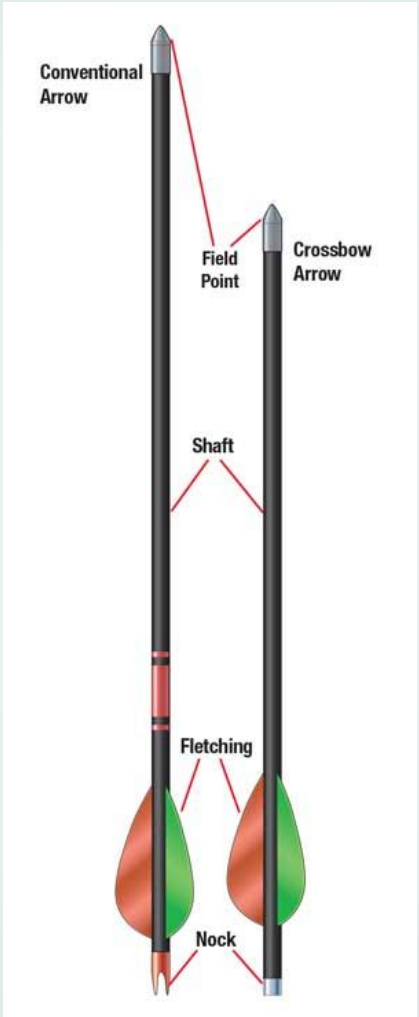
Will The Length Of The Vanes On A Crossbow Bolt Affect Its Accuracy?

Background Research: Parts Of A crossbow bolt

Crossbow bolts come in sizes varying from 15-22 inches long and can weigh between 6.5 and 11.3 grams each. A crossbow bolt consists of 4 parts, the shaft, the nock, fletchings or vanes, and the field point or broadhead.

The shaft is the main body of the bolt, all other components attach to the shaft. The ability of the bolt's shaft to resist bending is called stiffness, and all shafts have varying degrees of stiffness suited for different conditions. A shaft which is too flexible will veer slightly to the right when shot, while a shaft which is too stiff will veer slightly to the left. Therefore picking the right amount of stiffness can heavily affect the accuracy of a bolt. Today shafts are usually made with either aluminum or carbon, allowing the bolt to be strong, yet lightweight.



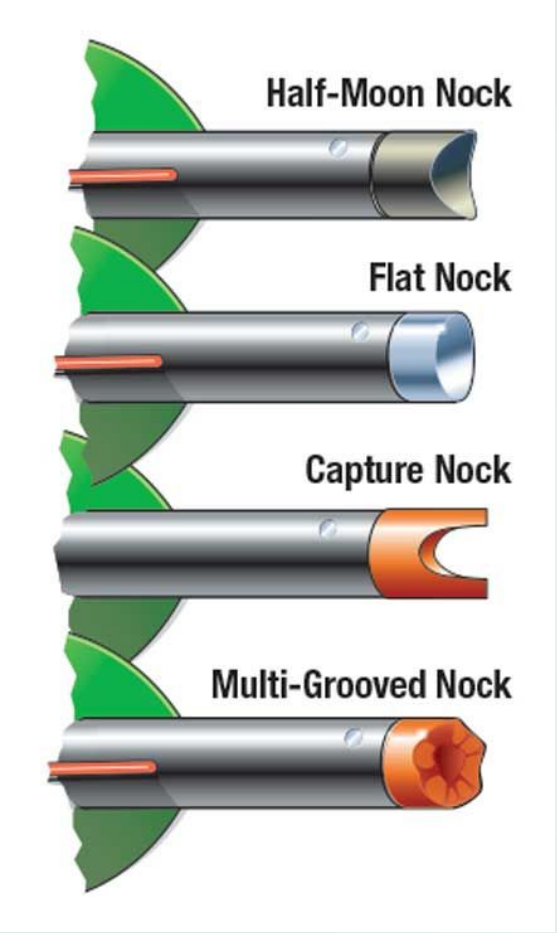

Conventional Arrow
Field Point
Crossbow Arrow
Shaft
Fletching
Nock



Background Research: Parts Of A crossbow bolt

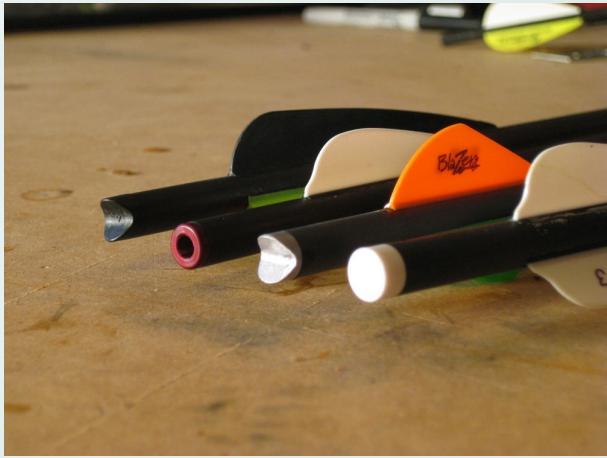
Nocks

The nock is attached to the back end of the shaft. The nock helps keep the bolt in line with the target while you are lining up the shot. There are 4 different types of nocks, the flat nock, the half moon, the capture nock, and the multi-grooved nock (also known as the omni nock). With flat nocks, you can place the bolt in any way you want so that the entire bolt gets worn equally, this also means it's faster to load. When using the half moon nock you always need to place the bolt the same way, and they are made of plastic. Manufacturers usually tell consumers which type of nock they should use for their certain crossbow.









Illustrations and pictures of the different types of nocks used on crossbow bolts

Background Research: Parts Of A crossbow bolt

Fletchings

Fletchings are small wing-like structures normally seen at the back end of the shaft slightly in front the nock, though the exact position varies based on preference. There are 2 types of fletchings, vanes and feathers. Vanes are normally made of plastics or silicone rubber, making them accurate and durable. Feathers are normally made from natural materials such as goose and turkey feathers. Feathers do not perform as well when wet since they are not as durable as vanes and cannot shed water as easily, but due to the fact that they can flex and lie flat while launching off the plate, they are still widely used today. However, feathers cannot be put on crossbow bolts. Fletchings stabilize the bolt while in the air, steering the bolt in the right direction, and preventing it from swaying to the right or left. They also cause the bolt to spin while in the air which increases stability. Longer vanes are normally only used on longer bolt shafts.



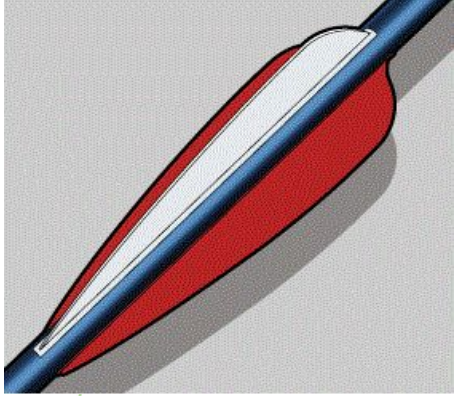
















Arrow vanes come in varying shapes and sizes and are made of different materials

Background Research: Parts Of A crossbow bolt

Field Points

Field points are normally seen at the tip of the shaft, they pierce into the target and leave a small opening. Field points are generally used for target practice and do not have any sharp edges, however the tip can easily pierce a target. Since field points are screwed onto the front end end of a crossbow bolt, they can be taken out and replaced if needed, or broadheads can be attached instead. Cheaper bolts usually come with the field points glued on making them much more difficult to replace. When replacing a field point, it is very important for the new one to be the same weight or heavier than the current one because lighter field points can damage the crossbow.









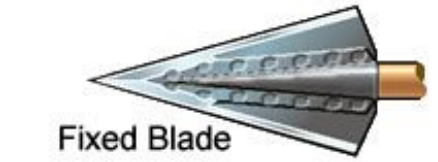


Field points come in various shapes, sizes, and weights

Background Research: Parts Of A Crossbow bolt

Broadheads

Broadheads can be used instead of field points, they are used mostly to hunt. Broadheads have sharp edges and tips allowing them to easily enter into an animal's body and cause major damage. Like field points they are also screwed on. There are 3 types of broadheads, fixed blade, removable blade, and expandable blade broadheads. Fixed broadheads come with sharp blades which cannot be removed. Removable broadheads have blades which can be removed and replaced with other blades. Expandable blade broadheads have blades which only open when it hits the target, causing a high amount of damage. It is recommended to use expandable blade broadheads as they only open up when the target is hit, so while the bolt is in the air no velocity will be lost, however they are more expensive than the other broadheads.

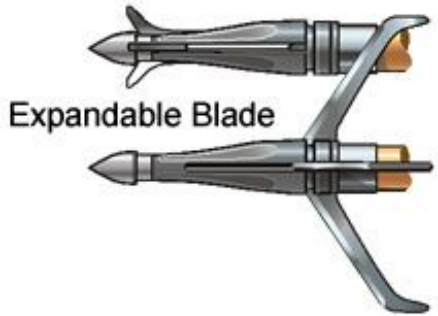


Fixed Blade



Removable Blade





Expandable Blade



Broadheads have many variations and styles all suited for different conditions and game.

Background Research: Drag forces

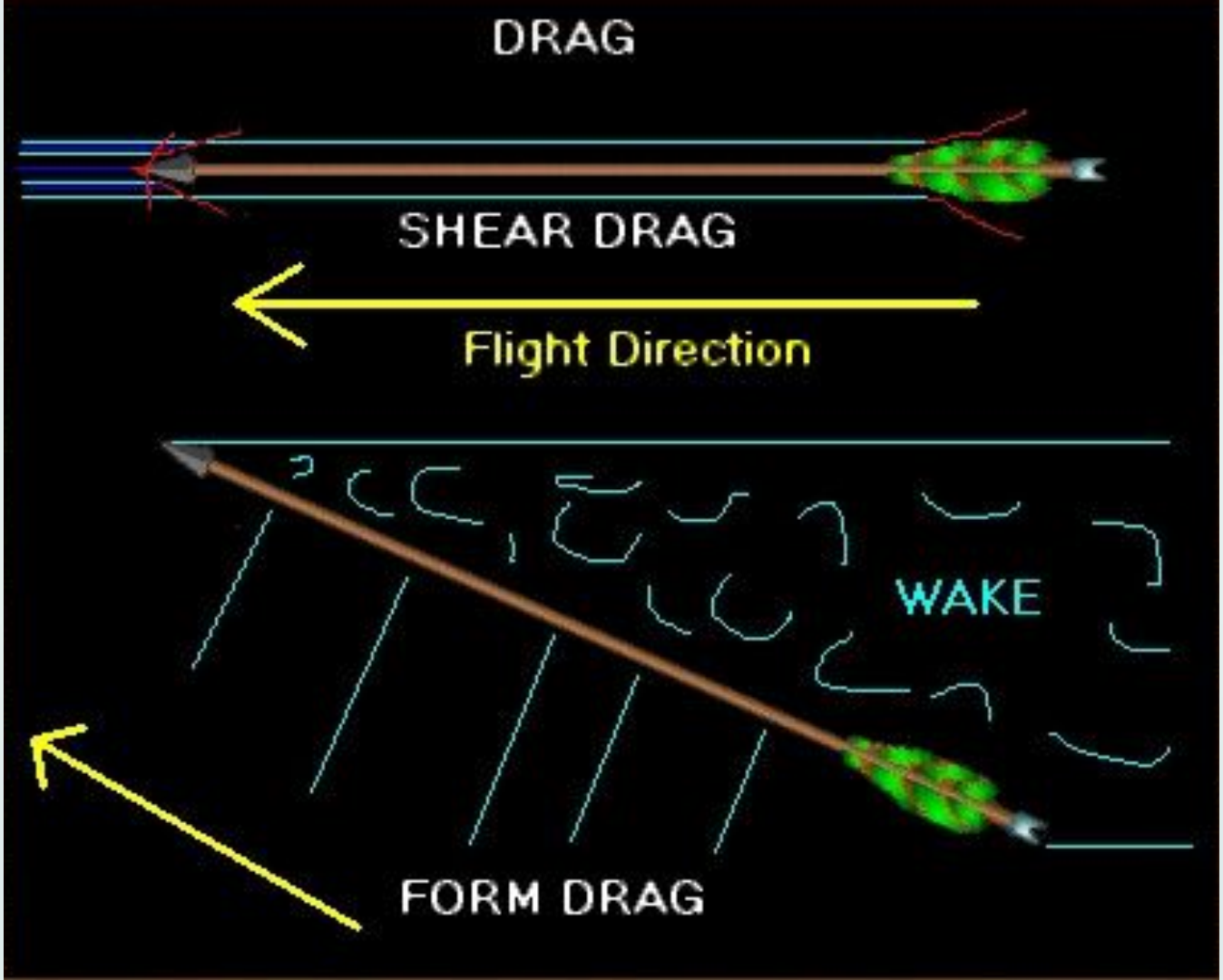
Shear Drag

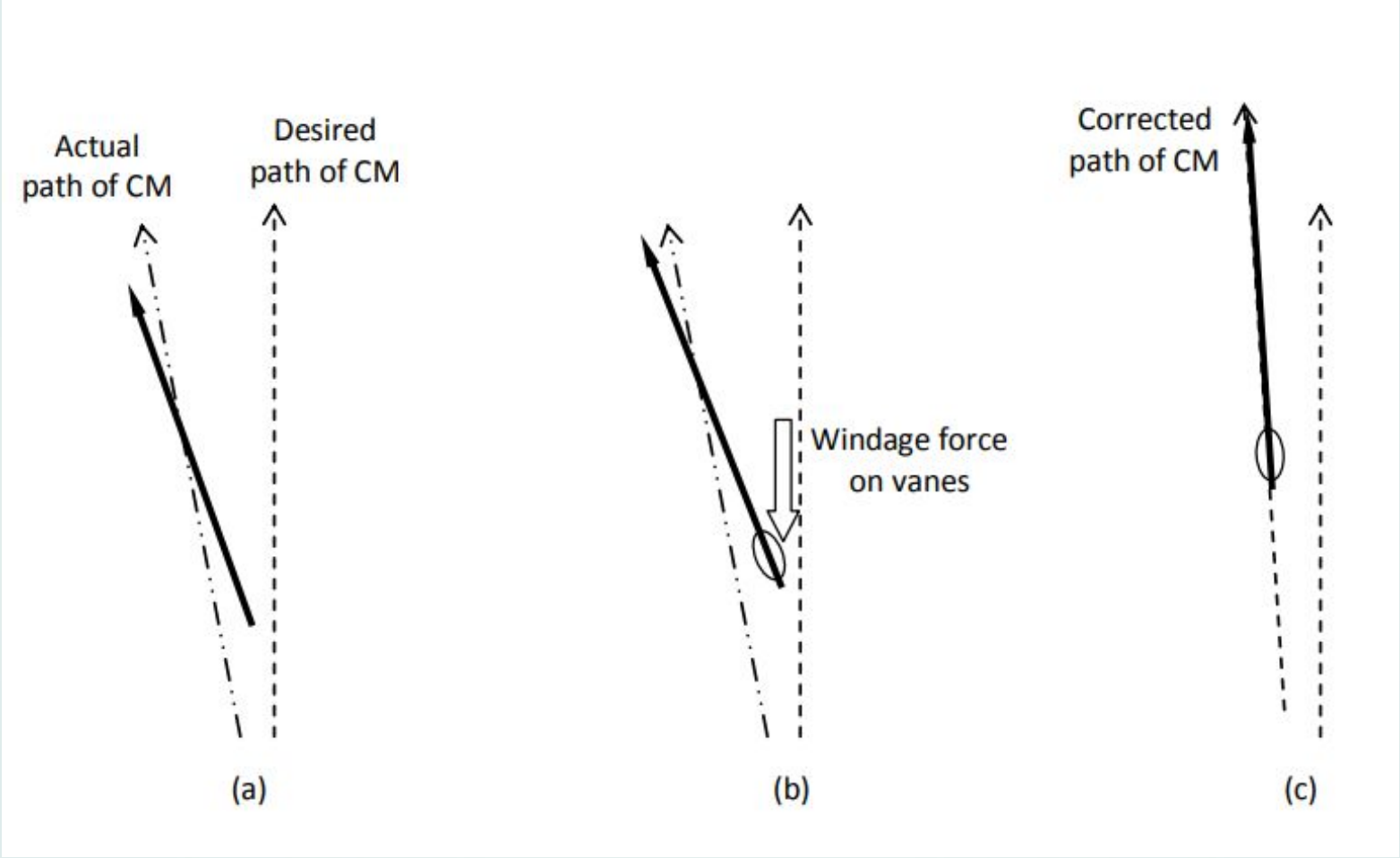
There are 2 types of drag forces that affect the velocity of a bolt during flight, shear drag and form drag. Shear drag is the result of the bolt simply moving through the air. Part of the kinetic energy the bolt receives when launched from the bow is expended on pushing the air, a fluid medium, out of the way.

Background Research: Drag forces

Form Drag

The second type of drag that influences the velocity of a bolt is known as form drag. In form drag, a force that, when applied alongside shear drag, pushes perpendicular to the current direction of flight of the bolt. This causes the bolt to tilt away from the intended flight path. This changed movement of the bolt through the air creates a layer of turbulent, low pressure air known as the wake. The wake is created using the kinetic energy of the bolt. The same kinetic energy also creates an apparent force that helps push the arrow further off the flight path. Now you might be asking what role fletchings play in all this. The apparent force caused by the effect of the drag acts on the fletchings on the back of the bolt, stabilizing the arrow. Without fletchings, the bolt would spin uncontrollably and therefore be inaccurate. Longer vanes will slow down the arrow more due to shear drag, but will be better suited to dealing with form drag, while shorter vanes will be better at avoiding shear drag, but will have problems when encountering form drag.


DRAG
SHEAR DRAG
Flight Direction
WAKE
FORM DRAG



This shows us how vanes contribute to redirecting the bolt.

Background Research: Arrow F.O.C.

Arrow F.O.C (arrow's front of center) is the percent of an arrow's weight located at the front half of the arrow. If there is more weight located at the front half, the arrows center of balance would also be moved more towards the front of the arrow. Arrow F.O.C is extremely important when shooting at longer ranges. High arrow F.O.C would make the arrow more stable, however the arrow would lose its velocity and trajectory faster. An arrow with low F.O.C will hold its trajectory better, but it will fly unpredictably. Adding heavier vanes to an arrow will make the arrow heavier near the back, reducing arrow F.O.C, while adding feathers will lighten the back of the arrow increasing arrow F.O.C. Heavier arrow tips will increase arrow F.O.C.



This image shows weights added to the arrow which helps increase arrow F.O.C

Testable question

Will changing the length of the vanes on a crossbow bolt from 2 inches, 3 inches, and 4 inches, affect its accuracy outdoors at a distance of 22 yards (20 meters) on a 12 inch wide target?

Hypothesis

If the length of the crossbow vanes is 4 inches, the crossbow bolt will hit the target the closest to the bullseye, because the longer vane will have a greater restoring force. Thus preventing the bolt from straying away from the intended flight path.

Variables

Uncontrolled Variable: The uncontrolled variables are the temperature, wind direction, humidity, and wind speed.

Manipulated Variable: The manipulated variable is the length of the fletchings on the crossbow bolt.

Responding Variable: The responding variable will be how far the crossbow bolt landed from the bulls-eye.

Controlled Variable: The controlled variables are the selected crossbow, the target we are shooting at, the draw weight of the crossbow (which is 60 pounds), the length of the crossbow bolts, and how far away we are from the target.

Materials

-Bear® X Desire XL Compact Crossbow (Qty:1)

-2 inch bolt vane (Qty:3)

-3 inch bolt vane (Qty:3)

-4 inch bolt vane (Qty:3)

-Fletching Adhesive (Qty:1)

-Crossbow Targets (Qty:1)

-Range Finder (Qty:1)

Procedure

Step 1: Attach the different vanes to the crossbow bolts.

Step 2: Secure the crossbow to prevent any unwanted movement

Step 3: Set up the target approximately 40 yards away.

Step 4: Cock back the crossbow and insert the crossbow bolt with the 2 inch vane.

Step 5: Shoot the crossbow bolt

Step 6: Repeat this process 3 times

Step 7: Record the results, and see how accurate the crossbow was with each vane.

Step 8: Complete this process for each vane length and record the results in your logbook.

Results

Accuracy of crossbow bolt with 2 inch vane at a distance of 22 yards (20 meters)

Trial 1- 2.4 centimeters off bulls-eye

Trial 2- 2.1 centimeters off bulls-eye

Trial 3- 2.5 centimeters off bulls-eye

Results

Accuracy of crossbow bolt with 3 inch vane at a distance of 22 yards (20 meters)

Trial 1- 1.9 centimeters off bulls-eye

Trial 2- 1.7 centimeters off bulls-eye

Trial 3- 2.0 centimeters off bulls-eye

Results

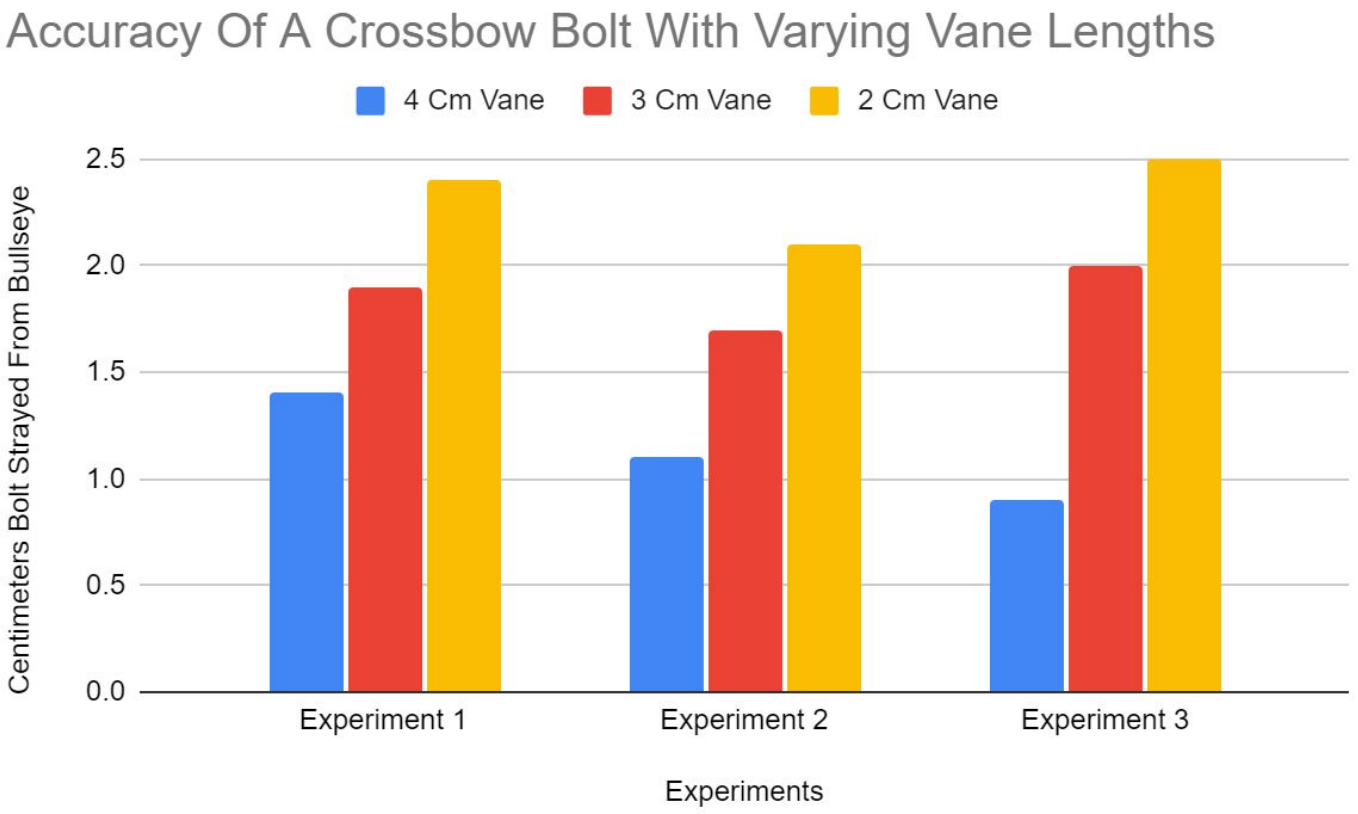
Accuracy of crossbow bolt with 4 inch vane at a distance of 22 yards (20 meters)

Trial 1- 1.4 centimeters off bulls-eye

Trial 2- 1.1 centimeters off bulls-eye

Trial 3- 0.9 centimeters off bulls-eye

Graph


Accuracy Of A Crossbow Bolt With Varying Vane Lengths
4 Cm Vane
3 Cm Vane
2 Cm Vane
Centimeters Bolt Strayed From Bullseye
2.5
2.0
1.5
1.0
0.5
0.0
Experiment 1
Experiment 2
Experiment 3
Experiments

Conclusion: Results Summary

The purpose of this experiment was to investigate the accuracy of crossbow bolts with varying vane lengths on a target with a diameter of 12 inches from 22 yards (20 meters) away. In order to do this the following steps were taken

1. Attach the 2 inch vanes on the bolt, stand 22 yards (20 meters) away from the target, aim the crossbow at the bullseye of the target and fire.

2. Attach the 3 inch vanes on the bolt, stand 22 yards (20 meters) away from the target, aim the crossbow at the bullseye of the target and fire.

3. Attach the 4 inch vanes on the bolt, stand 22 yards (20 meters) away from the target, aim the crossbow at the bullseye of the target and fire.

4. Record how many centimeters away from the bullseye of the target the bolts ended up for each vane length

Conclusion: Results Explained

The results showed that although all crossbow bolts hit fairly close to the bulls-eye, the bolts with the 4-inch vanes were more accurate and hit closer to the bulls-eye than any other bolt. With the least accurate 4-inch bolt hitting just 1.4 centimeters off the bulls-eye, while the bolts with shorter vanes couldn't reach closer than 1.9 centimeters off the bulls-eye. This is because longer vanes on crossbow bolts create more restoring force, which is a force that prevents the bolt from straying off the flight path, and the more restoring force there is, the more accurate the bolt will be. Which explains why the bolts with the 4-inch vanes were the most accurate and hit closest to the bulls-eye.

Conclusion: Hypothesis Revisited

Will changing the length of the vanes on a crossbow bolt from 2 inches, 3 inches, and 4 inches, affect its accuracy outdoors at a distance of 22 yards (20 meters) on a 12 inch wide target?

Our hypothesis was that, “If the length of the crossbow vanes is 4 inches, then the crossbow bolt will hit the target closer to the bullseye, because the longer vane will have a greater restoring force, thus preventing the bolt from straying away from the intended flight path.” Our hypothesis was accurate, we can tell this by looking at the graph and results, both of which show that the bolts with the 4 inch vanes were the most accurate and hit closest to the bulls-eye.

Conclusion: Sources Of Error

We did attempt to mitigate the effects of the uncontrollable variables by choosing to do the test on a day with little wind. However since this experiment was done outside, the weather still could have been a source of error, the temperature, humidity, wind speed, and wind direction could all have slightly impacted the results. The possibility of human error was minimized by using a stand and clamp to hold the crossbow in place, as to prevent any unwanted movement of the crossbow, which in turn could change the results.

Conclusion: Application

The results of this experiment could be particularly useful to people who hunt with crossbows. By increasing the length of vanes of the bolt, the hunter's shots will become more accurate, and therefore, make the hunter's job easier. This could also be used by students to learn about drag forces and aerodynamics, and how they work on objects such as arrows.

Conclusion: Next Experiment

In order to further study the result of this experiment and to gain additional insight into, will the length of the vanes on a crossbow bolt affect its accuracy? A follow up experiment could be, will changing the FOC of a crossbow bolt affect its accuracy. This is because it would answer the question of whether the center of balance of a crossbow bolt would affect its accuracy or not. Another follow up experiment could be, will the length of the vanes on a crossbow bolt affect its velocity, as it will tell us if changing the length of vanes on a crossbow bolt also changes velocity on top of accuracy.

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