Water Rocket Requirements

- 1. Read and familiarize yourself with the instructions in the "How to Build a Bottle Rocket" Slide show. Make sure you go through ALL of the information. Not just the part on how to build it.
- 2. Find the Rocket Simulator on the website and familiarize yourself with how to use it. Make sure you are using the Water Mode. Located in Media Library—Student Stuff—Water Rockets—Water Rocker Simulator—RocketModeler.
- 3. Start bringing in the materials you will need for your rocket. (Wings, nose cone, body, payload etc.)

Water Rocket Requirements

1. Make your Rocket Plans.
    1. Fill out the “Water Rocket Plan”. It is on slide 25 of this power point. (Copy and Paste it into your Power Point)

1. Test your Rocket in the Rocket Simulator. Located in Media Library—Student Stuff—Water Rockets—Water Rocker Simulator—RocketModeler. Use the Water Rocket Simulator Power point to help you understand the program.

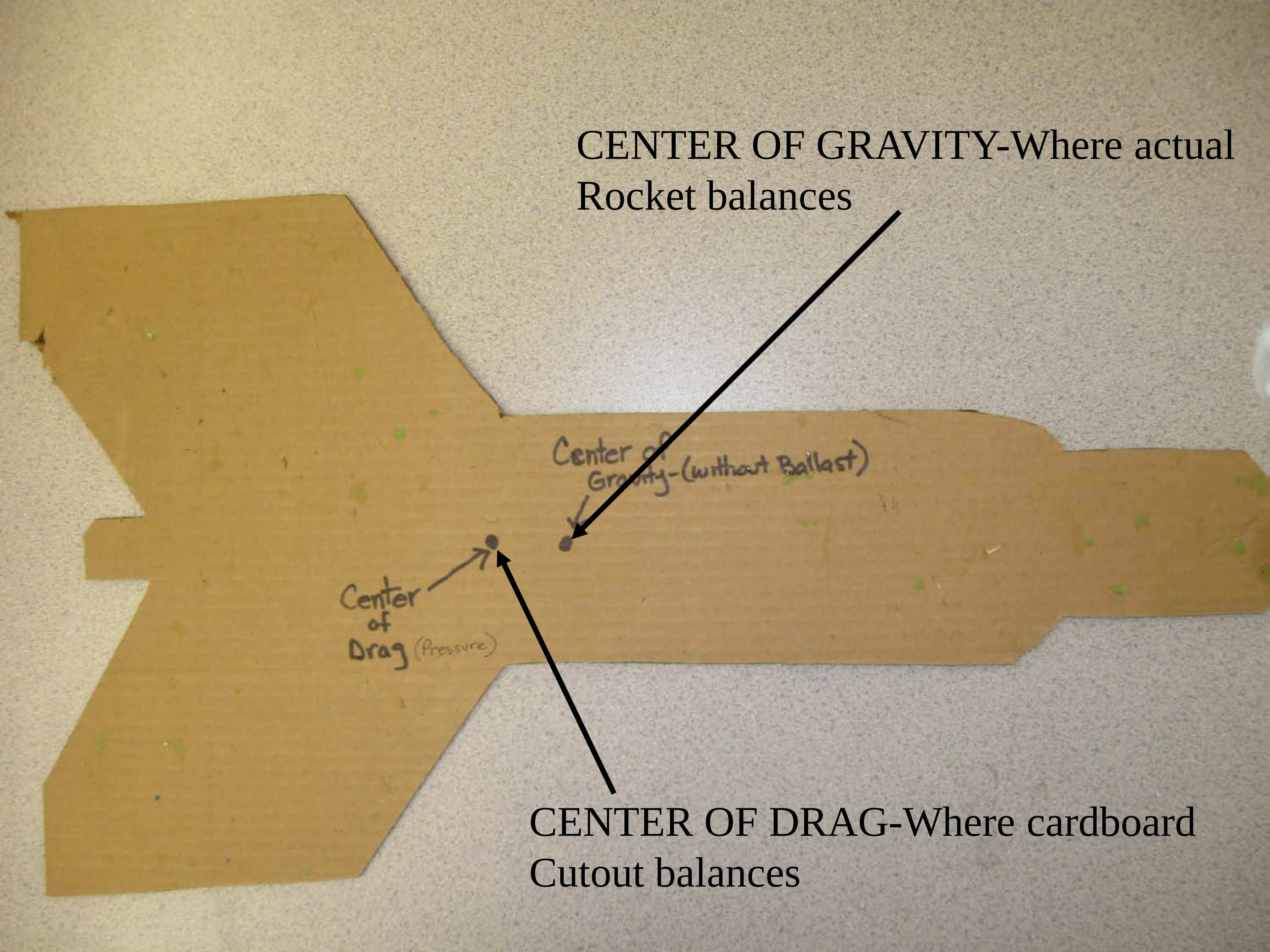
1. Include the results of your Simulation in your power point. Use the print screen function to show how you used it and the results as part of your power point presentation.

1. Redesign based on your tests.

Water Rocket Requirements (Cont.)

1. Gather your materials.
2. Build your Rocket.
    1. It must be decorated in a professional looking manner.
    2. You must have a pattern for the wings.
    3. You must have a plan for the wing alignment and spacing.
    4. Make a cardboard cut-out and test the COG and COD.
3. Test Flights- One test flight per rocket.
4. Rebuild- Redesign or reconfigure.
5. Final Tests-Time in the air will be the determining factor.

CARDBOARD CUT-OUT


CENTER OF GRAVITY-Where actual Rocket balances
Center of Gravity-(without Ballast)
Center of Drag (Pressure)
CENTER OF DRAG-Where cardboard Cutout balances

Power Point

- A labeled picture of your rocket with the components and the function of each.
  - Nose Cone
  - Payload-Lunar Module
  - Body-Propulsion Chamber
  - Wings
  - Nozzle
- Why did you design your rocket like you did?
- Results of your Simulation
- What factors effect the flight of the Rocket and how?
- Label the materials used and why it was or was not effective.
- ***You may use any part of this power point in your presentation.***

How to Build a Water Bottle Rocket

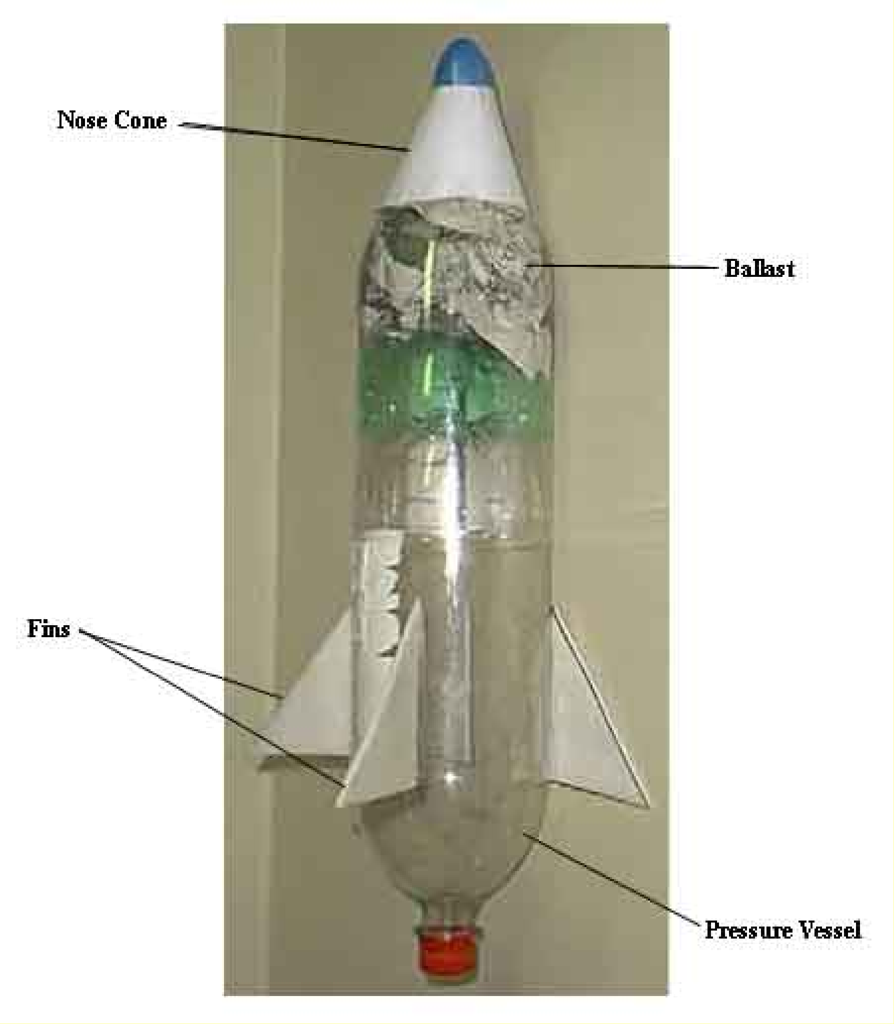
Science

Fall 2006

Materials

- 2 Two-Liter Bottles
- Newspaper (Ballast)
- Foam Tray (Fins)
- Paper (Nose Cone)
- Tape
- Scissors
- Marker

Parts of Rocket



- Nose Cone- For aerodynamic effect
- Ballast adds mass to rocket to increase stability.
- Fins- For aerodynamic effect
- Pressure vessel- source of rocket propulsion

Rocket Body

Step 1)

Cut the bottom portion of one of the two liter bottles off.

Rocket Body: Ballast

Step 2)

Roll up newspaper in balls and place in top half of two liter bottle.

- You can use other items as ballast such as: Sand, Foam peanuts, etc.

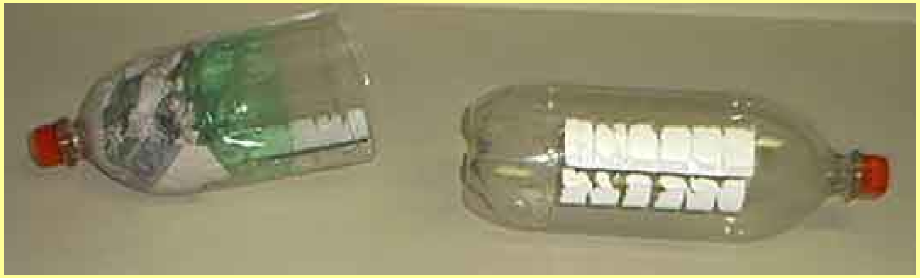
Rocket Body (cont.)

Step 3)

Push bottom half of two liter bottle upside down into top half – to keep ballast in place.

Use small pieces of tape to secure bottom piece inside bottle.

Rocket Body (cont.)



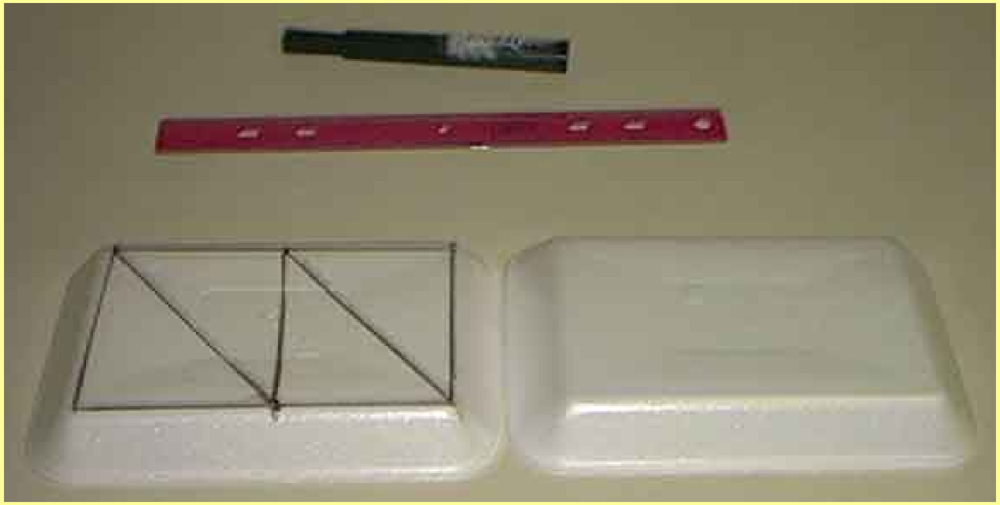
Step 4)

Place two liter bottle (pressure vessel) into top half. Try to make bottles straight. Use little pieces of tape to secure bottles.

Materials for Fins

- Foam trays
- Unused election signs **(Only after election is over)**
- Cardboard
- Corrugated Plastic

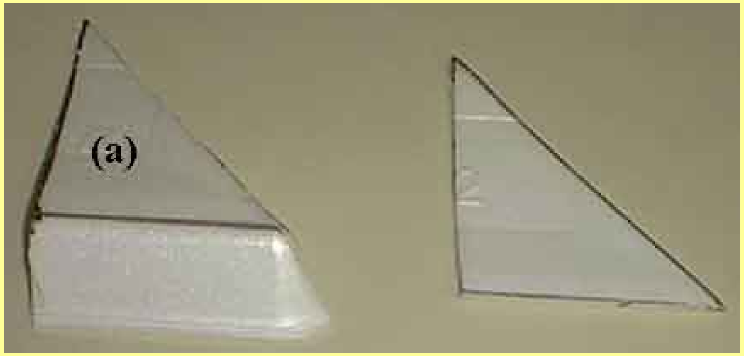
Fins

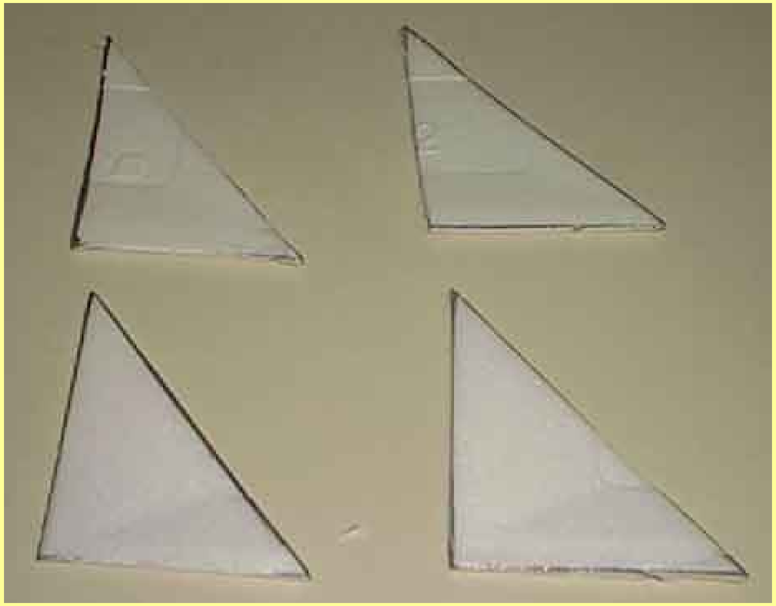


Step 5)

Use marker and draw fin patterns on foam trays.

Fins (cont.)





Step 6)

Cut fins out.

Note:

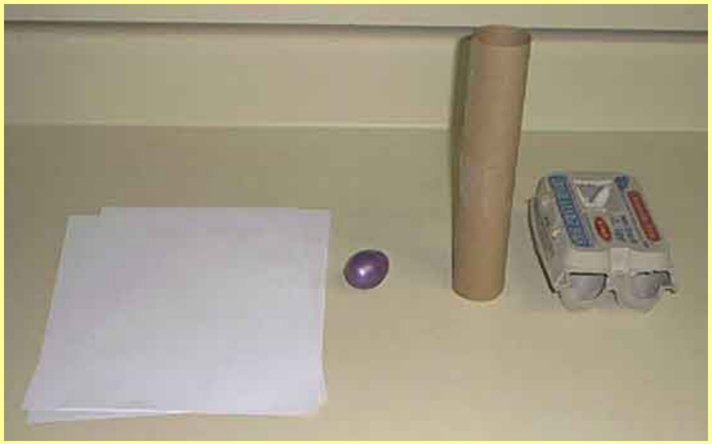
(a) If leave sides of tray attached to fins – will allow rocket to spin in flight.

Fins (cont.)

Step 7)

Attach fins to rocket using small pieces of tape.

