ABSTRACT

The Illinois Junior Academy of Science

CATEGORY _Physics_ _ STATE REGION # __#2

SCHOOL __Saint Luke School IJAS SCHOOL # _2077_

CITY/ZIP __River Forest, IL 60305 SCHOOL PHONE

_708-366-8587 SPONSOR ___Mrs. Dal Santo

NAME OF EXHIBITOR* _Jack Kurtenbach GRADE ____7_

*PROJECT TITLE ______The Mechanics of a Trebuchet

Purpose: The purpose of this experiment is to find out what aspects of a trebuchet will make a ball fly the farthest distance.

Procedure: First collect different lengths of string, Tie on end of the shortest length of string to the end of the arm of the trebuchet. Cut a small piece of cloth in an oval shape about 12 by 25 centimeters.Poke 2 holes in both ends of the cloth horizontally. Place the string through the holes. Tie the other end of the string in a small loop and place it over the same end of the trebuchet that the other end of string is on. pull the trebuchet arm back as far as you can. Place the skewer through the hole in the nearest k'nex connector. Place the projectile in the sling.Pull the skewer out of the hole to fire. Record your results. Repeat these procedures with the other lengths of string.

Conclusion: After completing the experiment, the scientist discovered that the hypothesis was incorrect.The 18 centimeter string made the projectile fly the farthest.

SAFETY SHEET

The Illinois Junior Academy of Science

DIRECTIONS: The student is asked to read this introduction carefully, fill out the bottom of this sheet, and sign it. The science teacher and/or advisor must sign in the indicated space.

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In the **box** below, list the principal hazards associated with your project, if any, and what specific precautions you have used as safeguards. Be sure to read the entire section in the *Policy and Procedure Manual of the Illinois Junior Academy of Science* entitled "SAFETY GUIDELINES FOR EXPERIMENTATION" before completing this form.

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2. Exhibitor will be careful when using batteries.
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SIGNED Jack Kurtenbach

Student Exhibitor(s)

SIGNED [signature]

Sponsor*

*As a sponsor, I assume all responsibilities related to this project.

This Sheet Must Be Typed

This form MUST be displayed on the front of the exhibitor's display board. It may be reduced to half a sheet of paper.

The Mechanics of a Trebuchet

Jack Kurtenbach
St.Luke School
7th Grade

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Acknowledgments

The scientist would like to thank a few people. First he would like to thank his parents, Mr. and Mrs. Doug Kurtenbach for transportation to and from the stores.

Next, the scientist would like to thank his teachers Ms. Dal Santo, Mrs. Crosswhite and Mrs. Magrady for helping with the editing of his paper.

Lastly, the scientist would like to thank you, the judge for judging my paper.

Purpose

The purpose of this experiment is to find what length of sling will make a projectile fly the farthest distance.

Hypothesis

The scientist predicts if trebuchet uses a 15 centimeter sling, then that will make the projectile will go the farthest distance.

The trebuchet is a medieval war machine used to destroy walls, castles, and fortresses. The trebuchet was built by the French in the middle of the thirteenth century . These giant structures were about twenty feet tall and able to fling 300 pound stones. The trebuchet was the most powerful siege weapon of its time (History of a trebuchet, 2009). What length of sling will the scientist have to use to make a projectile fly the farthest? To understand this question, it will be important to understand the science of motion, gravity, and the mechanics and parts of a trebuchet.

Motion

Motion is the action or process of moving or traveling. One of the most important things to understand if you want to understand motion are Newton's Laws of Motion. Newtons first law states that a body will continue in a state or uniform motion in a straight line, unless acted upon by a force. Basically, this says that something has to move an object or it will keep going the same way. Newton's second law states that the acceleration produced by a force acting on a body is directly proportional to the magnitude of the force an inversely proportional to the mass of the object. This says that something gets pushed a certain distance due to how heavy it is and how hard it is pushed. Newton's third law states that whenever a body exerts a force on a second body, the second body exerts a force that is equal in magnitude but opposite in direction back on the first body (Parker, 2007).

Kinetic Energy

"Kinetic energy is energy that a body processes by virtue of being in motion." (Hyperphysics, 2009). When something is moving or falling, it is in the process of

Kinetic energy. Potential energy is very much related to kinetic energy. Potential energy is when something has the potential or can move.

Momentum

"Momentum is the quantity of motion of a moving body, measured of a product of its mass and velocity"(The Physics Department,2009). If an object is very heavy and is going very fast, then the object will much farther then an object that is very light and isn't going very fast. Momentum is very important when you bring in the aspect of speed, velocity and acceleration.

Speed, Velocity, and Acceleration

Speed, velocity and acceleration are generally put in the same category together. Speed is the simplest type of motion. Speed is how fast something is moving (Parker, 2007). Speed is usually measured in miles per hour or MPH. Friction is the force that slows down speed (Parker, 2007). Speed is also known as magnitude. Velocity is the average speed that something is traveling at (Parker, 2007). Velocity keeps track of changes in speed . To find velocity, one must incorporate magnitude and direction into the equation (Parker, 2007). Direction is incorporated because something goes faster if it goes in a uniform line then if it turn at sudden moments. To find the rate of speed and velocity, you must use the operation of calculus (Parker, 2007). Calculus was supposedly invented by Sir Isaac Newton, but the first man to publish a article on calculus was Gottfried Wilhelm Leibniz in 1684 in Germany. Accelerations are changes in velocity. An increase in velocity is commonly known as an acceleration. A decrease in velocity is commonly known as a deceleration. Deceleration is nothing more then a negative acceleration. To find the numerical answer of acceleration you find the change in velocity divided by elapsed time. When acceleration is recorded over a long period of time, it is referred to as average acceleration. The most common reference to acceleration is in the form of instantaneous acceleration that is sought. Units of acceleration are the units of velocity divided by time. This equation gives us feet per second squared (Parker,2007).

Scalars

We refer to a quantity that only has magnitude as a scalar. Typical examples of scalars are time, speed, density, mass, energy, temperature, and volume. A scalar quantity or parameter has no directional component, only magnitude. For example, the units for time (minutes, days, hours, etc.) represent an amount of time only and tell nothing of direction (Parker, 2007).

Vectors

"A vector quantity is defined as a quantity that has both magnitude and direction" (Parker, 2007). To work with vector quantities, one must know the method for representing these quantities. Magnitude, or "size" of a vector, is also referred to as the vector's "displacement." It can be thought of as the scalar portion of the vector and is represented by the length of the vector. By definition, a vector has both magnitude and direction. Direction indicates how the vector is oriented relative to some reference axis (Nuclear Power Fundamentals, 2003). Examples of vectors are force, velocity, and momentum. "Arrows are commonly used to represent vectors" (Parker, 2007).

Trajectory

Trajectory is defined as the path described by a projectile flying or an object moving under the action of given forces. Definition: A projectile is a moving object that has only one force acting upon it: the force of gravity. The path it follows is called its trajectory. Projectiles travel with a parabolic trajectory because the force of gravity accelerates them downward from their otherwise straight-line, gravity-free trajectory. Neglecting air resistance, a projectile would maintain a constant horizontal velocity since there are no other horizontal forces acting on it. At the same time the downward force and acceleration results in a downward displacement from the position that the object would be if there were no gravity(Parker,2007).

In other words, projectile motion has two components: horizontal and vertical, causing the trajectory of the projectile to curve. In the horizontal component, velocity is constant so it continues straight forward covering equal distances in equal times. At the same time, it is accelerating downward because of gravity, traveling larger downward distances in each successive time interval. These two simultaneous components create a curved path (Physics 24/7, 2008).

Launch Angle

Launch angle is a very similar concept to trajectory. Launch angle is defined as the angle in which an object released from the normal (Timbercon, 2000).

Fulcrums and Levers

Fulcrums and levers always work together as a type of mechanism. The fulcrum is a point or support at which the lever pivots. Fulcrums are the part of a lever mechanism that turns the lever upward. Fulcrums make loads lighter. Levers are simple machines used to lift weights. A load is the thing you're lifting. An effort is the person pushing to make the objects move. There are three different categories of levers, first class, second class, and third class. An example of a first class lever is a seesaw. The load is the object that goes up, and the effort applied is the weight of the object that goes down. The fulcrum is in the center in between them. An example of a second class lever is a can opener. The difference from the first class lever is that the fulcrum is on the end, instead of in the middle. An example the third class lever is a fishing rod. The load is the fish; the handle end is the fulcrum (Lever, 2009).

Gravity

The force that attracts a body toward the center of the earth, or toward any other physical body that has mass is called gravity. In most cases involving gravity, Newtons laws of gravity apply, with minor modifications to take the general theory of relativity into account. It is believed that Aristotle and Galileo were the first of study gravity. Aristotle claimed that things fell or didn't drift away because it was their obliged place. Gravity always falls at the same rate. When Aristotle first studied the rate of gravity, there was no device to measure it, so he made one. Aristotle rolled a ball down a inclined plane and tried to measure the rate. The rate Aristotle came up with was 32 ft/sec squared. Sir Isaac Newton is known for being the first person to understand gravity. Some things with mass such as planets can vary in acceleration rates. Planets like Jupiter and Saturn, which are bigger than other planets, have higher acceleration rates (Parker,2007).

The Mechanics of a Trebuchet

The mechanics of a trebuchet are quite simple. There are only five parts to a trebuchet. They are the frame, the beam, counterweight, the sling and the guide chute. Each part of the trebuchet contributes to making the trebuchet work in a different way (Parker,2007).

The Frame

The frame acts as the body of the trebuchet. It consists of a trapezoid shape with an X holding the trapezoid together. The frame is on the right and left side of the trebuchet (Parker, 2007).

The Beam

The beam is usually a long, cylinder shaped rod. The beam acts as the lever. The fulcrum is in the middle of the beam and connected to the frame. The beam also holds the sling and the counterweight. The beam must be able to pivot because it is a first class lever and is connected to the sling, which holds the projectile (Parker,2007).

The Counterweight

The counterweight is the load on the trebuchet. The counterweight drops on one side of the beam which lifts the other side up. Generally, the counterweight should be about six times heavier then the rest of the trebuchet (Parker,2007).

The sling is the holder of the projectile. The sling is a string or another thin, long, and not elastic object. At one end of the sling, there is a loop. The loop is on a that is at the end of the beam. And the other end of the sling is connected to the beam. And in the middle of the sling is a wider object that can hold a projectile, such as a ball (Parker,2007).

The Guide Chute

The guide chute is the holder and the guide for the sling. The guide chute is a plank at the bottom of the trebuchet. It connects the two frames together. It holds the sling by putting it on gears and cranking them back (Parker,2007).

When the time comes, the gears release and release the sling, which is connected to the beam, which is connected to the counterweight. Then the counterweight drops lifting up the sling and projectile, which makes the projectile fly(Parker,2007).

Summary Paragraph

What length of sling will make a projectile fly the farthest? Depending on the length of the beam, the sling should be one sixth of the length of the of the beam. If the sling will be 15 centimeters long. The scientist's hypothesis is that if he uses a 15 centimeter sling, then the projectile will fly the farthest.

Materials

Rods:
Blue x 50
Yellow x 30
Grey x 1
Red x 8

Connectors:
Yellow x 9
White x 12
Light Grey x 2
Dark Grey x 2
Red x 18
Blue x !0
Purple x 10

Other Materials:
Tape two D cell batteries
4 different lengths of String
Scissors
12 x 15 cm oval piece of cloth

Procedures

Step 1. Connect all of the blue and purple connectors together.
Step 2. Collect 8 of the connected blue and purple connectors.
Step 3. Collect 4 yellow, 2 red, and 6 blue rods.
Step 4. Collect 2 red connectors.
Step 5. Make 2 identical squares that have 4 blue and purple connectors at each corner, 2 blue rods at the top and 2 yellow rods at the side.
Step 6. Make 2 triangles using one of the yellow rods from each of the squares as the base and two blue rods and a red connector as the rest of the triangle.
Step 7.Connect the two finished products with 2 orange connectors.
Step 8. That will be used as your base.
Step 9. Make 2 squares with a white connector on the top inside, a yellow connector on the top outside, blue rods connecting them and around the perimeter, and have a yellow rod inside the square diagonally.
Step 10. Make 4 triangles like the ones in the base.
Step 11. Place the square at the bottom, one triangle with the red connector facing in, and connected by the yellow connectors, and place the last triangle as a top corner.
Step 12. Repeat steps 9-11 again.
Step 13. Make a large triangle with 3 white connectors and 2 blue rods as the base and a red connector and 2 yellow rods as the rest of the triangle.
Step 14. Make 2 connected squares with red connectors at the top outside corners, a connected blue and purple connector in the middle, blue rods on the perimeter, and a yellow rod in the middle diagonally.
Step 15. Put the house shaped figure at the top, connected to the corner triangle.
Step 16.Repeat steps 9-15.
Step 17.Make a triangle out of 2 white connectors, a red connector, a yellow rod as the base, and 2 blue rods. Use the 2 white connectors as the base corners and the red connector as the top corner.
Step 18. Get 2 red rods, a red connector, a grey rod, and a yellow connector and make a triangle with one open end. Connect the open end to the white connector from the other triangle.
Step 19 Place one red rod one the end of the yellow connector with a yellow connector at the end of the red rod This is the arm
Step 20. Connect a dark grey connector to a blue rod and a length of sling.
Step 21. Tape 3 D-batteries together with the blue rod item that you just made in the middle of the batteries.
Step 22. Tie the open end of the string to the arm
Step 23. Place 2 light grey connectors on a yellow rod. This is the axle.
Step 24.Place the middle white connector in between the 2 light grey connectors on the axle.
Step 25. Connect the yellow rod to the inside of the purple and blue connector at the top of the frame.
Step 26.Place the first length of sling through the middle of the orange connector.

Step 27. Poke 2 holes in the ends of the oval cloth.
Step 28. Tie the string to the ends of the cloth. With the open ended side, make a small loop at the end.
Step 29. Connect the frames to the base.
Step 30. Tie a string to a wooden skewer. This will be the firing pin.
Step 31. Cock the arm back as far as you can.
Step 32. Place the wooden skewer in the bottom yellow connector over the cocked arm.
Step 33. Place the rubber door stopper in the cloth.
Step 34. Release the firing pin to fire.
Step 35. Repeat steps 31-35 with different lengths of string.

Trebuchet Results

If the scientist uses a 15 centimeter sling, then the projectile will fly the farthest. The independent variable in this experiment is the length of the sling. The dependent variable was that the 17 centimeter sling had the peak of tossed distance.

The controlled variables in the experiment were the rest of the trebuchet. The arm was cocked back the same length every time. As well as the body. The body never changed through out the experiment.

It was difficult to shoot the projectile at the same angle every time. The firing pin would constantly get caught on the end of the arm. It was also difficult to keep the body in place.

The Variables in the experiment were monitored well. If other scientists were to conduct this experiment, then they would have to make sure that the cloth used for the sling is cupped up around the projectile before you fire it off.

Results with a 15 cm sling

Trial Number	Distance Tossed
One	3.81m
Two	3.78m
Three	3.78m

Results with a 17 cm Sling

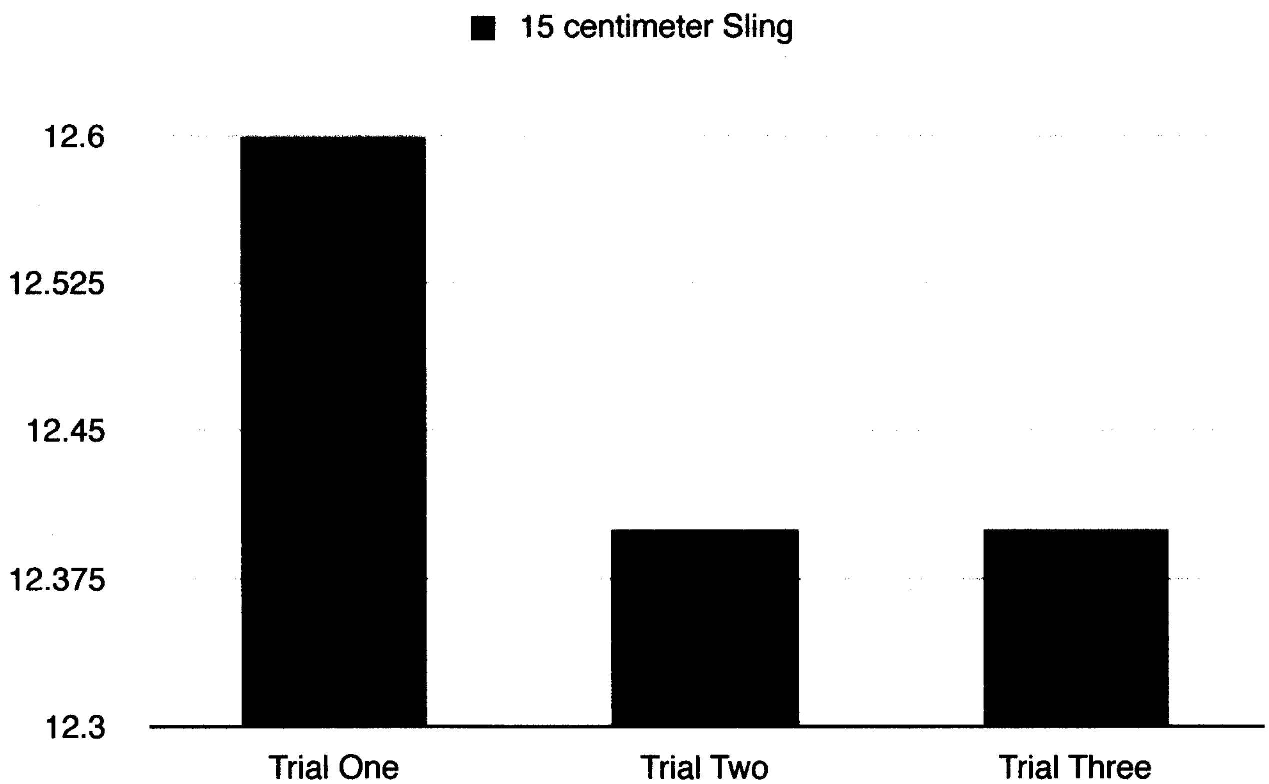
Trial Number	Distance Tossed
One	3.95m
Two	3.795m
Three	3.87m

