kilograms of force (kgf) or kilopond (kp). The newton is named for Isaac Newton (1642-1727), the British mathematician, physicist, and natural philosopher. He was the first person to understand clearly the relationship between force (F), mass (m), and acceleration (a), expressed by the formula $F = ma$.
From: http://www.unc.edu/~rowlett/units/dictN.html

A newton (N) measures magnitude of force. In order to understand what a newton is, students must first understand what it is not; a newton is not a measure of mass. Mass is measured by grams, using a balance scale, and force is measured in newtons, using a spring scale. This difference in mass and force, and how they are measured, will be made clear to students in this activity.

Mass is defined as the amount of matter that makes up an object. Mass is accurately measured using a balance scale. The story in this activity gives the hypothetical situation of Neil Armstrong using a balance scale on the moon. He measures the mass of different objects, and sees that the mass is the same on Earth and on the moon.

That is because the same amount of gravity that is affecting the object being weighed is also affecting the weights which the objects is being balanced against.

Force is defined as a push or a pull on an object. Force is accurately measured using a pull-spring scale. A spring scale measures the magnitude of a force, such as gravity, that is being exerted on an object. Force is measured in newtons (N). In the hypothetical scenario of this activity, the forces we will be dealing with are gravity and elastic force (tension and compression) from a bow. The elastic force (tension and compression) of the bow does not change on the moon. The elastic force of an object is a property of the matter of which the object is made.

Some students may ask about friction in the form of air pressure on the moon. Because there is no air on the moon, and no atmosphere, there is no air friction acting on flying objects on the moon. We will not be dealing with the force of friction in this activity because it is not a factor with flying objects on the moon.

So what does change on the moon? What changes is the magnitude of the force of gravity. The magnitude of gravity is measured by the spring scale, not the balance scale.

Pedagogical Approach

Before beginning this lesson, students should have studied mass and matter, and understand how mass is measured and how weight is measured.

Students should understand that mass is a measurement of how much matter is in an object, and is expressed in grams (g), while weight is a measure of the magnitude of gravitational force pulling on an object, and is expressed in newtons (N).

What this activity will help you do is show the students the difference between how mass is measured and how force is measured, and why we need to use different units and tools to measure each one.

An important tool for this activity is the balance scale, because it will give a good visual representation of how mass is measured. An image of a balance scale will suffice. The balance scale you use does not need to be functional, but it does need to clearly illustrate that when the mass on one side equals the mass on the other side, the scale will balance. The balance scale can be a large, exaggerated picture. It will be used as a visual aid when telling the story. Read the story "Neil Armstrong Shoots a Bow and Arrow on the Moon" before making your balance scale. The story will give you an idea of what might work for you if you do not have a true balance scale. Students will not be using the balance scale for any tests; it is simply used to illustrate a concept.

The spring scale is something the students will be using for their tests. This spring

scale measures newtons, so it is very important to this activity. Students will do experiments with the spring scales, testing their bows.
Any type of bow will suffice for this activity, even hand made bows created by the students out of sticks and string. The bow is important because it is a great tool to illustrate the concepts of elastic force. The bows need to withstand having the string pulled away from the bow to 25 centimeters (10 inches).

Procedure

1. Prepare students by giving them the definitions for the following words:

   A. force
   B. newton (N)

2. Tell the students the humorous, hypothetical story: "Neil Armstrong Shoots a Bow and Arrow on the Moon." Use a balance scale, a spring scale, and a bow as props while you tell the story. Give each group of three students a spring scale. They will use it during various parts of the story. Demonstrate the movements described in the story with as much humor and imagination as you can, or you can have one of the students act it out.

Imagine that you are Neil Armstrong, the first person to set foot on the moon. You have brought a bow and arrow with you to the moon. You really had to be sneaky because no one really knows what will happen if you shoot an arrow out of a bow on the moon. Before you, no one has even been to the moon — they have only dreamed about it! While you are waiting for your partner, Ed "Buzz" Aldrin, (the second person to set foot on the moon), to exit the landing module, you decide to do a couple experiments of your own. You take out your bow and arrow, your balance scale, and your grams/newtons pull spring scale, and begin to investigate a few things.

You can feel that there is less gravity on the moon. When the scientists back on Earth stood you on the Super Balance Scale (INCLUDE CLIP ART OF A BALANCE SCALE) wearing your space suit and gear, the scale showed 159 kilograms (350 pounds)! On the moon there is one-sixth the gravity. It is a strange sensation! You bounce around for a few minutes – laughing out loud (it is a good thing you turned down the micro-phone volume on your communicator). You put the Super Balance Scale down in the moon dust. When you step on the balance scale, you should have one-sixth the mass as on Earth. You step up on the balance scale, and … what? You still have the same mass, 159 kilograms (350 pounds)!

Ask your students: "What is happening?"

The force of gravity that is affecting you is also affecting the weights on the scale. You still have the same mass; the same amount of matter within you, whether you are on the moon or Earth.

Oh, wait! You remember! You still have the same mass on the moon as you do on Earth. You still have the same amount of matter making up your body.

You take out your bow, and set it on the Super Balance Scale. On Earth, when you set the bow on the balance scale, the scale measured 1.4 kilograms, or 1400 grams (3 pounds). You set the bow on the balance scale, and sure enough, the scale still measures the bow at 1.4 kilograms, or 1400 grams. The bow has the same mass.

Now you decide to do some tests with the spring scale. You hold up the spring scale, and pull the hook at the bottom with your finger to test it out. (*Tell the students to test their spring scale)* It still works! You hang the bow by the middle of the string on the spring scale.

On the moon, there is one-sixth the force of gravity pulling on the object. You hang the bow by its string on the scale, and it is only being pulled by one-sixth of the gravitational force of what it is pulled by on Earth. It only weighs 233.3 grams (0.5 pounds).

Ask students to look at their spring scale. How many newtons is 233.3 grams? Answer: About 2.2 newtons of force.

Force is measured in newtons. The force of gravity pulling on the bow on the moon is 2.2 newtons of force. Now, you are going to see how far you can shoot the arrow! You look around to make sure "Buzz" isn't out of the lander yet. First, you are going to test the force of the bow. You hold the bow up, as if you are going to fire an arrow, but instead of notching an arrow, you put the hook of the hanging scale around the middle of the string. When you did this on Earth, you pulled the string back 25 centimeters (approximately 10 inches) from the grip, and the scale measured 5 kilograms, or 5000 grams (11 pounds). You pull the string back 25 centimeters (~10 inches) from the grip, and, sure enough, the spring scale measures 5 kilograms, or 5000 grams (11 pounds).

Ask students to look at their spring scale. How many newtons of force is 5000 grams? 49 newtons

The elastic force of the bow is 49 newtons when it is pulled to 25 centimeters. The elastic force of the bow is the same on Earth as it is on the moon. Knowing this, do you think the arrow you shoot on the moon will travel a longer distance or shorter distance than the arrow you shoot with the same bow on the Earth? (*Accept any student answers at this time)*

Let's look at forces.

3. Give each group of three students a bow (or have them make their own simple bows using the Make Your Own Bow Activity).

4. Have the each group measure the force of gravity on their bows by hanging the bow from the spring scale, just as Neil Armstrong did in the story. Have students hang their bows by the middle of the string on the spring scale. Have students report the force of

gravity on their bows, reporting their results in newtons. Write each group's result on the board.

5. Have each group measure the elastic force of the bow. One student hooks the spring scale on the middle of the bowstring. Have that student draw the bowstring to 25 centimeters (10 inches) from the bow by pulling on the spring scale hooked to the string. (If students cannot pull to 25 centimeters, or if the handmade bows cannot be pulled that far, have students pull as far as they can) Have a second student in the group measure the distance of 25 centimeters (10 inches) from the bow to the bowstring. The third student can read the spring scale. Ask the students to report the elastic force of the bow in newtons. Record the data for each group on the board.

6. Ask the class: If you took your bows to the moon, and you shot an arrow out of your bows, what two forces would be acting on the arrow?

Answer: Force of gravity, from the moon, and elastic force, from the bow. Write these two forces on the board, separated by a line, with room to write underneath each force.

7. Ask the class: Which force would be the same on the moon?

Answer: Elastic force. The elastic force of the bow is the same.
On the board below elastic force, write same.

8. Ask the class: Which force would be different on the moon?
Answer: The gravitational force is less, one-sixth of the gravitational force of Earth.
On the board below gravity on the board, write 1/6.

9. Is the arrow going to fly longer or shorter distance on the moon?
Answer: Longer.

10. Can we estimate how much farther the arrow will fly on the moon, compared to Earth?
Answer: Yes, approximately 6 times farther.

Assessing Objectives

Review of objectives:
-Describe the difference between mass and force
-Identify a tool which measures mass and a tool which measures force
-Identify two forces (gravitational force and elastic force) which can act on an object, and whether these forces do or do not change in different places

Give students a copy of the *Neil Armstrong Shoots a Bow and Arrow on the Moon.* As homework, have students complete the take home quiz (student quiz provided). Students may use the story to answer questions on the quiz.

Take Home Quiz

(Teacher's copy with answers)

Describe the difference between what a gram measures and what a newton measures?

Answer: A gram measure mass. Mass is the amount of matter that is in an object. A newton measures the magnitude of force acting on an object. Force is a push or pull on an object.

Identify a tool which measures mass: A balance scale

Identify a tool which measures force: A spring scale

If Neil Armstrong shot an arrow on the moon, what two forces would act on the arrow?

Force of gravity from moon, and elastic force from bow.

Would either of these forces change if he shot the same bow and arrow on Earth?

Yes. Which one? The force of gravity

Extensions

Using the NASP (National Archery in Schools Program) curriculum and equipment, have students shoot actual bows and arrows. See NASP Curriculum supplemental for archery activities related to Physical Science.