Science Experiment: Straight as an Arrow Project: Shooting Sports

Introduction:

You've probably heard the expression, straight as an arrow. But, do arrows really travel in a straight line? We will be exploring this through this project.

Materials:

Prepare a bag of materials for each team of 2-3 youth to work with. Recommended items:

• Large craft sticks, 3 • Small craft sticks, 2 • Rubber bands, 3 • Coffee stirrers, 3 • Drinking straws, 3 • Dowel rod, 1	• Paperclips, 4 • Piece of string, 2 • Wood stirrers, 2 • Cotton swabs, 2 • Stiff paper • Marker

Challenge:

1. Build a ***prototype*** bow and arrow using only the items in your bag.
   Suggestion: talk about the materials that you have, sketch your design, and come up with a plan before you start building your bow and arrow.
2. Make a target with the paper and marker
3. Use your bow and arrow to aim at the center of the target at 1, 3, and 5 feet.
4. Make alterations to your prototype bow and/or arrow to improve its performance.
   a. Choose new materials or make changes to your bow and/or arrow.
5. Use your bow and arrow to aim at the center of the target at 1, 3, and 5 feet, first by aiming your arrow at the target before your draw and then by aiming your arrow at the target at full draw.
6. If time allows, redesign your prototype bow and/or arrow one more time. You may find additional materials if you wish. Make the same observations as before.

Discussion:

1. It takes *energy* to move an object. For example, when you throw a ball you are using your energy and transferring it to the ball. The distance that the ball travels depends on your aim and strength. The ***trajectory*** of the ball – path it follows – depends on your technique. The bow and arrow work in the same way. You use energy to pull back the bow string. When you release the string, energy is transferred from the string to the arrow which flies through the air. The distance that the arrow travels and its trajectory will depend on your aim, strength, and technique. You can improve these with practice and a knowledge of basic engineering principles.

2. Shooting an arrow requires different types of energy. The archer supplies the initial energy by drawing the bow. The limbs of the bow provide elastic *potential energy* as they are pulled back by the bow string. The energy that the arrow has is called *kinetic energy* – the energy of motion.

3. There is another consideration involved in shooting an arrow: the "archer's paradox." The term archer's paradox refers to the fact that an arrow must bend around the bow and flexes in a wave-like pattern until it hits the target.

STEM Chat:

- ***Share What Happened –***

1. What did you learn about how arrows travel?
2. Did the distance to your target matter? (Did the arrow take a different path at 1, 3, and 5 feet?)
3. Describe the trajectory of your arrow when you shot it.
4. How could you graph the data you collected today?
5. How do you think the "archer's paradox" affected your results?

- ***Apply –***

1. How can studying arrow design and trajectory help your shooting in any discipline?
2. Why is trajectory important in every shooting sports discipline?

- ***Generalize to Your Life***

1. Where could making a prototype and testing your design be useful in areas other than shooting sports?
2. What is involved in the transfer of energy for:
    - A car driving down the road?
    - A sailboat?
    - A marathon runner?

Glossary:

Draw – the process of pulling a bow string back

Kinetic energy – energy of motion. Example: a ball or arrow traveling through space. The kinetic energy will diminish until the ball or arrow stops.

Potential energy – energy of position. Example: a bowling ball that is dropped from a ladder will make much more of an impression than if it is dropped from a height of six inches due to its potential energy.

Prototype – original or first test models, created before production models are made

Trajectory: path along which something moves

Facilitator Information:

- See the You tube video, Smarter Every Day, # 136, www.youtube.com/watch?v=O7zewtuUM_0, for a better understanding of the forces working on the arrow.

- An arrow must flex around the bow as it is shot and then oscillates back-and-forth as it travels toward the target. Although an arrow seems rigid to the naked eye, in reality it bends and flexes when placed under the pressure of an accelerating bowstring and the lateral displacement caused by the bowstring sliding sideways when released from the fingers of the archer. The action in the bowstring accelerates the arrow in two directions: both sideways off the fingertips and forward towards the target. The arrow flexes in proportion to the force due to inertial resistance, primarily due to the weight of the tip, which is heavier than the shaft of the arrow. Newton's Law of Motion helps describe the flight of the arrow: for every action there is an equal and opposite reaction.

- The trajectory of an arrow is complex. The spine (stiffness) of the shaft, the weight of the tip, the strength of the bow limbs, the tension of the plunger, and the fingers motion all serve to determine how much bend will occur during flight. Experience and testing is critical: the spine for a given bow must be neither too stiff, nor too weak. Otherwise the arrow's tail end where the fletchings/vanes are strikes the bow and is deflected.

This lesson and more can be found at: https://extension.purdue.edu/4h/Pages/volunteerResources.aspx