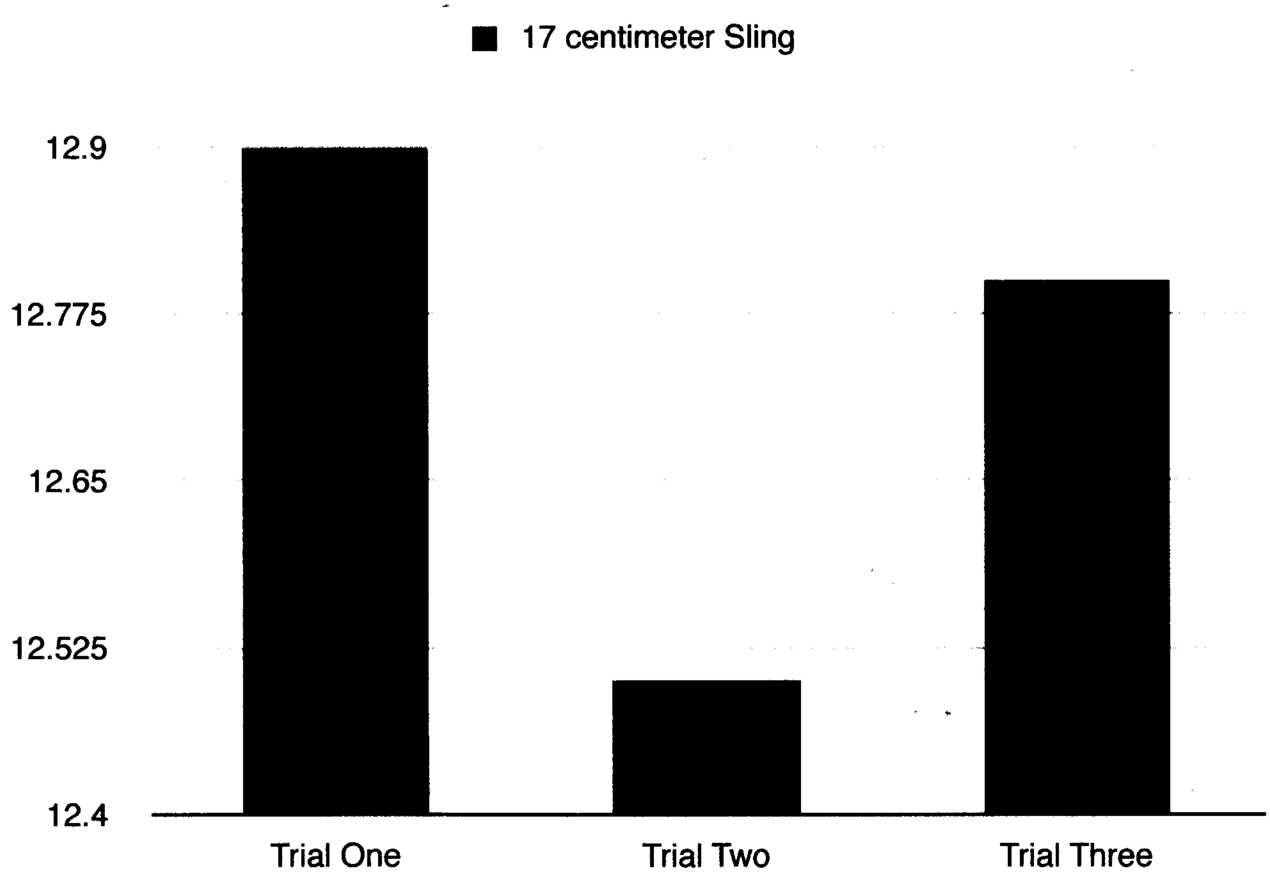
Results with a 20 cm Sling

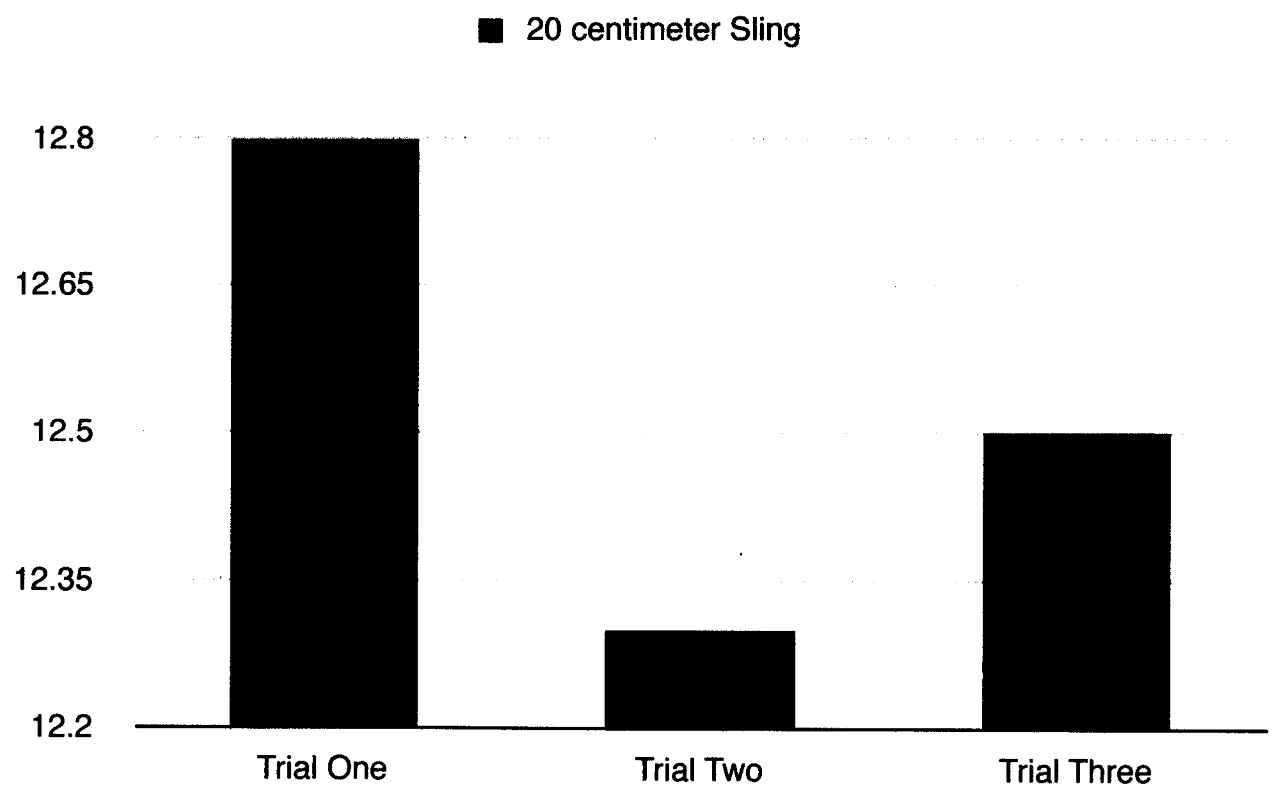
Trial Number	Distance Tossed
One	3.87m
Two	3.74m
Three	3.795m

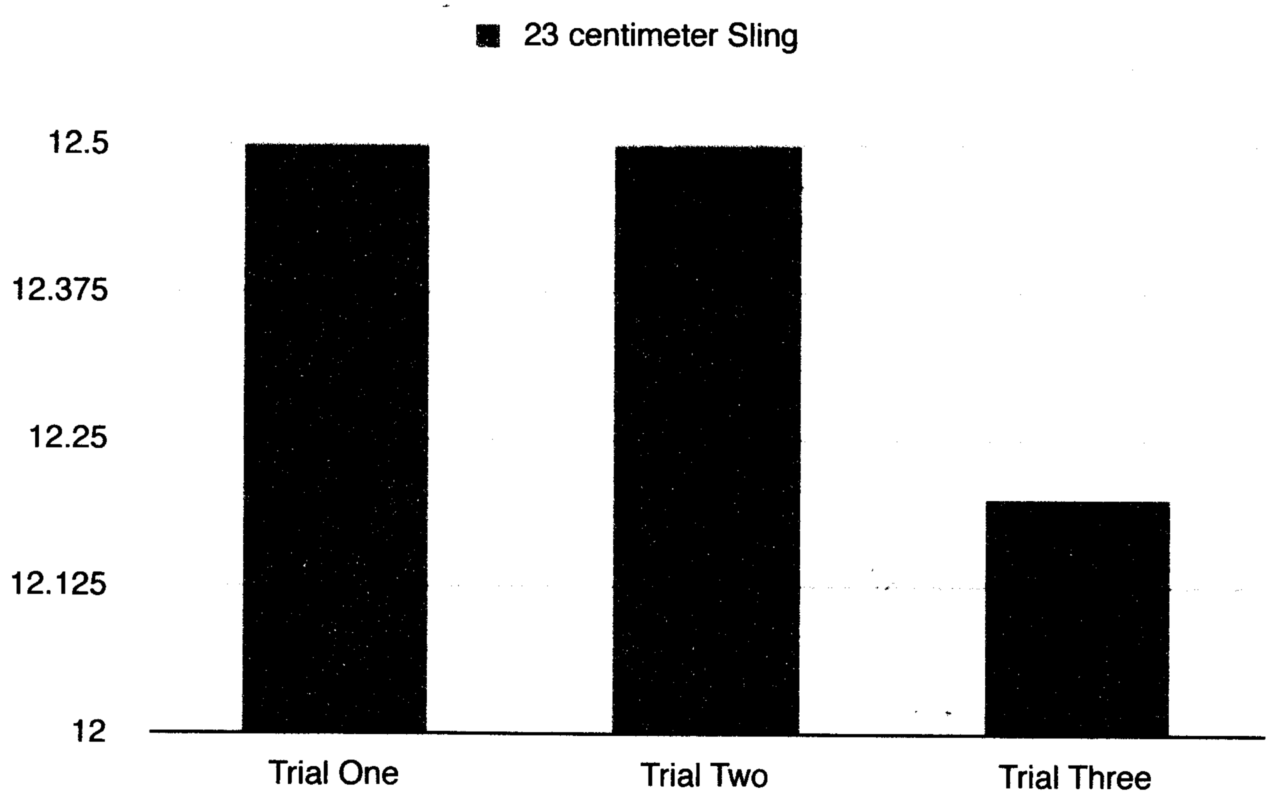
Results with a 23 cm Sling

Trial Number	Distance Tossed
One	3.795m
Two	3.795m
Three	3.70m


15 centimeter Sling
12.6
12.525
12.45
12.375
12.3
Trial One
Trial Two
Trial Three


17 centimeter Sling
12.9
12.775
12.65
12.525
12.4
Trial One
Trial Two
Trial Three


20 centimeter Sling
12.8
12.65
12.5
12.35
12.2
Trial One
Trial Two
Trial Three


23 centimeter Sling
12.5
12.375
12.25
12.125
12
Trial One
Trial Two
Trial Three

Conclusion

The purpose of this experiment is to find out what aspects of a trebuchet will make a projectile fly the farthest distance. The scientist predicts if the trebuchet uses a 15 centimeter sling, then that will make the ball go the farthest distance.

The hypothesis was proven wrong throughout the experiment. It was proven that the sling length that works best for the distance was 17 centimeters.

If the scientist were to do this experiment over he would add on Supports on the side of the trebuchet so it will stay in place. He would have also done more trials. The Trial number was just enough to get the data.

When it comes to studying, The scientist wishes he would have studied the history more. That should have been a huge chunk of his paper. If you were to do the research on a trebuchet, you should defiantly study up on your trebuchet history.

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