Nose Cone: Materials



- You can use many materials to make a nose cone.
- It is against the rules to have a point on your nose cone. The tip most be rounded. To create a rounded tip you can use an egg carton or a plastic egg shell.

Nose Cone

Step 8)

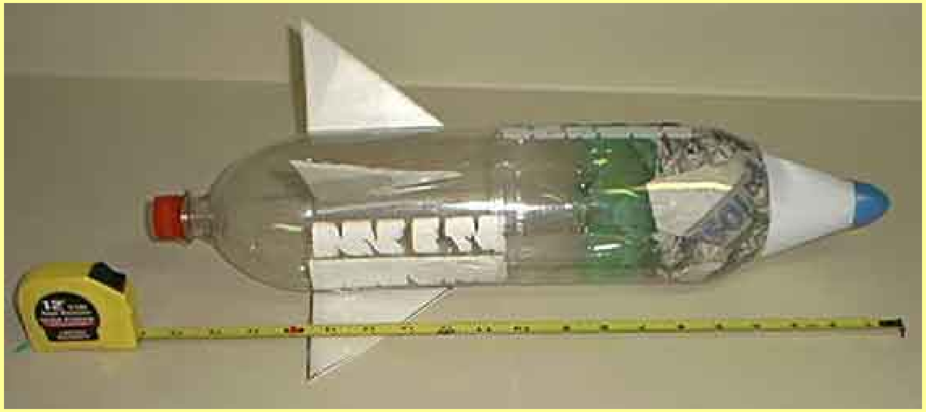
Roll paper into a cone. Use tape to hold paper in place. Place plastic egg shell on the cone as tip. Use tape to fasten tip to cone.

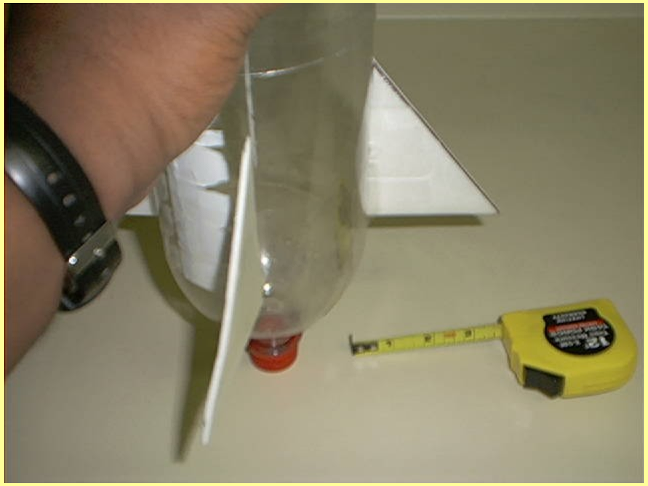
Nose Cone (cont.)

Step 9)

Fasten nose cone to body with tape.

Measure

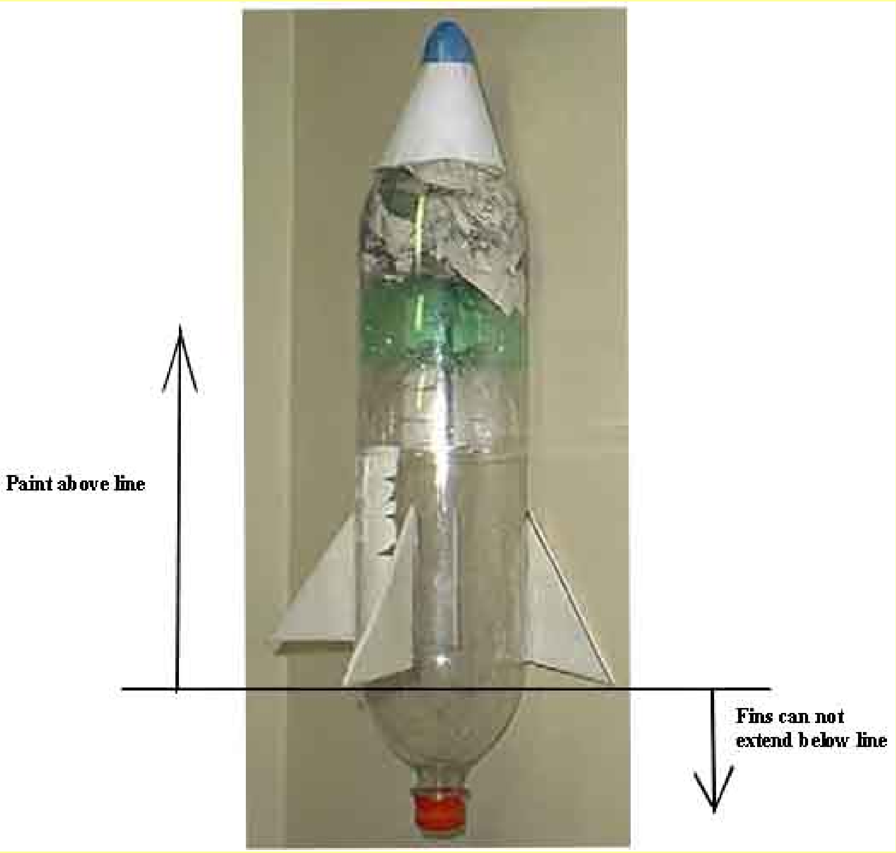




Step 10)

Measure parts of your rocket to make sure they are equally spaced.

Decorating

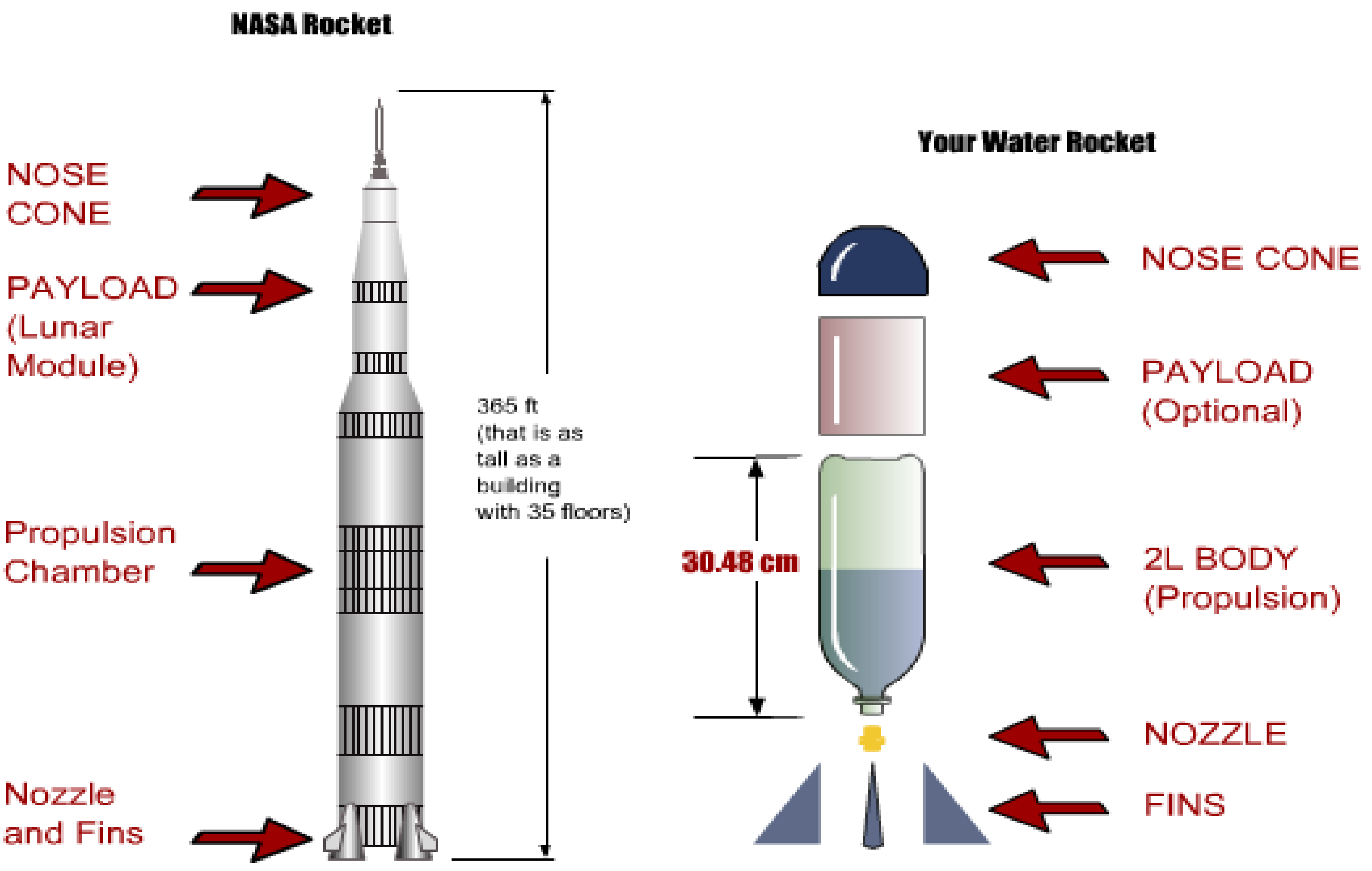


- You may decorate with stickers, your patch design, etc.
- The bottom half of your rocket must remain clear of any paint or decoration.
- Fins cannot extend past bottom half.

Tips

- Lengthening the rocket adds stability
- Experiment with different fin shapes
- Try different body shapes
- Try to make body smooth (no kinks with tape).
- Do not use hot glue gun to fasten parts of your rocket together.
- Use small pieces of tape (incase you mess up you can easily remove it).
- Do not leave two liter bottles in hot car.

Components of a Rocket



http://www.grc.nasa.gov - Rocket_Parts_animation - Mozilla Firefox

Water Rockets - The Parts

Water rockets consist of the following parts:

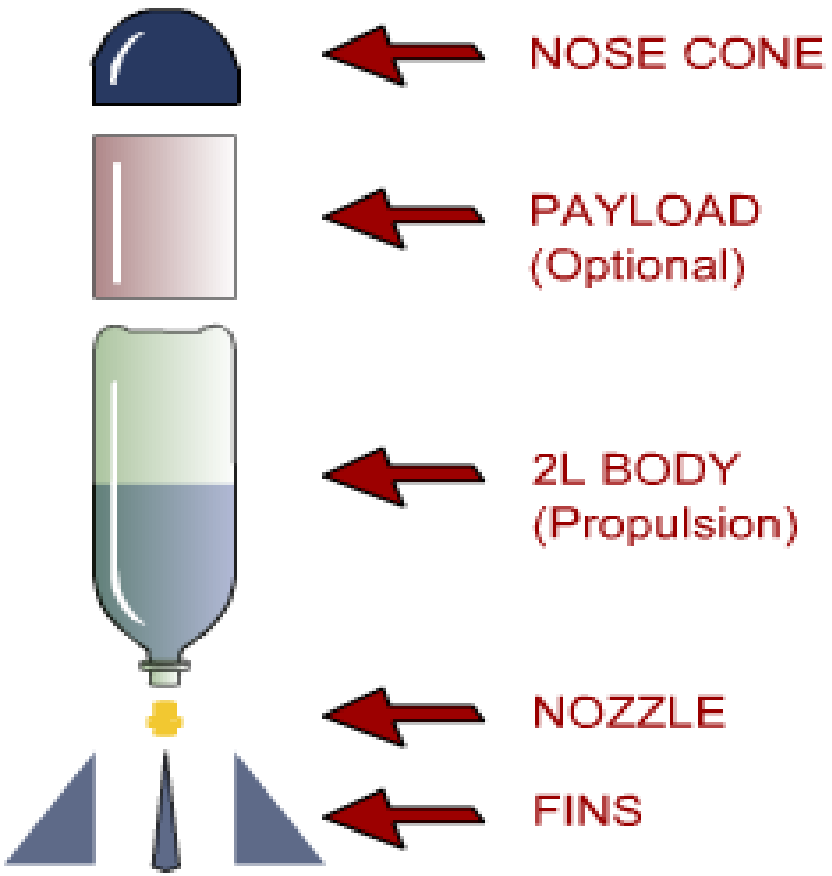
Nose Cone - an extension of the bottle that comes in a variety of shapes and is used to improve the aerodynamics of the rocket.

