BioEd℠

Think like an Engineer

TEACHER'S GUIDE

Javelin Rockets

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Baylor College of Medicine

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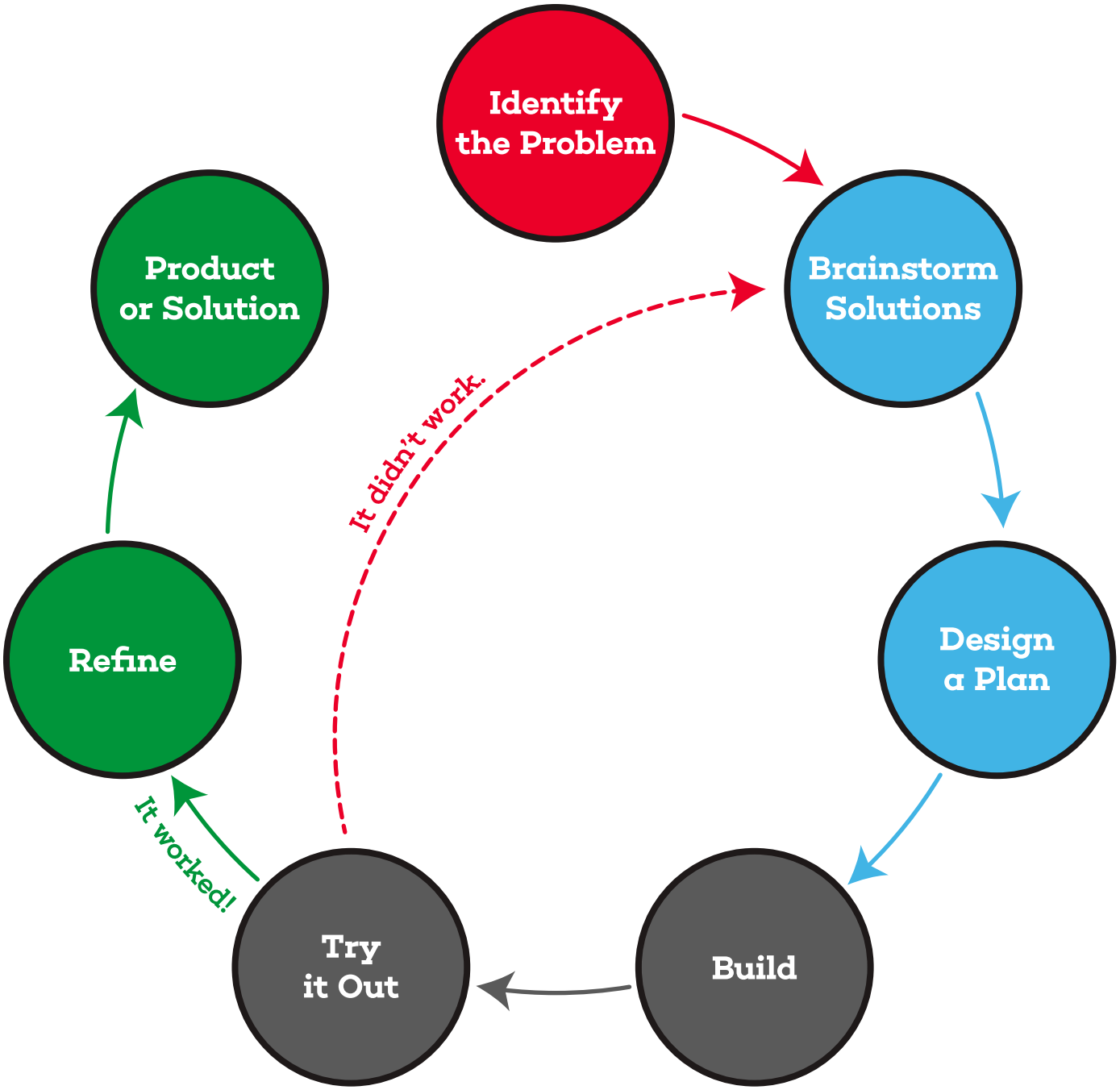
An Engineer's Approach



3

Javelin Rockets
Throwing to the Max

Time
1–2 sessions

Before You Start
See "What To Do in Advance."

You Need This Stuff
Teacher Materials
- 13 30-cm pieces of string
- 13 protractors
- 13 push pins
- 13 metersticks
- 8–9 narrow strips of duct tape, 3–4 cm in length
- 2 30-cm pieces of foam pipe insulation (for 3/4-in. diameter pipes)
- 2 rubber bands (large, sturdy)
- Hot glue gun and glue
- Manila folder (or thick card stock)
- Masking tape
- Pair of scissors

Per Pair of Students
- 8–9 narrow strips of duct tape, 3–4 cm in length
- 2 tennis balls
- 2 30-cm lengths of foam pipe insulation (for 3/4-in. diameter pipes)
- 2 manila folders (or thick card stock)
- 2 pairs of safety goggles
- 2 pairs of scissors
- 2 rubber bands (large, sturdy)
- Metric tape measure

Per Student
- Copy of "Make a Javelin Rocket," "Launch Instructions," and "Test Flight Data" pages

What It's About
This activity is a common personal challenge. Through experience, we learn to throw a ball at the correct angle and speed to reach our target.

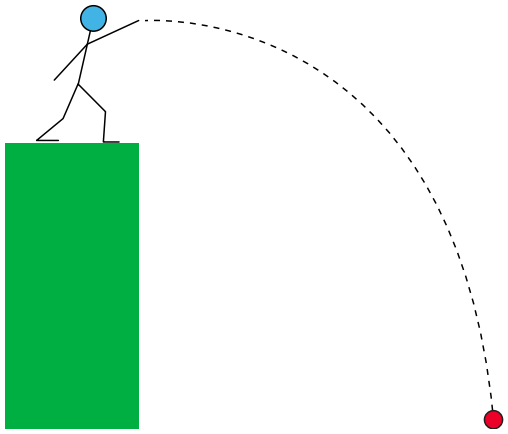
Bregje Crolla in competition, 2010. A javelin thrower must throw the javelin overhand, over his or her shoulder or upper arm, toward a sector extending outward from the arc at the end of the runway.

Of course, many sports involve throwing or hitting balls or other implements as far and accurately as possible. In baseball, a center fielder has to pick up a ground ball and throw it at the right angle and speed to the catcher waiting at home plate. A quarterback must be able to pass the football to a receiver running full speed toward the end zone. A golfer selects a driver with the right angle on the club face to launch a golf ball toward the hole. Athletes who throw javelins try to throw a javelin farther than their competitors.

In this activity, student teams will construct javelin rockets and use them to investigate the relationship between launch angle and range. They

Gravity and the Flight of Balls

Earth's gravity bends the trajectory of objects thrown horizontally across its surface. It also causes falling objects to accelerate. At the end of one second of falling, a ball will be traveling 9.8 meters per second. At the end of two seconds, it will be traveling 19.6 meters per second. After three seconds, it will be traveling at a speed of 29.4 meters per second. As a ball thrown horizontally accelerates toward Earth's surface, its downward curve becomes increasingly steep. To compensate for the effects of gravity, a ball thrown a long distance must be aimed upward so that its curved path ends at the target.



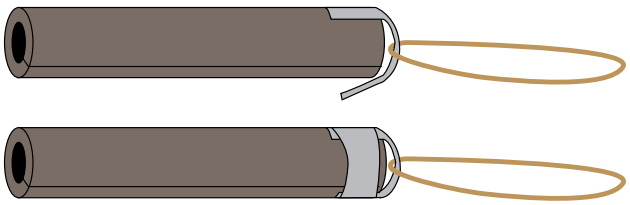
will discover that the best launch angle for the javelin also is the angle at which a ball should be thrown or hit to travel the maximum distance.

What's the Question?

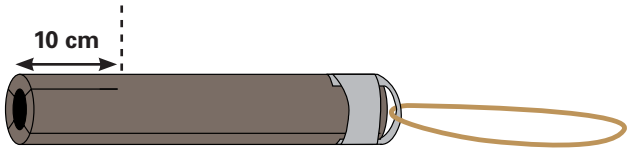
Does launch angle affect the distance a javelin rocket travels?

