CATAPULT

OBJECTIVE:

You will demonstrate the principles on which a catapult is based.

INTRODUCTION:

The catapult was one of the earliest war machines, dating from at least as long ago as the ancient Romans. They used a device they called an *onager*, meaning "wild ass," a name probably derived from the bucking action of the machine. Another catapult weapon used by the Romans was the *carroballista*, a horse-drawn cart carrying a catapult and requiring eleven people to operate.

Most of the ancient or medieval catapults relied on two basic principles: leverage and torsion, a force caused by twisting a length of material. A long throwing arm was secured at one end to strong cords, which were twisted by winches. This action lowered the arm to a horizontal position. Releasing the arm released the tension on the twisted cord, forcing the arm upright at a great force. Projectiles could be thrown up to 500 yards.

The principles on which the catapult is based apply in other weapons, including the slingshot and the crossbow. Today, catapults are no longer used as war machines in themselves, but they are used on ships such as aircraft carriers to launch military planes from the ship's deck.

Here you will make a model of the onager type of Roman catapult and demonstrate the force of torsion.

TIME NEEDED:

1 hour

MATERIALS:

Note: You will need a partner for this investigation.

- Funtak®
- 6 in. x 8 in. x 1 in. wooden block
- 2 4-in. nails
- hammer
- thick rubber band, 2–3 in. long and at least 3/16 in. wide
- 2 small rubber bands
- plastic teaspoon about 6 in. long
- tape measure
- transparent tape
- glue
- 2 pencils
- ruler
- drawing compass
- protractor
- paper clip
- 2 pieces of heavy cardboard, 8 in. x 6 in. and 6 in. x 4 in.
- piece of medium-weight cardboard, 4 in. x 3 in.
- electronic balance weighing to the nearest 0.25 gram

Note: You will need a table or other flat surface at least four feet long.

Original Materials:

In the onager, a large skein of grass was twisted and locked into position, causing the throwing arm to be parallel to the ground. A missile was placed in the spoon-shaped end of the throwing arm. Usually the missiles used were large rocks thrown at enemy walls, but sometimes burning objects were thrown to increase the damage, or rotting corpses were hurled into towns under siege to spread sickness.

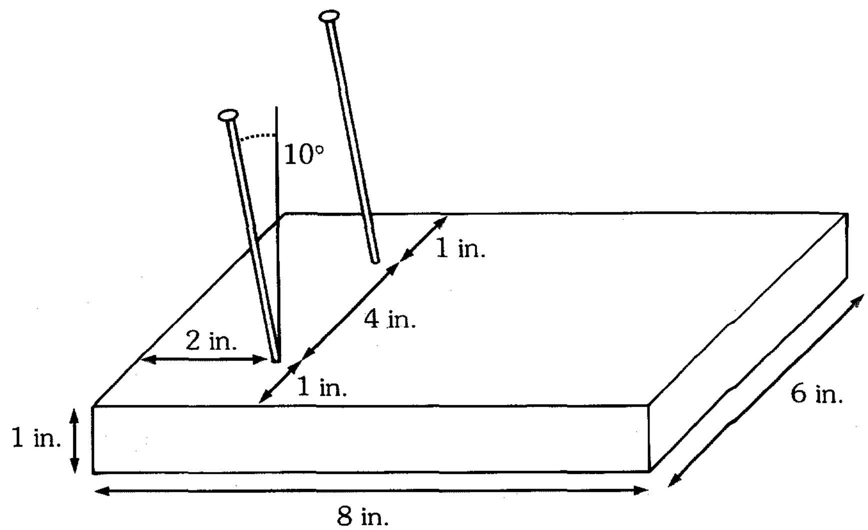
Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Be careful when twisting the rubber band and firing the catapult. Only fire soft projectiles (in this case, balls of Funtak®), and make sure no people or breakable objects are in the line of fire.

