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The following lesson was created by **Lauri Davis**, a teacher participating in a 2010 National Endowment for the Humanities Summer Institute for Teachers entitled, "Exploring the Past: Archaeology in the Upper Mississippi River Valley."

Investigating the Physics of the Atlatl

The lab is intended for a 9th grade Physical Science class. Routinely in Physical Science class, we study elements of everyday life and try to link them to the principles of physics. I thought it would be interesting for students to look at the development of prehistoric, Paleo-Indian weapon systems and try to link a type of weapon to the physics principles we discuss in class, such as velocity, acceleration, kinetic energy, etc… I start by having the students become familiar with the spear, the atlatl, and the bow and arrow systems by doing literature reviews and completing a paper giving detailed information on these three systems. This is followed by a experimental laboratory exercise where the students get to use a modern atlatl application (a Chuckit!© Dog ball launcher) to compare the use a an atlatl versus not using one based on simple physical principals. The students will be comparing between two different lengths of the Chuckit!© and then comparing that to just throwing the dog ball freehand. In the end, it will hopefully be clear, through the data, as to why the Paleo-Indians adopted the atlatl as a weapon.

Purpose: To gather background information on the development of the spear, atlatl, and bow & arrow. To conduct empirical studies on the physics principals involved when using an atlatl versus not using one, to try and see why the development of this weapon type was so important for the Paleo-Indian culture.

Introduction: An atlatl is a dart (or small spear)-throwing tool designed to increase distance and accuracy for hunting or warfare. The atlatl is basically a stick with a hook on one end to hold a dart and a handle on the other end that is grasped by the thrower. Atlatls were used in North America for more than 10,000 years, before being replaced by the bow and arrow.

The atlatl works by increasing the radius of rotation of the wrist, from about 6 cm for an unaided throw, to about 60 cm for a throw with the atlatl (think of the motion of a small wheel within a larger wheel; the radius of the larger wheel represents the atlatl and the radius of the smaller wheel represents the movement of your wrist). Therefore, when the same angular rotations are applied at the shoulder, elbow and wrist, the atlatl increases throwing distance. For an *experienced* atlatl thrower, the mechanical advantage of the atlatl over throwing with the arm alone is about 6:1. Thus, if you can throw a dart 15 meters with your arm alone, you could throw it about 91 meters with the atlatl. (Adapted from "The Mathematics of the Atlatl", Nishikawa & Ratliff, 2001; http://oak.ucc.nau.edu/ratliff/ccligrant/Atlatl.html)

Due to safety reasons, atlatls and darts can not be used in a school setting. Instead, we will be using Chuckit!© dog ball launchers (which is a modern day use of the atlatl technology) and tennis balls. We will be examining whether the use of an atlatl or the length of the atlatl affects various physical principals of the projectile (tennis ball), including the velocity, kinetic energy, and momentum of the projectile.

Materials:

Tape Measure   Chuckit!©   Chuckit!© Jr.   Tennis Ball   Stopwatch

Procedure:

Part A: Background Research

1. Research groups of three students will be assigned. Each group will need to gather information on each of the three weapon types (Spear, Atlatl, and Bow & Arrow). You may organize your research group anyway you see fit to complete this part of the assignment.

2. Each research group will put together one paper (typed, 12 point Times New Roman font, double spaced, no length limit; make sure you cite your information properly) detailing the following information pertaining to the above mentioned weapon types:

a. Description:
    i. Describe what each weapon is and the appearance of each weapon in detail (a diagram or picture here would help a lot!!).
    ii. Describe how the weapon is made and used (again diagrams or pictures would help).
    iii. Describe what type of prey was the primary type hunted with each weapon, including why that type of weapon was best for hunting that particular type of prey.

b. Time frame:
    i. When did each type of weapon show up in the archaeological record?
    ii. When did each type of weapon disappear from the archaeological record (if it has disappeared – if it is still in use, please describe how that weapon type is still being used, with examples, in detail).

<u>Part B: Determining the Physics of an Atlatl Style Weapon</u>

1. Collect the long (67.3 cm) ball launcher, the short (45.7 cm) ball launcher, a tennis ball with your group number on it, a tape measure, and a stop watch from the teacher.

2. Mass out the tennis ball and record mass in the space provided below:

Tennis Ball mass (g): ________________

3. In your group, assign a person to do the <u>launching</u> (you all can give it a try, but you need consistency, so choose one thrower for all three trials), another to do the <u>timing</u>, the third person can work with the thrower to <u>measure</u> how far the ball traveled when it hit the ground.

4. **Test 1:** No Launcher
    a. Determine where the Launcher will throw the ball from. Place a long piece of Duct tape on the ground at this point. Have the Launcher throw the tennis ball overhand as far as they can.
    b. The Timer must start the stopwatch when the ball leaves the Launcher's hand and stop the clock when it hits the ground. Record your <u>time</u> in the **Data Table 1**.
    c. **The Measurer must keep an eye on the ball!** Measure from the Launcher to where the ball landed in as straight as line as possible. Record your <u>distance</u> in the **Data Table 1**. Retrieve the ball.
    d. Repeat a-c two more times. Record the data in **Data Table 1**.
    e. Calculate averages for the distance and the time data and record them in **Data Table 1**.

5. **Test 2:** Short Chuckit!© Launcher
    a. From the same starting point, have the Launcher, using the short Chuckit!© to launch a tennis ball out into the field.
    b. The Time again starts the stopwatch when the ball leaves the launcher and stops it when the ball hits the ground. Record the time in the **Data Table 2**.
    c. Again, the Measurer must keep an eye on the ball! Measure from the Launcher to where the ball landed in as straight as line as possible. Record your distance in the **Data Table 2**. Retrieve the ball.
    d. Repeat a-c two more times. Record the data in **Data Table 2**.
    e. Calculate averages for the distance and the time data and record them in **Data Table 2**.

6. **Test 3:** Long Chuckit!© Launcher
    a. From the same starting point, have the Launcher, using the long Chuckit!© to launch a tennis ball out into the field.
    b. The Time again starts the stopwatch when the ball leaves the launcher and stops it when the ball hits the ground. Record the time in **Data Table 3**.
    c. Again, the Measurer must keep an eye on the ball! Measure from the Launcher to where the ball landed in as straight as line as possible. Record your distance in **Data Table 3**. Retrieve the ball.
    d. Repeat a-c two more times. Record the data in **Data Table 3**.
    e. Calculate averages for the distance and the time data and record them in **Data Table 3**.

7. Return all the equipment to the teacher.

8. Using the **average values from Data Tables 1, 2, and 3**, calculate the velocity of the projectile, the kinetic energy it possessed, the momentum, acceleration, force at impact, and the work performed by the projectile (Hint: we have already covered these properties in class, look in your notes for help). Show the math for ALL your calculations, neatly, on a separate sheet of paper. Record your answers in **Data Table 4**.

9. Answer the Analysis Questions.
10. When finished, hand in the weapons paper, this lab, the calculations sheet, and the analysis questions. Make sure your name is on all items.

Analysis Questions: (answer neatly and legibly on a separate sheet of paper)

1. Which launch method had the best average velocity? Which gave the ball the most kinetic energy? How are these two related?
2. Which launch method caused the ball to land with the most force? Why?
3. Read about the mechanical advantage of a typical atlatl in the introductory material at the beginning of this lab. Calculate the mechanical advantage for each of the launches using the Chuckit!© (short and long) by taking your average throw distance for each and dividing it by the average throw distance when no launcher was used. Did the mechanical advantages for either Chuckit!© compare to the typical atlatls? Why or why not? Show any math that helps you answer this question.
4. What type of simple machine is an atlatl? Be very specific.
5. Which of the launch types was the most *power*ful? Show the math to back up your answer!
6. Based on your research paper, where does the word "Atlatl" come from? What does it mean?
7. Based on your research paper and this lab, what conclusions can you make as to why the atlatl was an advancement over just hand throwing a spear and why the atlatl eventually was replaced by the bow and arrow (any and all theories will be acceptable, as long as they are well thought out and backed by a rational explanation).

DATA TABLES:

Data Table 1: Launch times and distances a tennis ball projectile traveled when using no launcher to throw the projectile.

	Trial 1	**Trial 2**	**Trial 3**	**Average**
Time				
Distance				

Data Table 2: Launch times and distances a tennis ball projectile traveled when using a short Chuckit!© Launcher to throw the projectile.

	Trial 1	**Trial 2**	**Trial 3**	**Average**
Time				
Distance				

Data Table 3: Launch times and distances a tennis ball projectile traveled when using a long Chuckit!© Launcher to throw the projectile.

	Trial 1	**Trial 2**	**Trial 3**	**Average**
Time				
Distance				

Data Table 4: Velocity, Kinetic Energy, Momentum, Acceleration, Force and Work done for a tennis ball projectile thrown without a launcher, with a short Chuckit!© Launcher, and with a long Chuckit!© Launcher.

	Velocity (m/s)	**Kinetic Energy (J)**	**Momentum (kg•m/s)**	**Acceleration (m/s^2)**	**Force (N)**	**Work (J)**
No Launcher						
Short Chuckit!© Launcher						
Long Chuckit!© Launcher						