What To Do in Advance

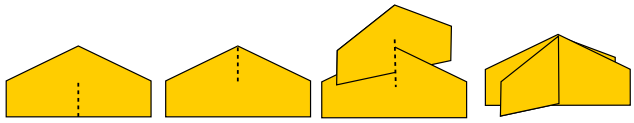
1. Build a model javelin rocket and launcher using the instructions below (illustrations are not to scale). Prepare the pieces for a second rocket javelin, but do not assemble it. You will use this second javelin to demonstrate how to build and assemble a rocket javelin.
   a. Cut a 30-cm piece of foam pipe insulation. This tube will serve as the javelin rocket body.



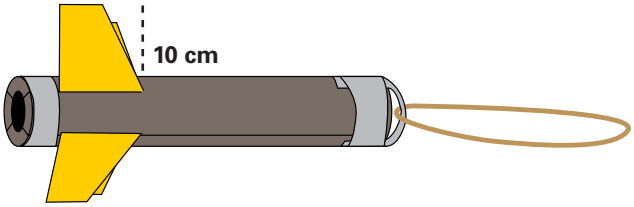
   b. Cut a narrow strip of duct tape and affix one end of it to one end of the tube. Slide a rubber band through the unattached end of the tape. Secure the unattached end of tape on the other side of the tube. Place a second strip of tape around the tube to hold the first strip in place.
   c. You will need four slits in the opposite end of the tube. Use the pre-cut manufacturer's slit as the first slit. Make three additional cuts into the end of the tube, spaced at 90° intervals. The three cuts need to be approximately 10 cm long.



   d. Make fins from a manila file folder. Cut slits in the fins so they can be nested, with four fin tips oriented at 90° angles to each other.

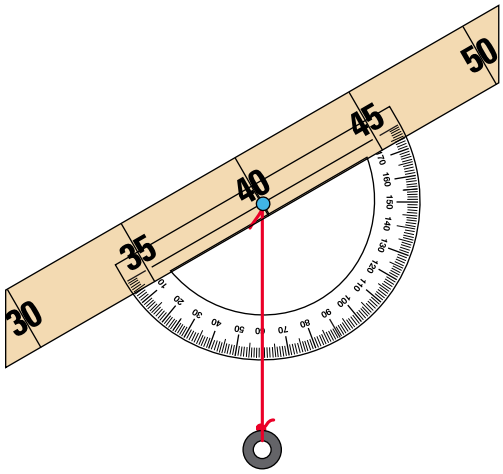


   e. Slide the fins into the four slits in the back end of the tube. Place a narrow strip of duct tape around the bottom of the tube to hold the fins in place.



2. Cut one 30-cm length of foam pipe insulation for each student.

3. Construct enough rocket launchers for the entire class (one launcher for every two students), and one for you to use for demonstration.
   a. Hot glue a protractor to the middle of a meterstick.
   b. Insert a push pin through the hole at the protractor's apex, into the meterstick.
   c. Hang a string loop around the push pin and tie a metal washer to the other end of the string. The launcher is ready.



To determine the angle, subtract the number of degrees on the protractor from 90. In this case, the launch angle is 30° (see p. 19).

4. Place team materials in a central location for students to pick up. Have students work in teams of two.

What To Do: Ball Toss

1. Prompt students to talk about the seemingly simple process of throwing a ball. Ask, *How do you throw a ball to someone standing close to you? How do you throw a ball to someone far away? What is the difference?* Bring students to a large open area and separate them into small groups. Direct two students from each group to toss a tennis ball back and forth, while the other students observe the ball's flight path from the side. The students playing catch should start about five yards apart and slowly double the distance with subsequent throws. Have observer students switch with the throwers so that all can throw and observe the ball's flight path. Afterward, have students diagram the ball's path on the board or in their notebooks.

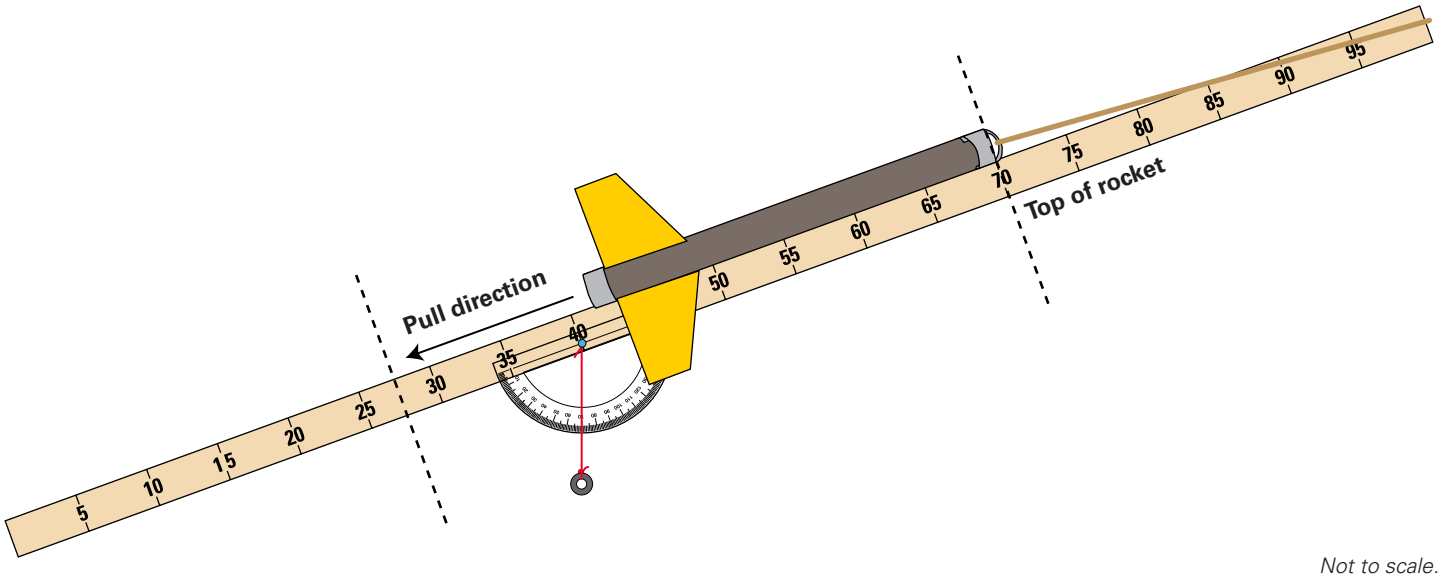
2. Draw three stick figures on a white board. Have two figures about two feet apart, with the first at the left edge of the board. Place the third figure at the right edge of the board. Invite students to draw lines estimating the path of a ball thrown from the figure at the left board edge to the nearest figure, and also to the figure at the right edge of the board. In each case, the ball's trajectory (path through the air) should be curved. Ask, *Why is the path curved?* (gravity)

What To Do: Build/Test Javelin Rockets

1. Tell students they will make and fly javelin rockets, and investigate the best launch angle to achieve maximum distance. Show the completed rocket javelin to the class, explaining the different parts. Next, show how to mount the rocket javelin on the launcher and launch the rocket javelin. Point out the protractor and string/weight, and explain how to measure the launch angle. Also explain to students that they can control for launch force by stretching the rocket javelin back to the exact same point on the meterstick each time they launch.
2. Distribute the student sheets and have students begin assembling their rockets, using the instruction diagram as a guide. While they work, assemble the second model javelin rocket, discussing each step and checking to make sure students are following the instructions properly.

   Tip: Peel off narrow lengths of duct tape in advance and stick them to table edges for students to access easily when needed.
3. When all students have completed their rockets,

Javelin Rocket Positioned on the Launcher



Not to scale.

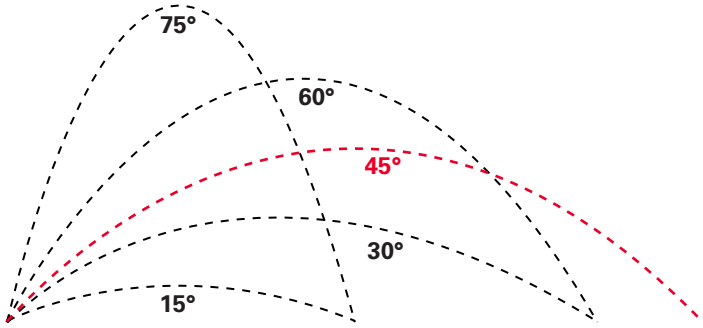
demonstrate the launch technique once again. Move students to an open area where they can safely attempt test flights and become familiar with the launchers. Set up a launching line. Measure two-meter intervals from 0 to 16 meters. Mark each interval with a strip of masking tape.

4. Divide the class into teams of two and have each team launch its rockets. One student should launch while the other checks the launch angle. For each launch angle used, teams should record the distances their rockets fly. Be sure they measure distance to the landing point, not the point at which the rockets come to rest after sliding on the floor.

Caution: Warn students not to aim their rockets at anyone. Always aim for an open area.

Wrapping Up

Ask your students, *What is the best launch angle for long-distance flights?* If they can't agree on a number, average students' responses. Compare their results to the actual ideal angle: 45 degrees. Anything more or less than 45 degrees will produce shorter flights (see illustration, right). Ask, *How does this discovery apply to sports?* (Throwing or hitting a ball the longest distance requires launching it upward at an angle of 45 degrees.)



Extra

Hold a launch competition. Set a basketball or other target on the floor about 10 meters from a launch line. Challenge students to hit the target—on the fly—with their rockets (sliding into the target does not count). Instruct students to adjust their launch angles as needed to reach the target. To launch the rocket with more or less force, students also can change how far back they pull their launchers before release. ■

Make a Javelin Rocket

You will need the following materials to build a javelin rocket.

- 30-cm length of foam pipe insulation
- 4–5 narrow strips of duct tape, 3–4 cm in length
- Large, sturdy rubber band
- Manila file folder (or thick card stock)
- Pair of scissors
- Metric tape measure

Use the illustrations as guides to build a javelin rocket.

1. Cut a narrow strip of duct tape and affix one end of it to one end of the tube of foam pipe insulation. Slide the rubber band through the unattached end of the tape. Secure the unattached end of tape to the other side of the tube.

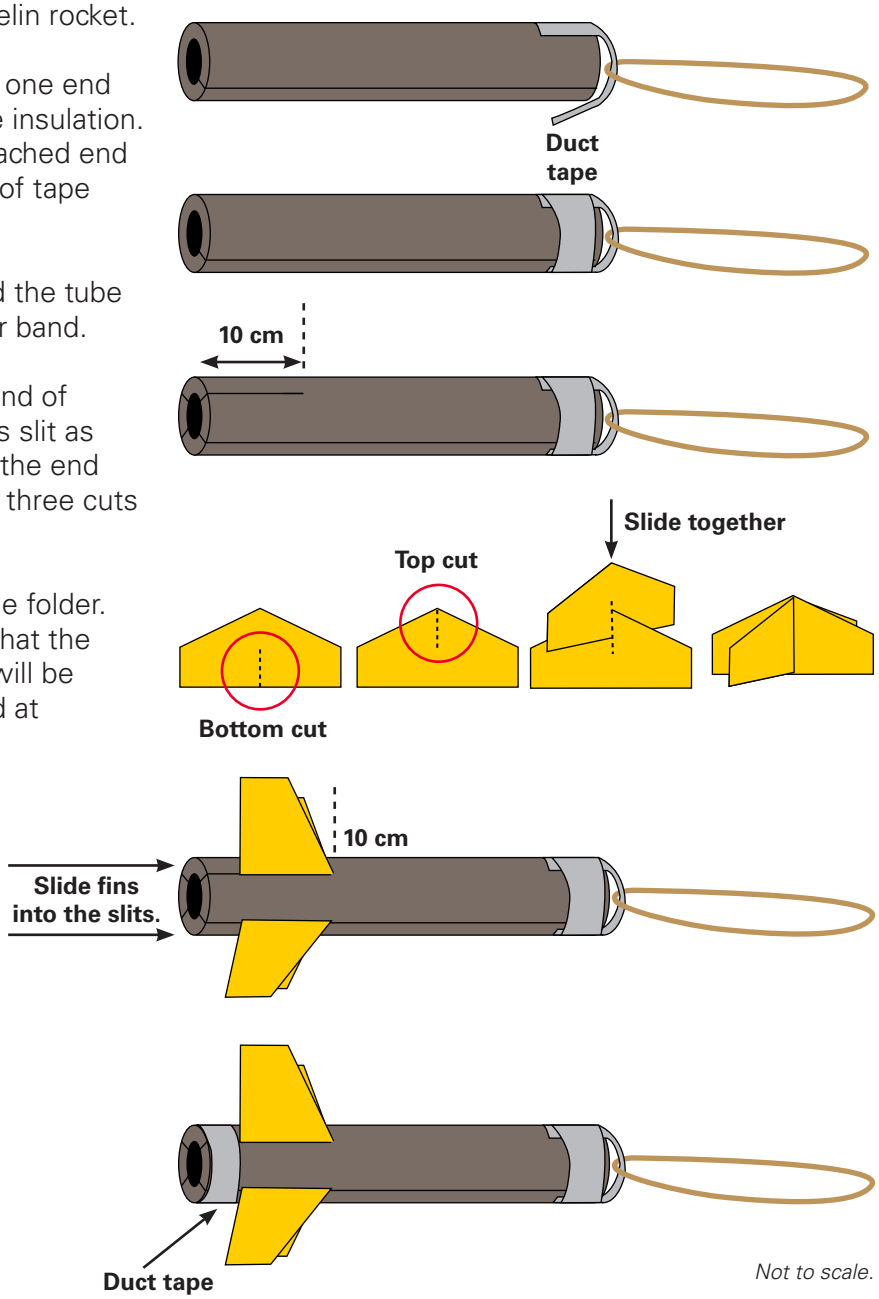
2. Place a second strip of duct tape around the tube to firmly secure the first strip and rubber band.

3. You will need four slits in the opposite end of the tube. Use the pre-cut manufacturer's slit as the first slit. Make three more cuts into the end of the tube, spaced at 90° intervals. The three cuts need to be approximately 10 cm long.

4. Cut two identical fins from the manila file folder. Make one cut in each fin as shown, so that the fins can be nested together. The result will be one set of fins with four fin tips oriented at 90° angles to each other.

5. Slide the fins into the four slits in the back end of the tube.

6. Cut one or two narrow strips of duct tape. Place them around the bottom of the tube to hold the fins in place.



Not to scale.

Launch Instructions

You will need a completed javelin rocket and a launcher. You also will need a data sheet to record your tests and results.

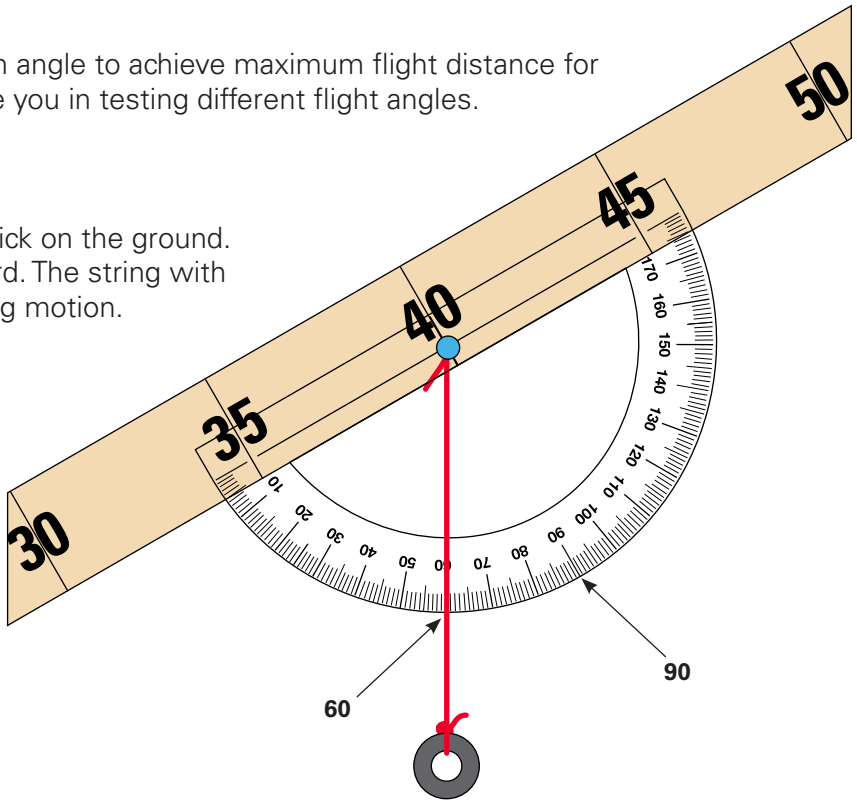
The goal of the tests is to find the best launch angle to achieve maximum flight distance for the javelin rocket. Use the illustration to guide you in testing different flight angles.

How to Find the Angle on the Launcher

1. Place the number "1" end of the meterstick on the ground. Tilt the other end of the meterstick upward. The string with the metal washer will move with the tilting motion.
2. Look at the number on the protractor where the string stops.
3. Subtract that number from 90. In the example given, the number is 60.

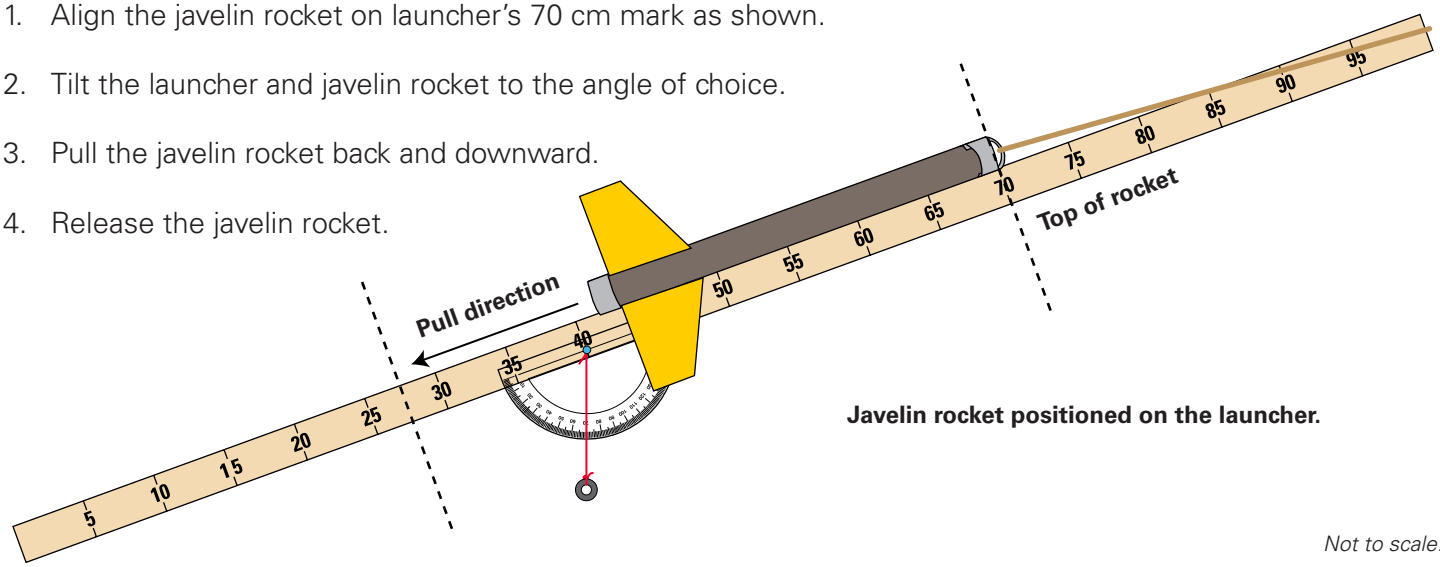
   90 – 60 = 30

   The launch angle in this example is 30°.



Launching the Javelin Rocket

1. Align the javelin rocket on launcher's 70 cm mark as shown.
2. Tilt the launcher and javelin rocket to the angle of choice.
3. Pull the javelin rocket back and downward.
4. Release the javelin rocket.



Javelin rocket positioned on the launcher.

Not to scale.

Test Flight Data

Name _____ Name _____

You and a partner will conduct tests to examine the relationship between a rocket's launch angle and flight distance. Try launching at low to high angles—and everything in between!

1. Place a piece of masking tape where the base of the launcher will rest on the ground/floor. Adjust the rocket and launcher for the first flight angle. Have your partner record the angle in degrees on the chart to the right. Launch your rocket.

2. Use a piece of masking tape to mark the spot where the rocket first hits the ground or floor—not where it comes to a stop after sliding. Measure the distance the rocket traveled and have your partner record the distance on the chart.

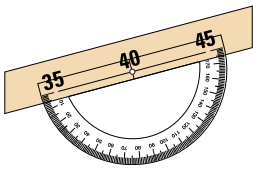
4. Switch roles so that you are now the distance recorder for your partner's test.

5. Continue switching roles as you both complete the chart with flight data.

6. What is the best angle for obtaining the longest flight distance?

   _____°

Flight Launch Log



Launch Number	Launch Angle	Distance Traveled
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		