



science & sports

Educational Product	
Educators and Students	Grades 5-8

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National Content Standards

1. National Research Council
2. National Council of Teachers of Mathematics
3. International Technology and Engineering Education Association

Hovering on a Cushion of Air
 Center of All Things
 Let's Do the Twist
 Crazy Balloons
 Javelin Rockets
 Space Helmet Challenge

	Hovering on a Cushion of Air	Center of All Things	Let's Do the Twist	Crazy Balloons	Javelin Rockets	Space Helmet Challenge
<p>SCIENCE STANDARDS¹ Physical Science</p> <p>Motions and Forces</p> <ul style="list-style-type: none"> • Understand motions and the forces that cause motion <p>Transfer of Energy</p> <ul style="list-style-type: none"> • Understand ways in which energy is transferred • Understand the relationship between energy and force <p>Science and Technology</p> <ul style="list-style-type: none"> • Abilities of Technological Design • Design a solution to a problem and evaluate its effectiveness 						
<p>MATHEMATICS STANDARDS²</p> <p>Number and Operations</p> <ul style="list-style-type: none"> • Perform operations with multi-digit whole numbers and with decimals to the hundredths <p>Algebra</p> <ul style="list-style-type: none"> • Write and interpret numerical expressions • Analyze patterns and relationships <p>Geometry</p> <ul style="list-style-type: none"> • Graph points on the coordinate plane to solve real-world and mathematical problems • Classify two-dimensional figures into categories based on their properties • Solve real-world and mathematical problems involving area, surface area, and volume <p>Measurement</p> <ul style="list-style-type: none"> • Represent and interpret data 						
<p>TECHNOLOGY STANDARDS³</p> <p>Design</p> <p>Standard 8. Students will develop an understanding of the attributes of design.</p> <p>Standard 9. Students will develop an understanding of engineering design.</p> <p>Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.</p>						

Javelin Rockets

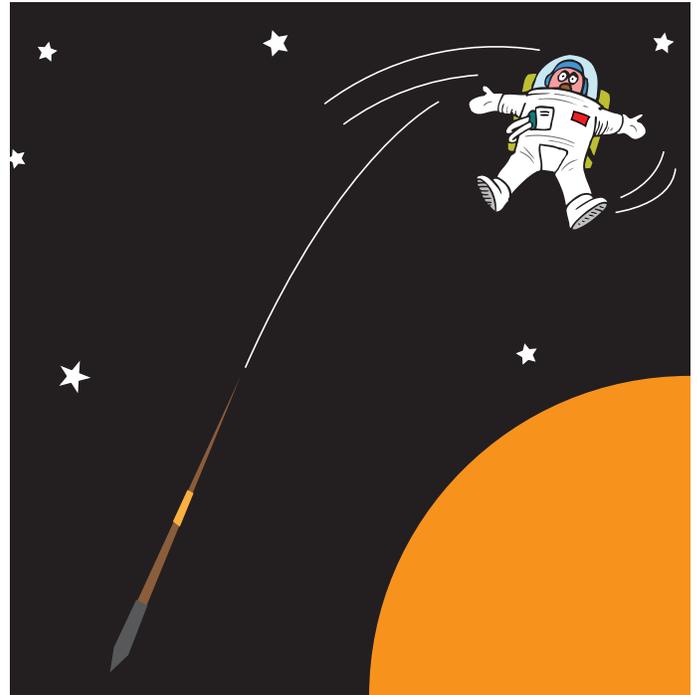
Pre-game Talk Show

Welcome to the 2038 Solar System Olympics. Today's events include the ever-popular Javelin Rockets. Our interplanetary teams are readying their rockets and fine-tuning their guidance systems. It should be a great event.

We have a few minutes before the event begins. Let's look back at the roots of this exciting competition.

The first Olympic competition is said to have been held in ancient Greece in the year 776 B.C. Those ancient games featured running, jumping, wrestling, discus and javelin throwing. The original javelin was a throwing spear used in battles. Soldiers had to throw spears accurately or their enemies could throw them back. This led to the popular javelin throwing event at the Olympics. The object of the event is to throw the javelin the farthest.

In the terrestrial Olympics, javelins for men are sticks that are about 2.6 meters long and have a mass of about 800 grams (8.5 feet, 1.75 pounds). Javelins for women are 2.2 meters long and 600 grams in mass (7.2 feet, 1.3 pounds). The center of mass for



the javelin is about a meter from the tip. That means that the front end of the javelin is slightly heavier than the back end. This helps provide stability in flight. With the javelin flying true and not wobbling, air friction is reduced and the distance the javelin can travel is greater. If you didn't know better, you would think we were not talking sports but talking science. Well, we are talking science. Sports is mostly science in action.

Consider again the javelin's center of mass. As we learned earlier, all objects in flight tend to rotate around their centers of mass. Astronauts quickly discover this when they push off the wall of the International Space Station. A javelin with its center of mass in the very middle of the shaft will tumble or wobble when it is thrown. However, when the center of mass is moved toward the front end, it will fly true without wobbling and achieve the longest distance.

The reason for a javelin's true flight is the same reason a rocket flies true. Rockets have fins at their back ends. As long as they



Over 900 years ago, the first Chinese rockets were really rocket-powered spears (javelins).

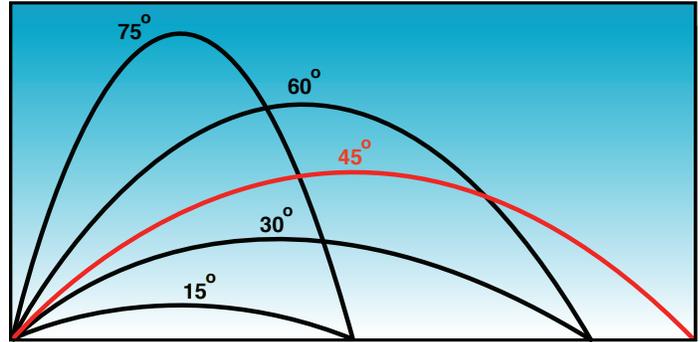
fly straight, the fins provide little friction, or drag, with the air. However, if the rocket begins fishtailing or wobbling from side to side, drag on the fins increases. Drag from the air exerts a force on the fins, turning them so that the rocket flies true again. It works the same way with javelins. They don't have fins but their lighter back ends stabilize the flight. Fins work better, but the principle is the same.

Another thing to know about the flight of a javelin or rockets is that the trajectory, or flight path, of both is curved. That's because of gravity. Inside the International Space Station, astronauts appear to move in straight lines. A push against the back wall of a module sends them straight down the middle to the other end. At least, their flight looks straight. It's really curved. The reason it looks straight is that the ISS is traveling on a curved orbit around Earth. If someone on the outside could watch you move down the module, that observer would see that you and the ISS are following curved paths together. It just looks like you are traveling straight when you're inside.

Let's go back to our Solar System Olympics. The javelin rocket event is about to start. Competing teams will be aiming their rockets at targets. They have to remember that gravity will affect the flight of their javelin rockets. That means they have to aim above the target so that gravity will curve the javelin rocket's flight right into the bull's-eye. How high they aim above the target depends upon how fast the rocket goes. Fast rockets arrive quickly, so gravity doesn't have much time to curve their paths. Slower rockets have bigger curves. The trick is to select the right launch

angle for your javelin rocket's speed.

Long ago on Earth, soldiers and Olympic javelin throwers understood the relationship between the speed of a javelin and the throwing angle. Look at the chart below. It shows five different javelin throws. If the javelin is given the same speed each time, the longest throw is achieved if the javelin is thrown at a 45 degree angle.



The arcs above reflect the flight of five javelins thrown with the same force. Gravity bends the javelin path. The difference in the flights is caused by the different launch angles.

The same applies for javelins thrown on the moon or Mars. The gravity of these two bodies will curve the javelin flight. However, gravity on the moon or Mars is considerably less than on Earth. The moon's gravity is only one-sixth that of Earth, and Mars' gravity is about two-fifths that of Earth. That means javelins will travel much farther if thrown with the same force and angle as on Earth.

The competition is starting. Competitors are aiming their rockets toward the targets. When ready, a blast of air will send the javelin rockets flying.



Thomas Morstead, punter for the Super Bowl Champion New Orleans Saints, employs the same science as a javelin thrower. Morstead has to judge precisely the angle of his punt to determine hangtime and distance. How far do you think his punts would travel on the Moon, or on Mars? Which of Newton's Laws is at work here?

Javelin Rockets

Objectives:

Students will:

- construct and fly paper rockets with Velcro-covered nose cones
- investigate launch angle versus distance with their rockets
- compete in a rocket javelin sports event

Preparation:

Obtain and cut 15-inch lengths of 1/2" PVC pipes, one for each student. See Page 13 for information on how to cut PVC. A PVC cutter from hardware stores is recommended but a fine-tooth saw and sandpaper will work as well. Also, prepare a felt target.

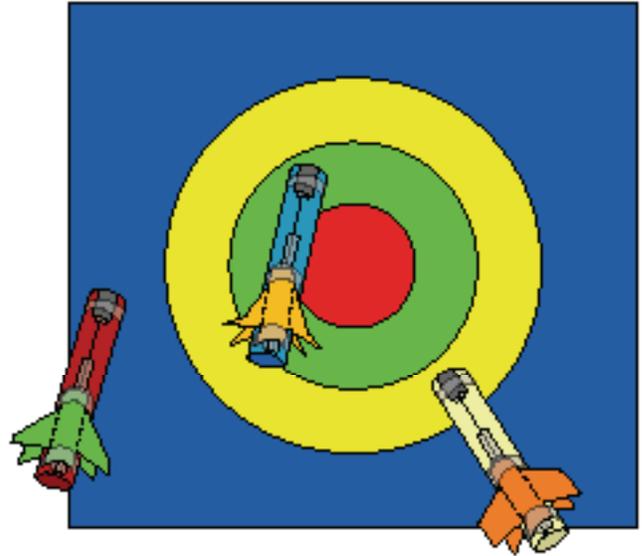
Materials:

 Per student or group

- 15-inch lengths of 1/2-inch PVC pipe (One per student)
- One rocket pattern on copy machine paper per student
- Scissors
- Cellophane tape
- Rulers
- Felt target (see instructions below)
- Two- to three-inch Velcro strips (adhesive or Velcro for sewing can be used)
- Marker pens or crayons for decorating rockets (optional)
- Meter stick or tape measure for measuring flight distances
- 12 inches of string or thread
- Small metal washer or nut

Management Tips:

Students will use the PVC pipe as construction forms for building their rockets. They will also use the pipe for launching their rockets by blowing through the end. Because of the low cost of PVC pipe, it is recommended that one pipe segment should be made for each student with their names written on them. Otherwise, pipes will have to be disinfected with a good cleansing and sanitizing agent between uses.



Some students may have trouble generating enough wind power to launch their rockets. Have them practice blowing through the pipes. Tell them to inflate their cheeks with lips closed to build up pressure inside their mouths, then sharply puff through the tube.

An alternative to students blowing through the pipes is to construct several “Pop! Rocket Launchers.” The launcher employs a 2-liter soft drink bottle as the pressure chamber, and students stomp on the bottle to force air through a PVC pipe to launch their rocket. The guide for constructing the launchers can be downloaded from the following NASA site:

<http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html>

Have students practice launching their rockets at different angles in an open space, such as a gym or cafeteria or outside. Let them discover the relationship between angle and distance. After students have explored launching their rockets informally, have students diagram what happens at different trajectories. Discuss their conclusions and other factors that might affect the flight of their javelins and then start the rocket javelin competition.

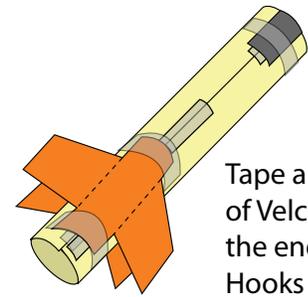
Making the Target

Obtain a large piece of felt from a fabric store. Felt is available in 72-inch bolts. Buy some smaller pieces of different colors for making the rings. Use fabric glue or stitching to hold the rings and bull's-eye in place. Mount the target loosely against a wall. Allowing the target to hang free provides some cushioning for the rockets and better gripping of the Velcro.

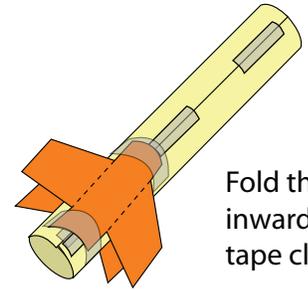
Procedure: Building javelin rockets

1. Set up a supply area for paper and tools.
2. Review the procedure for making javelin rockets. The diagram to the right shows the construction steps.
3. Have students cut their sheets of paper in half across the middle to make two sheets 8.5 by 5.5 inches in size. One sheet will be used to roll the rocket body, and the other will be used for making rocket fins.
4. Encourage students to design their own fins. Shapes for fin ideas are shown. The rectangular shape between the different fin shapes has been scaled and does not match the paper tube.
5. Conduct a preflight checkout. Make sure that the front end of the rocket is closed and that the Velcro is mounted securely with cellophane tape across the nose cone. If you are using adhesive-backed Velcro, it may not be necessary to use tape as well, but tape will help the Velcro stay in place.
6. Select an open area to test the rocket javelins. Caution students about aiming their rockets. They must not shoot their rockets at each other. Set up a firing line behind which all students must stand. Remind students to take notes on their data sheets. After all rockets have been fired, students may retrieve them. Remind students to try different launch angles and compare the angles to the distances the rockets fly.
7. Allow students to modify the fins on their rockets. They may wish to reduce their size or change their shape.
8. When all students are proficient with their rockets, then it is time to hold the javelin rocket event. Have students create the basic rules (e.g., how far away the target is, a point

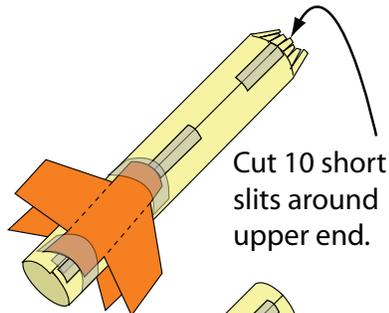
Ready for
LAUNCH!



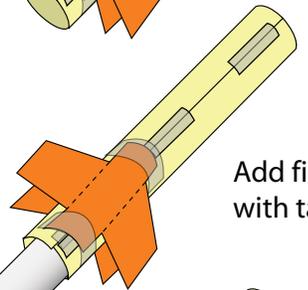
Tape a piece of Velcro over the end. Hooks outward!



Fold the tabs inward and tape closed.



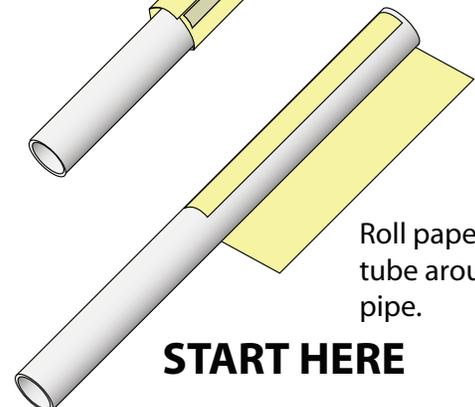
Cut 10 short slits around upper end.



Add fins with tape.



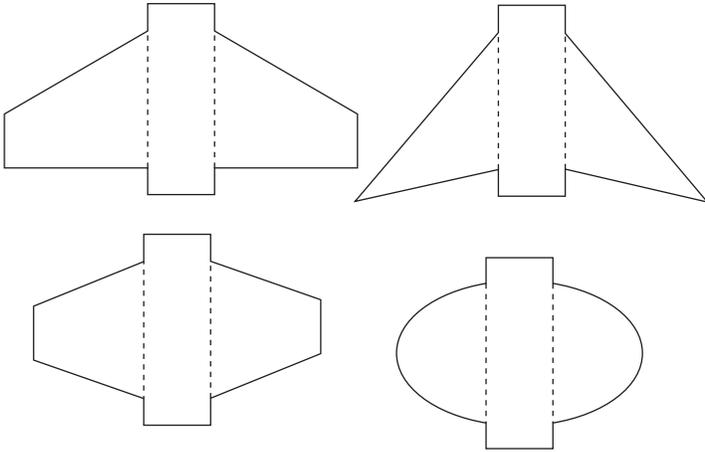
Tape seam.



Roll paper tube around pipe.

START HERE

Ideas for rocket fin shapes



(Not drawn to scale.)

scoring system, how many tries per person, etc.).

9. Hold the javelin rocket event and have the winners share their secrets - design of their rocket, aiming strategy, etc.

Assessment:

Collect student data sheets.

Discussion Questions:

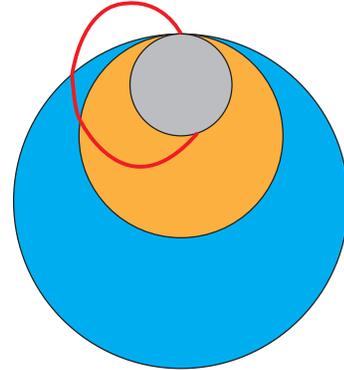
Is there a relationship between the launch angle and the distance the rockets flew? Explain.

Assuming students used the same force to launch their rockets each time, the answer is yes. Through trial and error, rockets launched at a 45-degree angle will fly the farthest. Rockets launched at a lower angle will be drawn to the floor by gravity before they have gone very far. Rockets launched at a higher angle will use up some of their momentum opposing gravity and will land closer to the launch site.

Will rockets travel farther across the surface of the moon or Mars if the same launch force is used? Explain.

Yes. There are three reasons for this. First, the rockets will fall more slowly on the moon or Mars because their gravity is not as strong as Earth's. Second, both bodies are much smaller than Earth. Although each is round, the curvature of Earth is flatter than that of the moon or Mars. A well-launched rocket javelin on the moon or Mars will fly over

the horizon and have farther to go before hitting the surface. Third, the moon doesn't have an atmosphere and the atmosphere of Mars is about 1/100 the density of Earth's atmosphere, at sea level. With little or no atmosphere, atmospheric drag is eliminated and greater distances are possible.



The same rocket flight is shown for Earth, Mars, and the Moon. Because of different diameters, the rocket will hit Earth's surface at a shorter distance from the launch site than it would on Mars or the Moon.

If rocket javelins were flown inside the International Space Station, how would they be aimed to hit the target? Explain.

The ISS and astronauts inside it are traveling together on a curved path that enables them to orbit the Earth. Because of this, a rocket javelin launched down the length of the ISS modules would appear to travel in a straight line. This requires a mental adjustment. On Earth, rocket javelins have to be aimed above the target because gravity causes the rocket to fall towards the ground. With just the right direction and speed, the rocket arcs to the target. In orbit, the illusion of traveling in a straight line means that you have to aim directly at the target.

Extensions:

- Challenge students to design a throwing game for the International Space Station. What is the object of the game? What will be used to make the game equipment? How could the game be made safe so it wouldn't hurt anyone or damage equipment in the ISS modules? Should a target be mounted or free-floating? Etc.

Javeline Rocket

Name: _____

1. Design and build your javelin rocket .

2. Follow the steps provided by your teacher to make the rocket body.

This is the long tube. One end of the tube will be closed off with tape and a Velcro strip will be taped over that end.

3. Decide what kinds of rocket fins you want your javelin rocket to have.

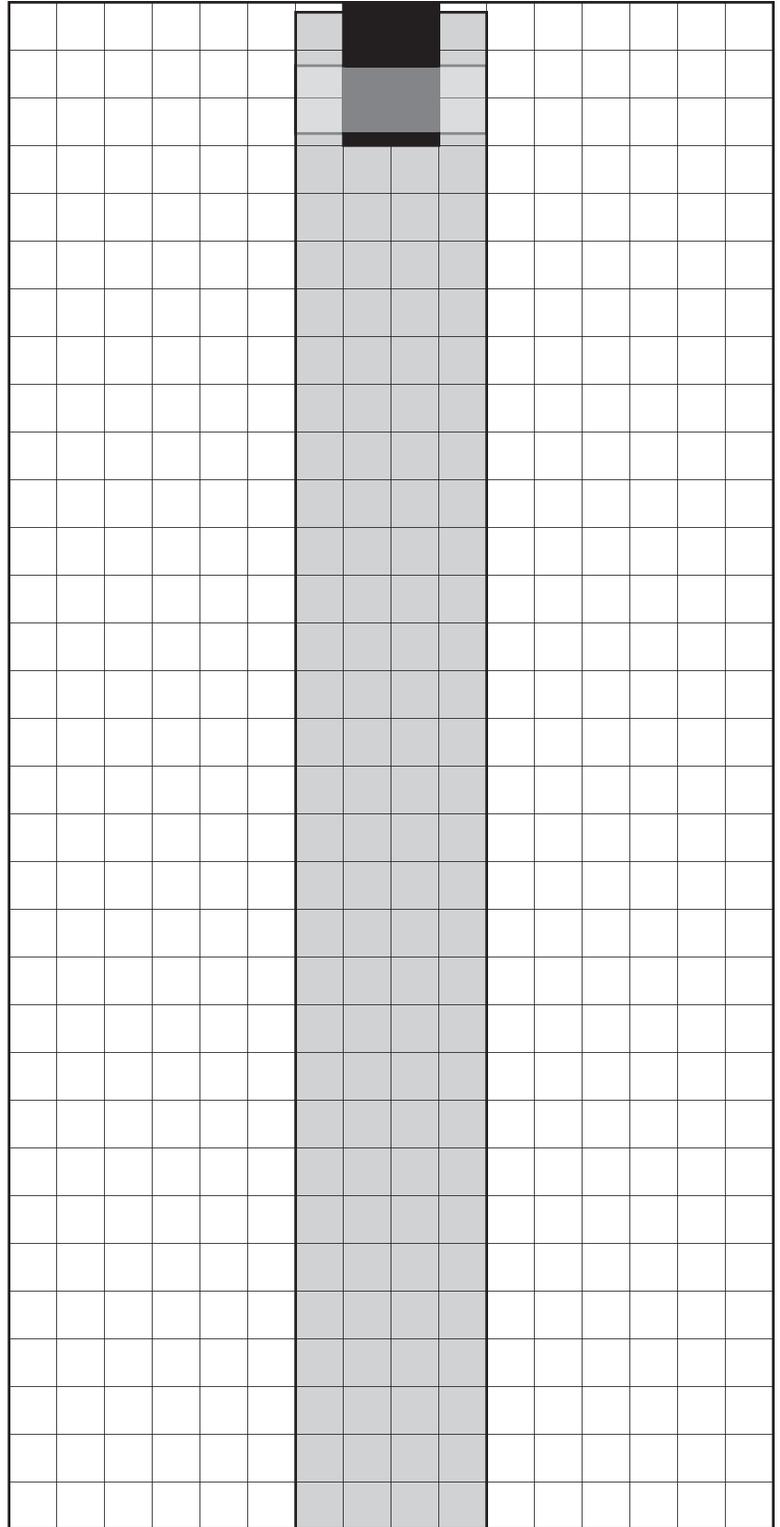
Draw a picture of what you want them to look like.

4. Make your fins and tape them to the lower end of the rocket.

If you want to change the shape of the fins, use the scissors to trim them.

Your rocket is ready to fly!

Front end of Javelin Rocket with Velcro held with tape.



Fins go on this end of the rocket.

Javeline Rocket

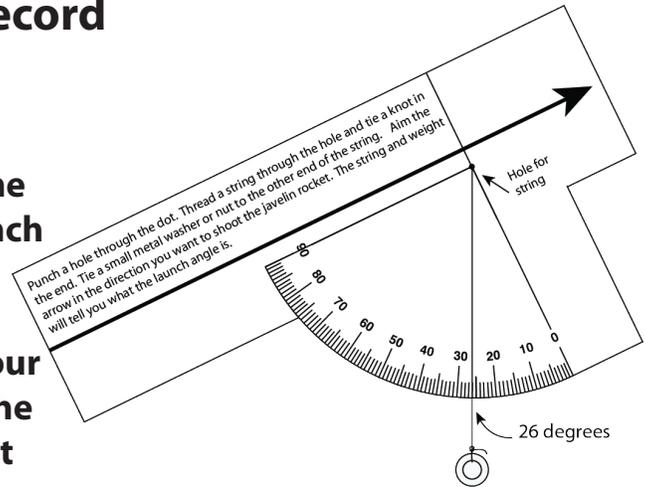
Name: _____

Practice Record

Test Flights - Launch Angle and Distance

Launch your rocket several times. Use the same amount of force each time. Estimate your launch angle using the quadrant sighting device.

Write the angle below and measure how far your rocket traveled. Measure to the point where the rocket hit the floor and not to where the rocket slides or bounces to.



Which launch angle worked best?

Launch Angle	Flight Distance

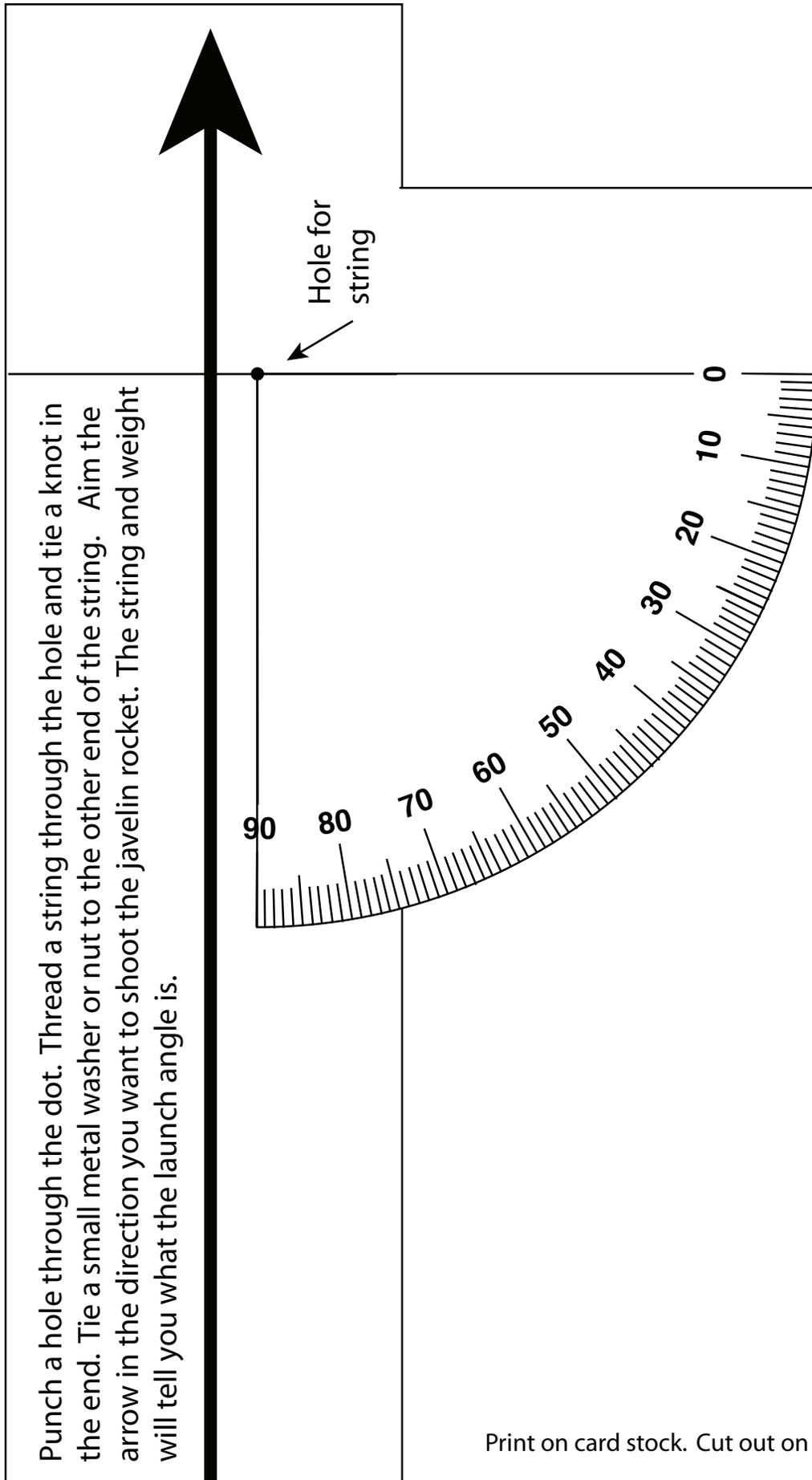
Using the space below, describe how your rocket flew. (straight, curved, spun, etc.)
Did you do anything to make it fly better?

Javelin Rocket Competition Record

Try to hit the target with your javelin rocket. Use your practice flights to determine which launch angle will send your rocket to the bulls-eye.

Use the space below to describe your results.
(on target, dead center, missed, close, etc.)

Sighting Quadrant for Javelin Rocket



Print on card stock. Cut out on solid lines.