PROCEDURE:

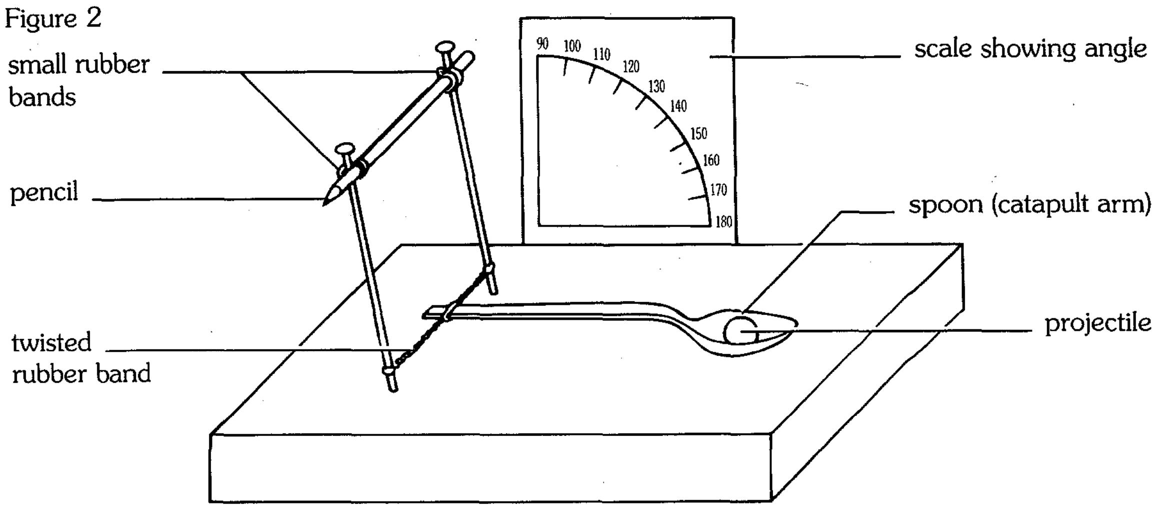
1. Take the wooden block and lay it flat. This is your catapult base. Measure and mark two holes, 4 in. apart, each 2 in. from a short edge and 1 in. from a long edge (see figure 1).
2. Hammer one nail into each hole in the catapult base. The nails should be pointing slightly forwards at 10-degree angles (see figure 1).

Figure 1



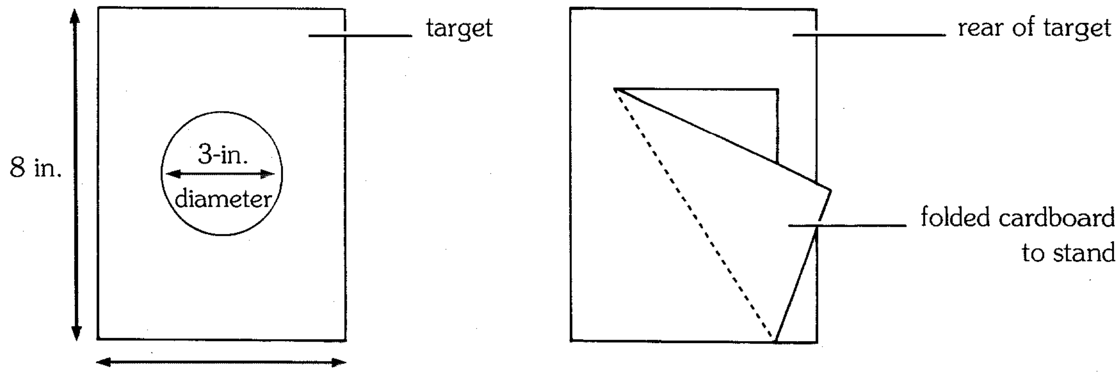
3. Loop the thick rubber band around the two nails near the base. Insert the paper clip in the middle of the rubber band and use it to twist the band by twenty turns. Insert a plastic spoon between the paper clip and the elastic band and then withdraw the paper clip so that the spoon is caught in the twisted band. Adjust the height of the band so that the spoon is horizontal when pulled back fully.
4. Attach the pencil horizontally to the nails using the small rubber bands. Adjust the position of the pencil (throwing bar) so that when the spoon is released, it comes to a halt in the vertical position (see figure 2).
5. Using a protractor, draw a scale from 90 to 180 degrees on the 4 in. x 3 in. sheet of cardboard. Tape this to the side of the catapult base. It is important to align the left-hand bottom corner of the scale with the twisted rubber band so that you can obtain correct readings for the angle of release.

Figure 2



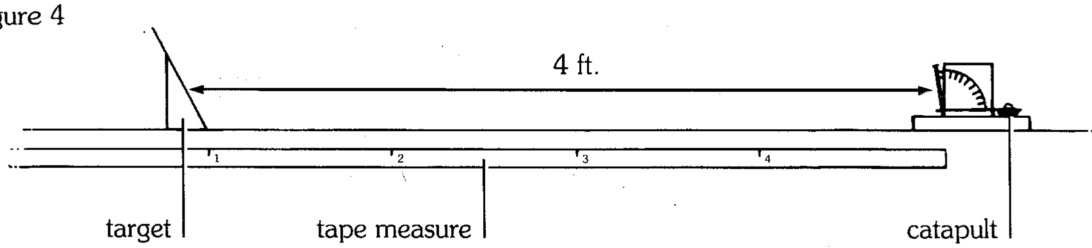
6. Use a drawing compass to draw a target on the 8 in. x 6 in. sheet of cardboard, as shown in figure 3. Fold the remaining sheet of cardboard to form a stand on which the target can rest (see figure 3). Glue this to the back of the target.

Figure 3



7. Set up the catapult on a level surface four feet away from the target (see figure 4). Extend the tape measure from the catapult to the target and tape it in place, either on the side of the table or on the table. This will allow you to measure the distance traveled by fired projectiles.

Figure 4



8. You will investigate two factors: the size of projectile and the angle of release of the catapult. Begin by investigating the effect of using projectiles of different sizes. Mold Funtak® into balls weighing 1/4 g, 1/2 g, 1 g, and 2 g.

9. Place the 1/4 g ball in the spoon. Hold the spoon in its horizontal position (full power)—or 180 degrees—with your index finger, then release it. Have your partner note the distance traveled by the projectile. Repeat this procedure twice, and work out the average of the three readings.

10. Repeat step 9 using the 1/2g, 1g, and 2g projectiles. Record the average for each.

11. Decide which is the most appropriate size of projectile to reach the target, based on your findings. Fire this projectile by releasing the catapult at an angle of 160 degrees. To do this, hold the spoon at the point where the scale reads 160, then release it. Record the distance traveled. Repeat this procedure twice, and calculate the average of the three readings.

12. Repeat step 10, but hold the spoon at an angle of 140 degrees. Record the average, then repeat at angles of 120 and 100 degrees.

ANALYSIS:

1. Which size of projectile is most effective at reaching the target? Why do you think this is so? (Hint: Try to use the relationship between force and mass—force = mass x acceleration—in your explanation.)

2. At which angle of the spoon (throwing arm) is the catapult most effective? Why do you think this is so?

3. In this investigation, you studied two variables that affected the distance traveled by the projectile. Using the same equipment, which other variables might you have studied?

4. Do some research. The projectile fired from a catapult is subject to two forces. What are these forces?

5. Do some research. The projectile in motion falls toward the earth in an arc. What is the name of this curve? Why would it be useful to know about this curve when firing a catapult?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific investigation. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly when you are constructing or demonstrating a model invention. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each project you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while carrying out these projects. Be sure to check the individual projects in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning projects
—Read the instructions before you start
—Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one project at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk or bench
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders
—Never look directly at the sun with your observation devices

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES