# Bottle Rocket Launcher

P4-2000

## BACKGROUND:

The Bottle Rocket Launcher allows for the exploration of launching rockets using commonly available materials such as plastic soda bottles and cardboard tubes. It also provides an exciting introduction to aerodynamics and rocketry.

## CONTENTS:

One (1) Launcher (includes locking mechanism and check valve)
One (1) Plumb line with weight.

## REQUIRED ACCESSORIES:

Bicycle or other air pump
Tire pressure gauge
Dowels or straight sticks (3 or 4)
Tape
Glue
Scrap cardboard
Water
Common pin, tack, or nail

## WARNINGS:

**Do:**
Do Wear Protective Eye Gear
Do Wear Protective Clothing (rain gear)
Do Stake Launcher Securely into the Ground
**Do Not:**



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Do Not Aim at Anyone
Do Not Pressurize beyond 40 psi
Do Not Stand Over Pressurized Rocket
Do Not Stand Within 10 Feet of Launching Rocket

## ASSEMBLY:

Congratulations! Your new bottle rocket launcher will let you use any ***standard plastic soda bottle*** with capacities of 500 ml to 2 liters! When choosing a bottle to use for rocketry, remove the cap and check the bottle's neck ring for any cracks or defects that may fail when pressurizing the bottle. If the bottle looks good you're ready to begin building your rocket. You're probably anxious to get started right away; and there's no reason you can't!

Pass the air hose through the center of the metal apparatus. Press the rubber stopper firmly into the neck of the bottle. Notice the two molded arms. Swing these arms up so that each fits over the neck ring on your bottle. When the neck ring is firmly held by both arms, insert the U-shaped locking bar. As manufactured, this should allow for easy bar removal even though bottles vary. See the assembly diagram for details.

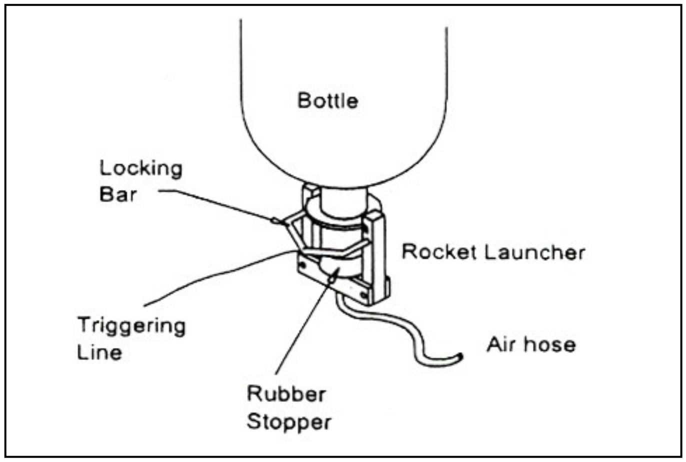


Figure 1
Attaching the rocket launcher to your bottle

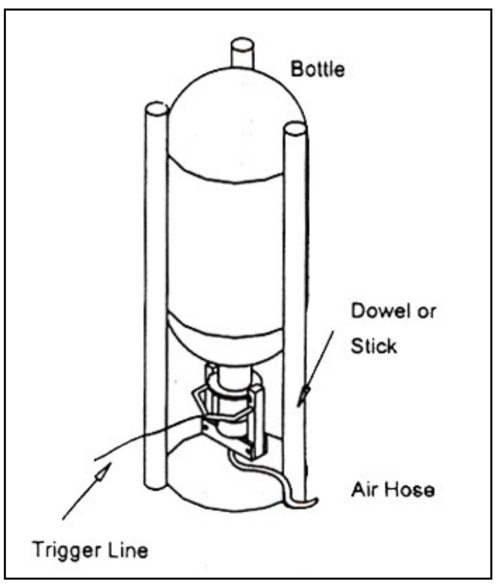


Figure 2
Building a Launch Pad

Remove the stopper and partially fill the bottle with water, reassemble, and prepare according to the details below. When you've found an appropriate launch site, press the two long pointed legs of the launcher a few inches into the ground. This will anchor the launcher in place. ***A quick launch pad can be made by pushing three dowels or sticks into the ground equally spaced around each bottle.*** These dowels will help hold the bottle (and any later payload) upright while pressurizing and launching the rocket. Before you begin to pump up the bottle, there are a few precautions you must take and most of these are common sense.


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## PRECAUTIONS:

1. While pumping up the bottle, periodically check the pressure. Use a pump with a built in pressure gauge and measure the pressure while pumping.
2. Do not exceed 40 psi.
3. Don't look down on the rocket during or after pressurization.
4. Don't aim your rocket at any people, buildings, or other structures.
5. Always set up your rocket well away from any trees, telephone wires, or houses.
6. Do not launch your rocket in parking lots where it may damage someone's car.

Remember, when you pull the cord, you are the pilot in command and are responsible for that particular flight! So be careful! Now that you understand the precautions that must be observed with every flight, the bottle is now ready to be pressurized!

## LET'S BLAST OFF!

Begin by "fueling" your rocket with ordinary water. This works because every bit of water that gets forced out of the bottle produces an equal and opposite momentum that speeds the bottle upward! The more water and the faster the water escapes the bottle, the faster the bottle will move and the higher it will go.

When the bottle is half full, reassemble the stopper, molded arms and locking bar as before. <u>Before pressurizing, make sure that the stopper and arms are well centered on the bottle.</u> Then, attach your bicycle pump to the valve stem into the end of the pressurizing hose and start pumping. When you have reached 40 psi you are ready to launch. Stand away from the rocket and tension the trigger string. After announcing the countdown to launch (every professional rocket pilot should count down from 10…9…8…) give the trigger line a sharp tug. This will release locking mechanism and the rocket will blast off from the pad with lightning speed! This marks the successful launch of your first rocket!

## DISCUSSION:

Now that you've launched some rockets, your head may be full of ideas for better designs to get it to go higher, fly further, or have increased thrust. The following are a few suggestions to help you get started.

The stability of the rocket depends upon the rocket's length. You'll find that longer rockets fly straighter than shorter rockets. Long cardboard tubes make excellent bodies for bottle rockets. The larger diameter tubes often found in rolls of gift and Christmas wrapping paper will make the best bodies. Smaller diameter tubes will work but they are not as strong and may not hold up as well under repeated use. Another method of constructing rocket bodies is to tape several paper towel tubes together.

Fins can also improve the stability of the rocket. Experiment with different size and shape fins. The fins do not have to be very large to be very effective! The fins can be made using scrap cardboard from old boxes. Select your cardboard carefully, making sure that it is reasonably flat and does not have bends or folds in it. Draw your fin pattern on a sheet of paper and then use this pattern to cut the number of fins you need from the cardboard sheets.



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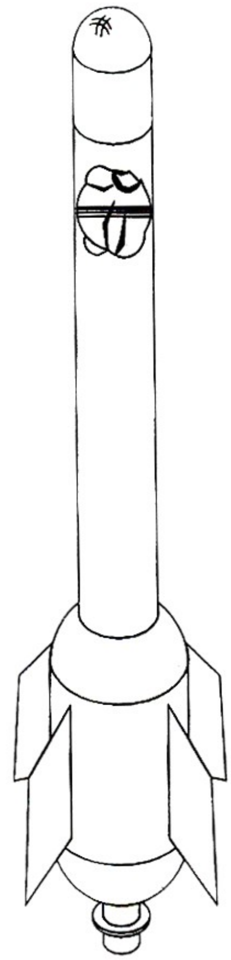
These fins can then be glued or taped to the body of the rocket.  The fins could also be taped to the bottle itself!  The fins work the best when placed near the bottom of the rocket, but you can also experiment by placing the fins at varying positions along the body. **Do not use metal fins.**



The nose of the rocket is another point of consideration.  The nose of the rocket must do two things: first it must streamline the rocket so the air will pass over it more efficiently, second: it must hold the parachute or other recovery system or it must be able to absorb the impact of the rocket as it hits the ground.  The nose cone can be made of cardboard rolled into a cone and then taped to the top of the rocket, or you may want to use a smaller plastic bottle turned upside down so the smooth round bottom of the bottle points upward on the rocket. **Do not use metal parts.**

The parachute can be made by cutting a circular patch from a large plastic garbage bag.  Six lengths of string each about sixty centimeters long (2 feet) can be cut and taped around the perimeter of the parachute.  After each string is taped in place, gather the free ends of the string together and tie them into a knot.  This knot can then be taped to the inside of the rocket body tube.  The parachute can then be gently rolled up and placed in the rocket body.  After the parachute is loaded the nose cone can be rested on top of the rocket.  Don't tape the nose cone to the rocket body if you want the parachute to come out!

