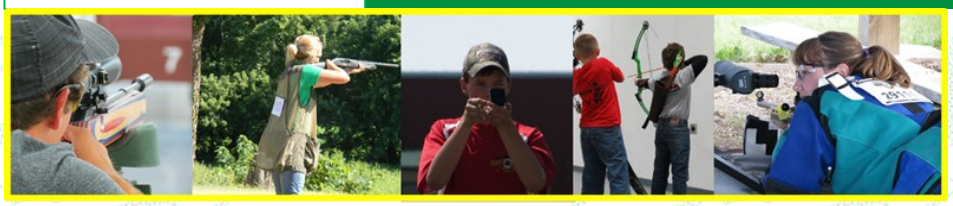


NATIONAL SHOOTING SPORTS LEARN BY DOING

Arrow Design & Velocity

Discipline: All
Age Level: All
Time: 90 minutes

Next Generation Science Standard : 3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

4-PS3-1 Energy: The faster a given object is moving, the more energy it possesses. Energy can be transferred in various ways and between objects.

MS-PS3-5 Energy: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Author: Michelle Simmons & Troy Cooper, Utah State University

I pledge my... Head Heart Hands Health 18 U.S.C. 707 ...To Make the Best Better.

Objective/Success Indicators: Youth will understand how velocity affects distance.

Assessment Question: Which arrow will travel the farthest down range when shot by the same person from the same bow?

Supplies:

3—1/4 inch dowel rods, 3 ft. long
3.5 ft. nylon braided string
1– 1/2 inch PVC pipe, 4 feet long
Scissors
Hacksaw
Permanent marker (to number arrows)
1—6 inch section of 3/4 inch foam pipe insulation
Duct tape
3 cap eraser (for pencils)
1 copy of Handout/team
100 ft. measuring tape

Lesson Outline:

1. Divide youth into three groups. Each group will have a job to do, and each group may nominate one member to be a shooter when the experiment is conducted.

2. Have one group assemble the PVC bow, using the Bow Assembly instructions. Have the second group design and assemble 3 sets of fletchings using duct tape and scissors. (Each arrow will need a set) Have the third group assemble the arrows, using the Arrow Assembly instructions.

3. When all the groups are completed with the assembly of the equipment, have them inspect the equipment, and then as a team, make predictions about which arrows will travel farther down range, along with any other notes, and write them on their data chart.

4. Have each team's representative (or an adult) shoot the three arrows, taking care to make sure that they shoot from the same position each time. The teams can monitor one another to make sure that arrow placement and bow alignment is the same each time. Measure the distance each arrow travels, making certain that measurements are placed in the correct column.

5. Bring the group together for a discussion. Have each group share their predictions. Did having a different shooter change the ranking of an arrow? Did that happen with every arrow, or just a certain one? What might a shooter do that could affect the distance an arrow traveled? Do you think three shooters provide enough data to reach a conclusion? If yes, why? If no, how many shooters do you think it would take?

Now move on to the construction of the arrows. Is there a design that worked much better or worse than the others? Why do you think that is so? Consider the "worst" arrow, what could you change in the design, to make it go further?

Now discuss the terms weight, inertia, momentum and velocity and ask the teams to describe the features of the winning arrow in relation to these terms. Where did the energy the arrow needed to fly come from?

Finally, ask the youth how this information might affect the way that they care for their arrows, and what design elements are important when selecting new arrows. Is it important to inspect arrows after every practice? Why or why not?

For more on the physics of archery, watch this video and answer the following questions.

http://www.wisegeek.com/what-is-a-bow-and-arrow.htm#didyouknowout

1. What materials are used to make bows? What properties must these materials have to be useful for this purpose?

2. The force the bow can exert on the arrow depends on the bow's draw weight. What is the draw weight?

3. What determines the draw weight of a bow?

4. How do fletchings on the end of an arrow help an archer to shoot?

5. Contrast a longbow and a recurve bow.

6. Explain why a compound bow can deliver more force than a regular bow.

7. A bow with a sight system allows an archer to shoot more accurately. How does a sight system work?

This video explains more about the physics of Archery:

http://www.ck12.org/physical-science/Potential-Energy-in-Physical-Science/rwa/Physics-of-Archery/

Background Information:

Weight—a function of gravity (9.8 meters/second^2). Objects with a higher mass will weigh more than objects with a lower mass. Would an arrow's weight be greatly affected by adding or subtracting the number of fletchings?

Inertia—a measure of resistance of a body to change its motion.

Momentum—this is mass in motion. Mathematically, it is mass X velocity.

Velocity—is speed, measured in meters/second

- Archeologists have found evidence of bows and arrows dating back to 20,000 years ago. Since prehistoric times, the bow and arrow was used for hunting and warfare. It is still used for hunting today.
- The bow and arrow is also used in the sport of archery, in which athletes compete to shoot with the greatest accuracy. Archery is an Olympic sport.

- A bow is basically a long rod with the two ends connected by a string. The bow bends when the archer pulls back on the string. The bow can bend because it is made of an elastic material. Bending the bow gives it elastic potential energy.
- Archery is practiced as both a sport and hunting technique
- The arrow is a long, straight shaft. It has a pointed object on one end (the arrowhead) and a balancing device, such as a feather, on the other end.
- The archer holds the feather end of the arrow against the string while pulling it back. Releasing the string thrusts the arrow forward with the elastic force of the bow. The elastic potential energy of the bow is converted to the kinetic energy of the arrow.

Check out this introduction to archery video: http://www.youtube.com/user/archerytv

To learn about different types of bows and shooting techniques, watch this video.

http://www.youtube.com/watch?v=V4TVh1F46kY

http://www.ck12.org/physical-science/Potential-Energy-in-Physical-Science/rwa/Physics-of-Archery/

Bow Assembly Instructions

Step 1: CAREFULLY, cut a 1/2—3/4 inch notch in each end of the PCV pipe using the hacksaw.

Step 2: Tie a loop in each end of the nylon string and place a loop in one notch on the PVC pipe.

Step 3: Bend the PVC pip to form a curve and place the other loop in the other notch.

Step 4: Center pipe insulation in the middle of the bow, where the arrow will rest. Secure with duct tape (or zip ties) on each end and on both sides of the shelf.

Arrow Assembly Instructions

Step 1: CAREFULLY, cut a nock in the bottom of each dowel rod.

Step 2: Place cap erasers (for arrowheads) on the opposite end of each dowel rod and secure with duct tape.

Step 3: When ready attach the fletchings with duct tape and number the arrows 1, 2 and 3, writing on the fletching.

Step 4: Write a description of each arrow, including the number of fletchings, and any special notes about how you attached them to the shaft. If you like, draw a diagram explaining how each arrow's fletching was attached.

Arrow 1

Arrow 2

Arrow 1

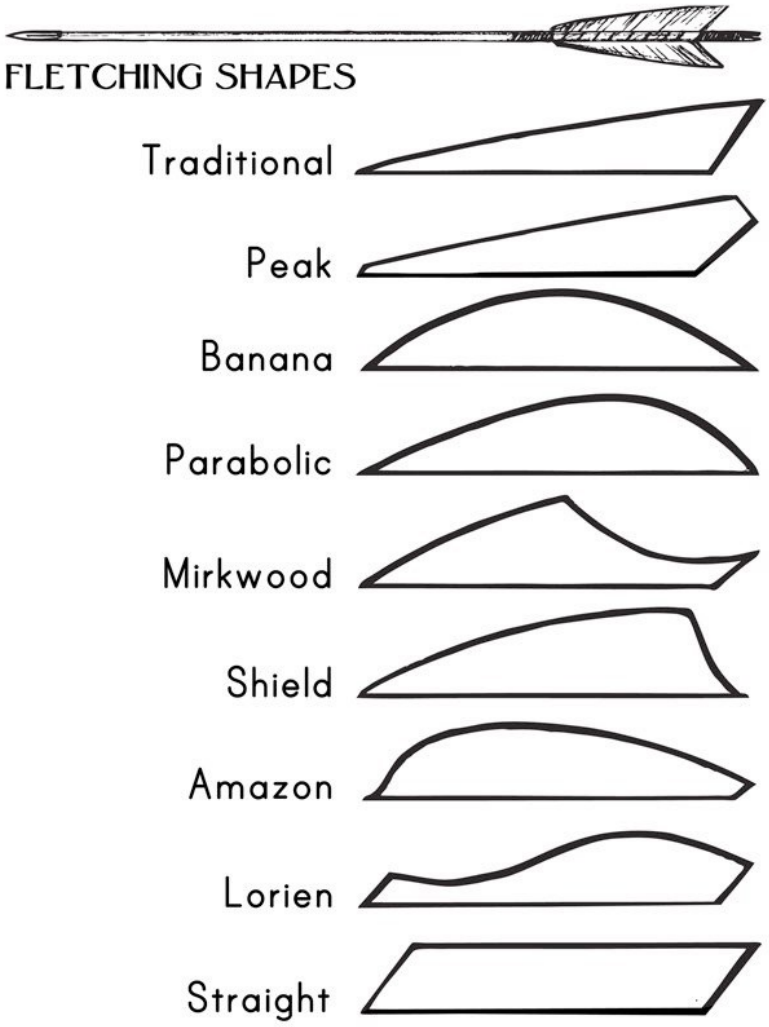
Fletching Design Instructions

Step 1: Design three different arrow fletchings. You can use different shapes or a different number of fletchings per arrow. You are trying to make the arrows fly as far as possible.

Step 2: Divide your team into three work groups and work fast on the design, so you have time to be very accurate when you cut them out.

Step 3: Send the completed fletchings to the arrow team so they can attach them to the arrows.

Here are some fletching ideas to get you started.



Drawing provided by Egan & Ives, LLC

Velocity Experiment

Purpose: _____

_____

_____

Hypothesis:

Experiment

Observations:

Analyze:

Conclusion: