551

Young Scientist Project Entry Form

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School Name * Glenbrook PS

Project Name * THE POWER OF BOWS

Starting date of Experimentation - 3rd March 2015

Age Section * 3-6

Category * **Scientific Investigations** only

Individual or Team entry * Individual

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MyScience 2015
The Power of Bows

Introduction

The aim of my experiment is to help hunters to know roughly how far they will shoot at certain draws. For my experiment, I used a 30lbs double recurve bow, (a horse bow) to shoot arrows at 5 different draw lengths and measure the ranges.

Hypothesis

My hypothesis is that the range of the arrow and the force required to draw the bow string are proportional to the draw length.

Background Information

Recurve Bows

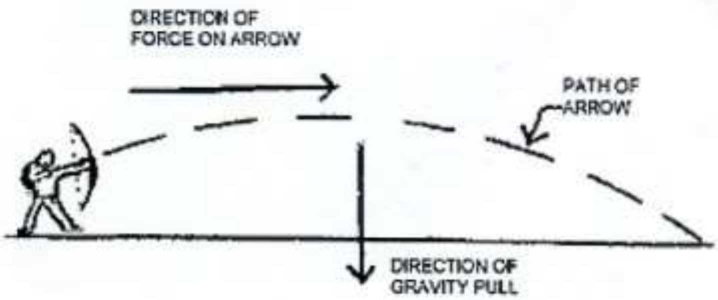
My bow is a recurve bow. Recurve bows store more energy and are more efficient than longbows, giving the arrow more speed and energy. The limbs curve away from the archer when it isn't strung. Archers generally preferred recurve bows to long bows because they were smaller and easier to carry. Unstrung recurve bows have a confusing shape and sometimes get strung the wrong way. This happened to some Native American bows that were strung the wrong way round and broken.

The Mechanics of Bows

The mechanics of bows is extremely complicated, in fact someone wrote a PhD on it (B.W. Kooi, 1983)! The theory is based on Newton's Second Law which says that the acceleration of an object is proportional to the force applied.

$$F = ma$$

In the case of a bow and arrow the force is applied by the string to the arrow causing the arrow to accelerate until it leaves the string. The speed achieved as it leaves the bow will determine how fast the arrow goes and will depend on how far you draw back the string. The further back the string is drawn, the more force is applied and the force is also applied for a longer distance before the arrow leaves the string. Both of these effects combine to make the arrow go faster and further. Newton's law also applies after the arrow is in the air. The forces acting on the arrow then are gravity, pulling it down, and drag, slowing it down. The range will be proportional to the initial speed of the arrow.



Procedure

1. Preparation:
   - Make protractor with bob to measure firing angle
   - Put marks on arrow to measure draw length
   - Place rocks at 5m intervals at firing range out to 45m using tape measure
2. Shooting – For each draw:
   - Use protractor to ensure arrow is at an angle of 30°
   - Draw arrow to required draw by lining up the mark on the arrow with the bow
   - FIRE!
   - Estimate range by using the rock markers
   - Repeat 5 times
3. Force – For each draw measure the force required to draw the string. Repeat 5 times

Risks

1. You could get shot (aim carefully).
2. Bowstring can scrape along your arm (wear vambrace).

3. The arrow can break while firing, cutting your arm (check arrow for damage before each shot and wear a vambrace).

Data Collection

Table 1 below shows the range measured for the 5 shots and the mean and standard deviation at each draw. The mean and standard deviation were calculated using Excel. The standard deviation is given as a percentage of the mean for each draw.

	Range (m)						
Draw (cm)	1	2	3	4	5	Mean (m)	Stnd Dev (%)
9	5	5	4	6	5	5	14%
13.5	14	12	12	13	12	12.6	7%
18	18.5	18	18	20	20	18.9	5%
22.5	23	32	27	26	32	28	14%
27	42	43	45	43	47	44	5%

Table 1: Range measured for each draw.

Table 2 below shows the force measured for the 5 trials and the mean and standard deviation at each draw. As above, the standard deviation is given as a percentage of the mean for each draw.

	Force (N)						
Draw (cm)	1	2	3	4	5	Mean (N)	Stnd Dev (%)
9	24	22	25	22	23	23.2	6%
13.5	38	37	34	39	38	37.2	5%
18	49	50	49	51	50	49.8	2%
22.5	61	58	57	60	60	59.2	3%
27	70	69	69	71	70	69.8	1%

Table 2: Force measured for each draw.

Data Analysis

Figure 1 below shows the range measured for the 5 shots at the different draws. The range of the arrow is quite short for the draw of 9cm. This is probably because the release of the arrow from the string requires the knock to unclip from the string which absorbs most of the arrows momentum. At longer draws the range increases more and more as the draw increases, in other words, it isn't simply proportional to draw as I thought in my hypothesis.

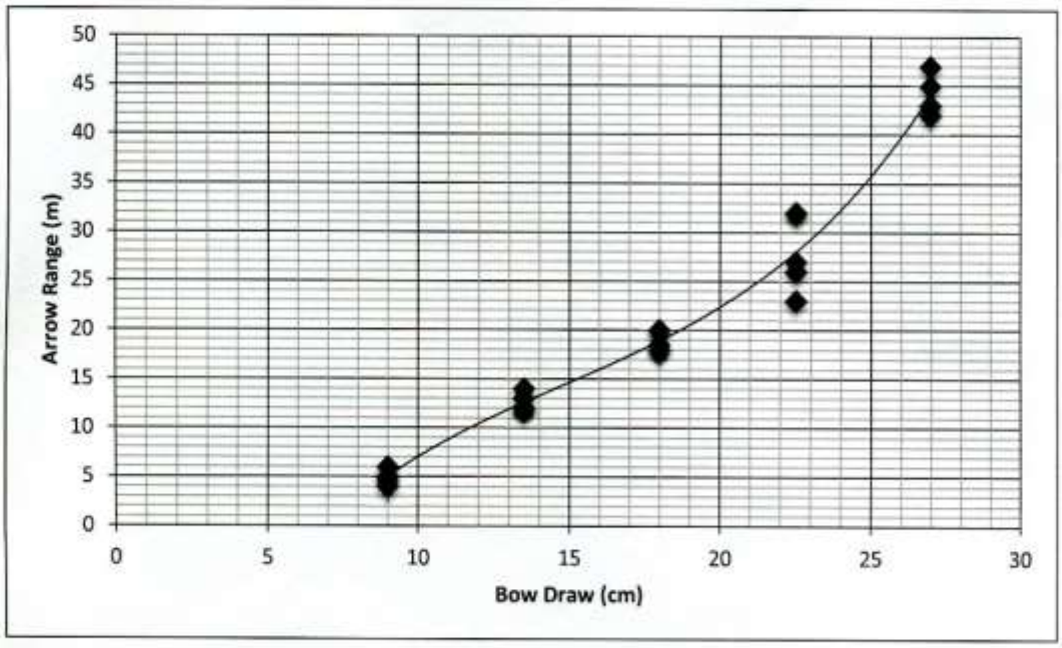


Figure 1: Arrow range plotted against draw. Diamonds represent measured ranges.

Figure 2 below shows the force measured for the 5 trials at the different draws. The increase in force is proportional to draw.

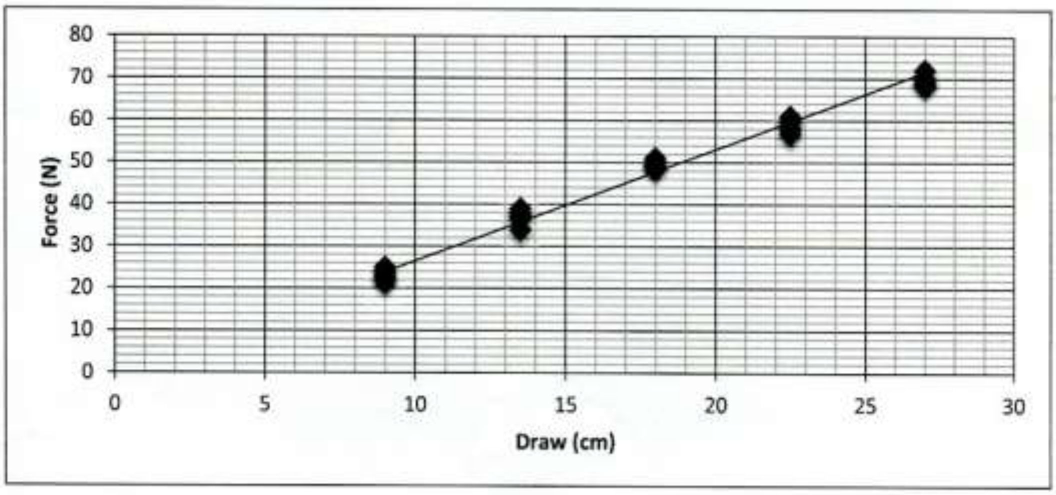


Figure 2: Force plotted against draw. Diamonds represent measured forces.

The range of the arrow should be proportional to the speed of the arrow as it leaves the bow. The speed is due to the acceleration of the arrow while it is in contact with the string. Newton's Second Law of motion says that acceleration is proportional to the force applied which we have shown to be proportional to the draw. However the speed of the arrow also depends on the time that the arrow is in contact with the string and is accelerating. These two effects combine to cause the increasing increase in range with draw shown in Figure 1.

Reflection

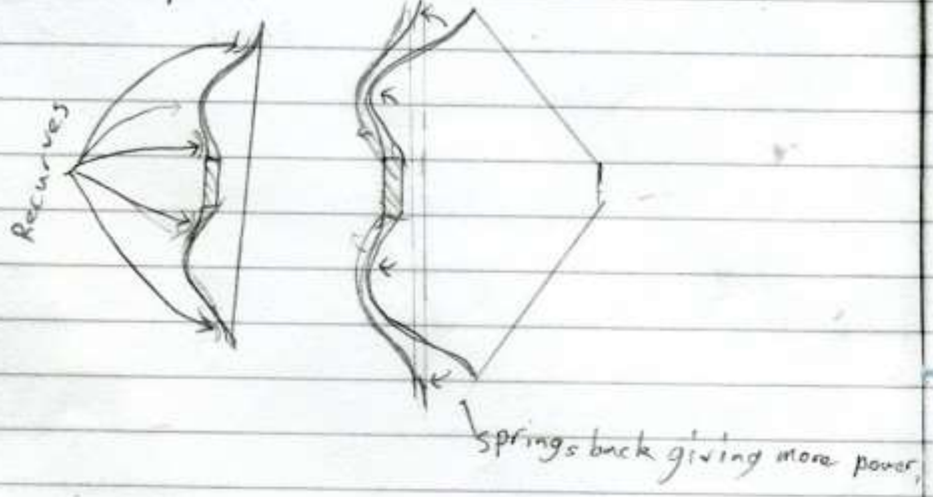
We measured the range with rocks that were 5 metres apart so we may not have estimated the range as accurately as we could have. To avoid that problem, we could have put more rocks down. The wind may also have affected the trajectory of the arrow. We could have done it inside to get more accurate data. I may not have released the string cleanly every time I fired which may have made a difference to the arrow's flight. It was also getting dark so we may not have measured everything as accurately as we could have. We did 5 shots for each draw lengths, getting more accurate data.

Log Book

Log Book

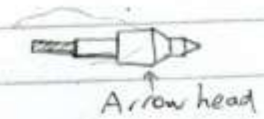
6/3/15 Today we set up our science books.
17.3.15 Today the mentors came and I met my mentor (His name is Elliot), and we wrote down the question, the equipment we needed, the aim of the experiment, the risks we would take by doing it and how we could prevent them and we started on the method ideas. I am going to bring my bow next week to show Elliot.

18.3.15 For the experiment I will be using a 30 Lbs double-recurve bow. A recurve bow is designed to get more arrow speed for less draw-weight. This works because the bow has two sets of recurves-backwards curves-that each spring back along with the rest of the bow giving the arrow more speed for less draw.



*28cm

The arrows I am using are aluminium(?), 28 cm long and use target arrowheads. The heads can be taken off and new ones put on.

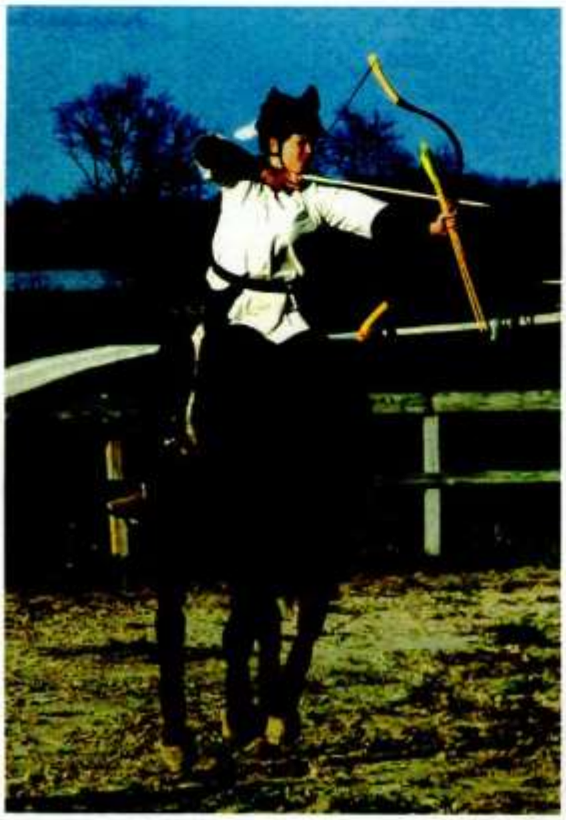


28.4.15 Today I did my experiment with my dad. First I did 2 practice shots. The last of the two went into the bush but we found it. Then we did the proper experiments. ~~It was~~

18.7.15 Today we did ~~half~~ most of ~~the~~ my booklet. We decided not to estimate the arrow speed. We also discovered that the physics of recurve bows is EXTREMELY complicated.

21.7.15 I did more of my booklet.

22.7.15 I finnished my booklet.



Bibliography

B.W. Kooi, On the Mechanics of the Bow and Arrow, PhD-thesis, Mathematisch Instituut, Rijksuniversiteit Groningen, The Netherlands (1983) (http://www.bio.vu.nl/thb/users/kooi/thesis.pdf)

https://en.wikipedia.org/wiki/Recurve_bow