An inverted nose cone, securely taped, can carry a parachute—or even a ball. The bottom 10cm of a 2 liter bottle, well taped to the top of the pressurized bottle, has lofted a real soccer ball!

## ROCKET SAFETY:

Now that you have finished building your high performance rocket, it is worth repeating a few of the safety rules that have already been mentioned.

1. Do not exceed 40 psi while pressurizing the bottle.
2. Don't look down on the rocket during or after the pressurization.
3. Don't aim your rocket at any people, buildings, or other structures.
4. Always set up your rocket well away from any trees, telephone wires, or houses.
5. Do not launch your rocket in parking lots where it may damage a car.

**Remember-as pilot in command, you are responsible for each and every flight!**



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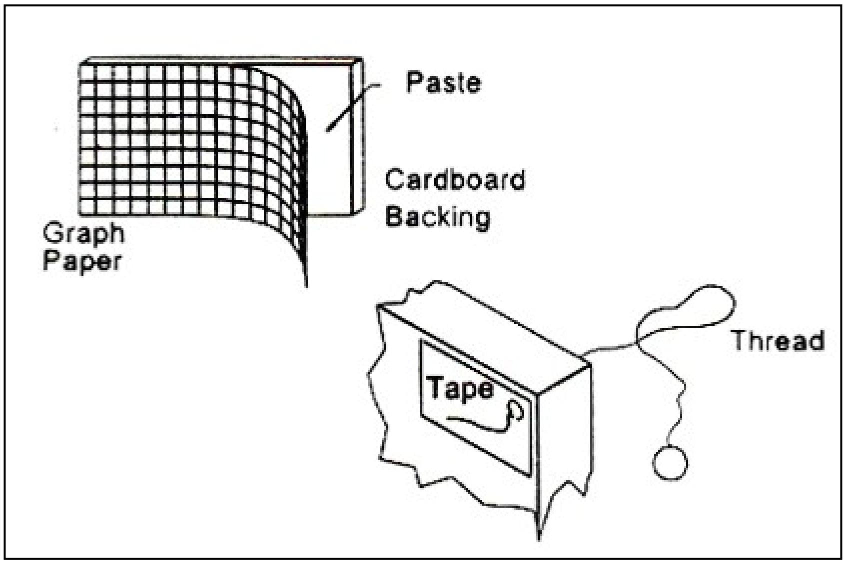
## ROCKET EXPERIMENTS:

"Whoa! How high did that thing go?" has probably been a question you've asked several times as you watched your rocket soar overhead. There is a Relatively simple method you can use to measure the altitude of your rocket! It is simply a sheet of graph paper mounted on a sheet of cardboard with a plumb line attached to one corner.




To assemble the altimeter, paste the altimeter face (found at the end of this manual) to a flat sheet of cardboard that has been cut to the same size. Make sure the top edge of the cardboard is flush with the top edge of the altimeter page. Use a common pin to poke a hole through the cardboard at the top front corner where indicated. Slip one end of the plumb line (thread for this is included) through this hole.

**Figure 4**
**Assembling the Altimeter**

Tape the thread to the cardboard backing where it comes through the hole. Tie weight (large washer) to the free end of the thread as in **Figure 4.** Your altimeter is now ready to use.

Let's start by measuring the height of something you know. First, measure the distance between the object you're measuring and the position you will be standing when you measure its height. This distance is called the "BASE" and should be at least 10 meters. Hold the altimeter card at eye level and sight along its top edge. **Some find it easier to tape or glue a soda straw along the top edge as a sighting tube.** The place where the thread is taped to the cardboard should be away from you. Tip the cardboard upward until the top edge of the cardboard is pointing at the top of the object you're measuring. When the string is hanging freely and no longer swinging, pinch it against the face of the altimeter with your finger, as in **Figure 5.** You can now read the altimeter by finding an intersection on the graph paper that the string crosses.

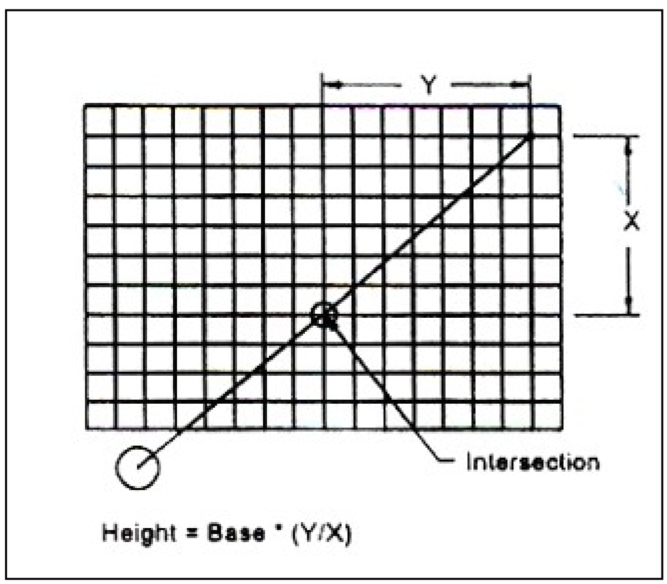



**Figure 5**
**Reading the Altimeter**



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Read the quantity "Y" from the horizontal axis of the graph paper (this is proportional to the height of the object) and read the quantity "X" from the vertical axis of the graph paper (this is proportional to the distance between you and the object). Using similar triangles, the rocket altitude or "HEIGHT" can be calculated by using the following formula:

HEIGHT = BASE * (Y/X)

Where: HEIGHT = height of the object
BASE = horizontal distance from the object
Y = measured from the altimeter (horizontally)
X = measured from the altimeter (vertically)

Don't forget to add your own height to the calculated height! Actually, you should measure the distance from the string hole down to the ground, and add that to your calculated height. Your most accurate measurements of height, using this device, will be found when your horizontal distance from the object, in value, is close to the actual altitude of the object.

The altitude of the object will have the same units as does the horizontal distance from the object. In other words, if you measured the distance from the launch pad in meters, then your calculations will produce an altitude in meters. If you measured the distance from the launch pad in feet, then the altitude will be in feet.

**Note:** Altitudes can be easily found using the Arbor Scientific **Altitude Finder** (P4-2250).

Now that you are able to get accurate measurements of the rocket's altitude, you're ready to do some serious experimenting! Remember – change only one thing at a time; keep everything else constant!

For example, to measure the effect of pressure on the rocket's altitude, use the same rocket, pour the same amount of water into the bottle, and then, for each experiment, pressurize the bottle to different amounts. Record each launch on a data sheet that might look like Table 1.

Table 1.

**Rocket Launch Data:**

| Launch # | Water Used Ounces or Grams | Rocket Weight Pounds or Kilograms | Pressure Used PSI or kPa | Altitude Feet or Meters |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |



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You could then plot the data on a graph with the pressure on the horizontal axis and the altitude on the vertical axis. The next series of experiments might increase or decrease the amount of water used but keep the pressure the same each time. In this case, use a high enough pressure so that all the water gets expelled. Notice the relationship between amount of water expelled and the altitude reached. By throwing water in one direction, the rocket is thrown in the opposite direction. Water and rocket have equal and opposite momenta, according to Newton's Third Law.

Try changing the rocket's length, or the rocket's weight. The combinations are almost endless! Just remember, keep records, plot graphs, and only change one parameter at a time!

## EXTENSIONS:

You may want to have competitions with friends to see whose rocket will go the highest, stay in the air the longest, carry the most weight, or land closest to a specified spot.

What happens if no water is used, only air? What happens if there is more water in the rocket than the air can expel?

What exciting ways can you find to recover a rocket and a payload by separate parachutes?

## PRODUCT MODIFICATION NOTE:

The Bottle Rocket Launch has had a part change from the older U-Shaped Wire Locking bar to a the new

Easy Release Clear Plastic Locking Bar. See the figure below for launch placement.

When inserting the "Clear Plastic Locking Bar", insert at the top of the launcher arms as shown here



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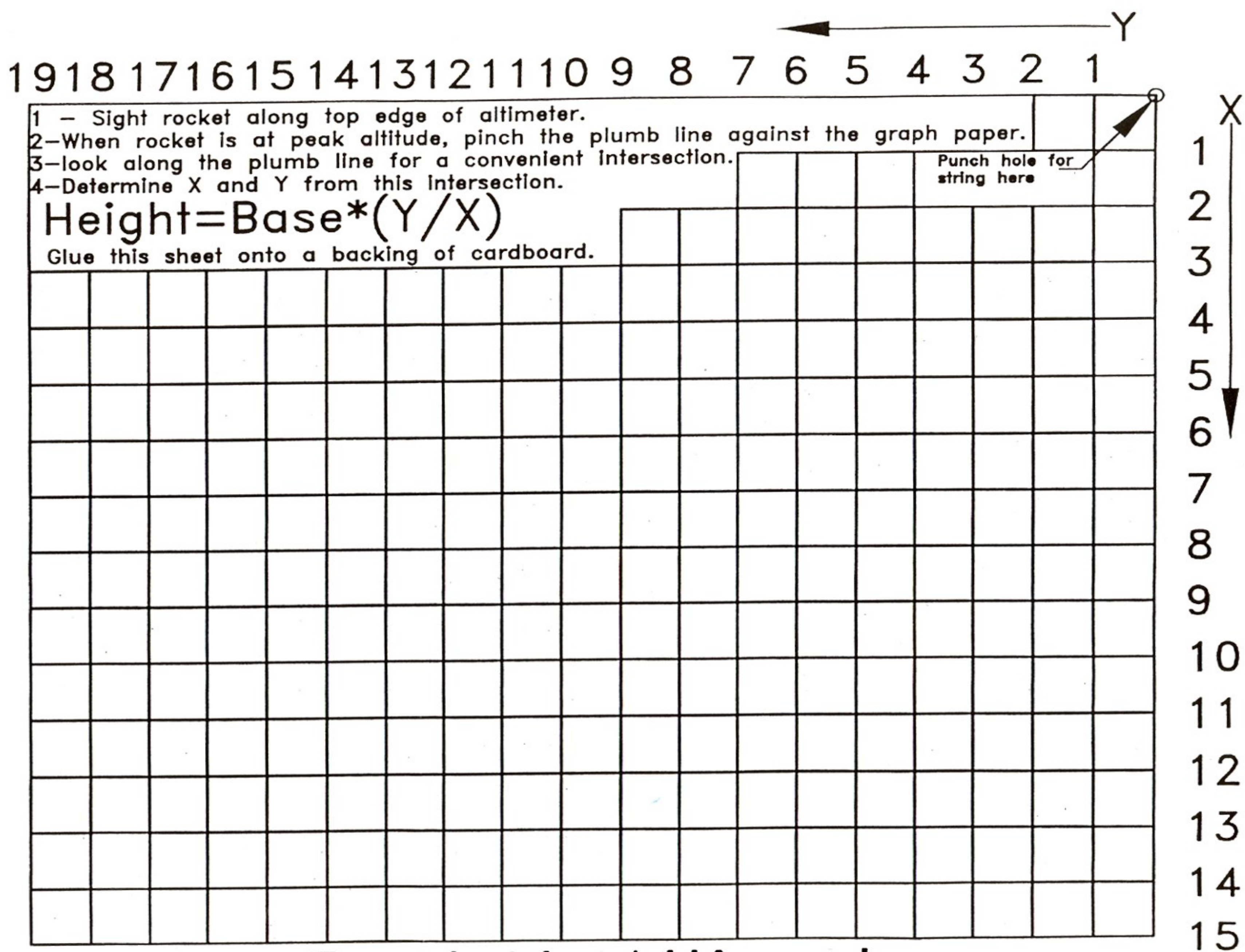


# –Rocket Altimeter–