BOW AND ARROW

Interactive Physics Simulation

To visit this simulation:
http://interactives.ck12.org/simulations/physics/bow-and-arrow/app/
Intriguing Question

Where does an arrow get its energy of motion?

Illustrative Video

The archer burns calories when she pulls back on the string. Energy stored in the cells in her body is used to do work on the bow. The work she does increases the elastic potential energy of the bow. When she releases the string, the string does work accelerating the arrow. The energy of motion of the arrow came from the archer herself.

To access this physics simulation visit: http://goo.gl/Cgo6VD
**Interactive Simulation**

**Force** - This slider adjusts how much force is required to pull back on the bowstring to achieve a certain amount of stretch. In this simulation, the force increases with distance in a simple way - can you see the relationship between force and distance?

**Stretch Distance** - This slider adjusts how far back the archer pulls on the string. If you pull back twice as far, it requires twice the applied force. However, more than twice the energy is stored.

**Elastic Constant** - This slider adjusts how “stiff” the bow and string feel. A higher elastic constant "k" corresponds to a bow & string that is harder to bend. Look at how the amount of force you need to pull with changes as you increase this value. Look, as well, at how the energy stored in the system increases, and how the speed of the fired arrow increases.

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**Force Vs. Stretch Distance** - This is a plot of the force applied (on the vertical axis) vs. the stretch distance (on the horizontal axis). Note that the force increases linearly with distance. The slope of this graph can be written using the familiar equation for a line "y = mx + b". In this case, y refers to the force F, m refers to the elastic constant k, and x refers to the stretch distance. Since no force is required for zero stretch, the value b = 0.

**Stored Energy Vs. Stretch Distance** - This is a plot of the energy stored in the bow-string system (on the vertical axis) vs. the stretch distance (on the horizontal axis). The relationship is not linear in this case, but parabolic. In this simple system, the value of this graph should equal the triangle area bounded by the graph on the left. In general, the work done when a force is applied is the area bounded by a force vs. distance graph.

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Interpreting Results

Adjust the sliders to maximize the stored energy of the bow and arrow system. *(Adjust the stretch distance slider and elastic constant slider so that the stored energy, as shown in the upper left graph, is at its greatest possible value.)*

Adjust the sliders so that the force applied by the archer is 9 kx. *(Adjust the stretch distance slider and elastic constant slider so that the force is 9 kx.)*

Launch an arrow with 25 kx² of kinetic energy. *(Adjust the sliders so that you store 25kx² of potential energy in the bow.)*
**Challenge ME!**

- What is the relationship between the triangular area on the force vs. stretch distance graph and the value of the stored energy?

- Does the archer do more work (expend more energy) stretching the bow from 0 to x, or from x to 2x? Or is the work done the same?

- What does doubling the value of the elastic constant “k” do to the speed of the arrow, assuming the stretch distance stays the same?

**Need Help?**

Check out the Bow And Arrow Walkthrough video at: [https://youtu.be/bnMv15xGuGc](https://youtu.be/bnMv15xGuGc)
Interesting Questions

How does a mouse trap work?
A loaded mousetrap is like a stretched bow. When the mouse triggers the release mechanism, the energy is released.

It's fun to bounce on a trampoline. How do they work?
Springs at the edge of the trampoline store and release elastic potential energy, just like the archer's bow. Instead of a shooting an arrow, the trampoline shoots you!

Why does a basketball bounce back when you dribble it?
When you drop a basketball, it briefly compresses upon impact, storing elastic potential energy. When it rebounds, this energy is released.

Does a bungee jump cord store energy in the same way?
Initially, as a bungee jumper falls, gravitational potential energy is converted to kinetic energy. When the cord starts to stretch, the jumper slows down as the elastic band begins to store energy. The band also dissipates heat energy, which is why the jumper doesn't keep bouncing forever!

Physics Concepts | Click on the link below to learn more.


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