Payload section - an optional section that could hold a parachute or a payload.

Body - a 2 liter soda or pop bottle that serves as the propusion compartment or "engine" of the water rocket.

Nozzle - a part that fits into the bottle opening to help in the propulsion of the rocket and provides a mounting point for launchers.

Fins - a part that helps to stabilize the water rocket.



Example Water Rocket

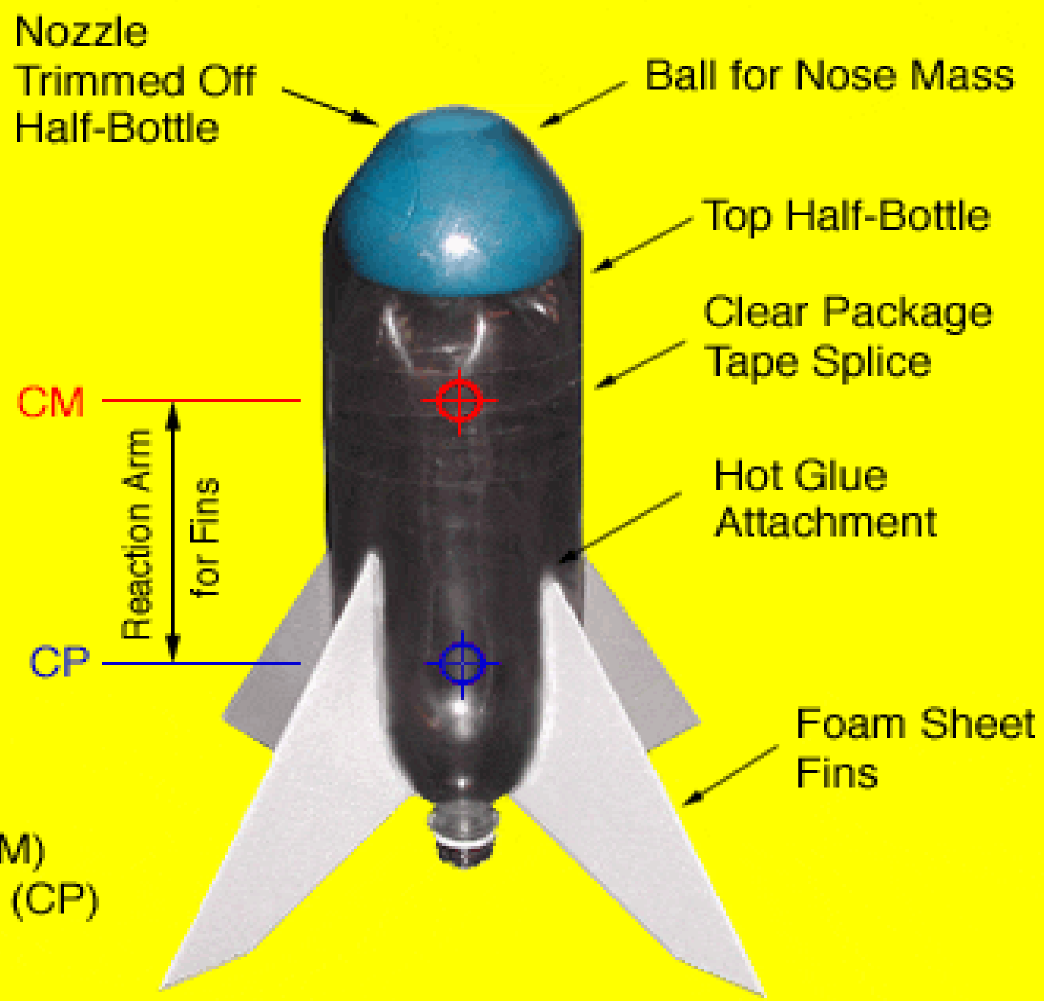
Parameters to Consider

Nose
- Smooth
- Streamlined
- Rugged
- Optimal Mass

Body
- Smooth
- Holds Pressure
- Optimal Length

Fins
- Smooth and Thin
- Light & Stiff
- Optimal Shape

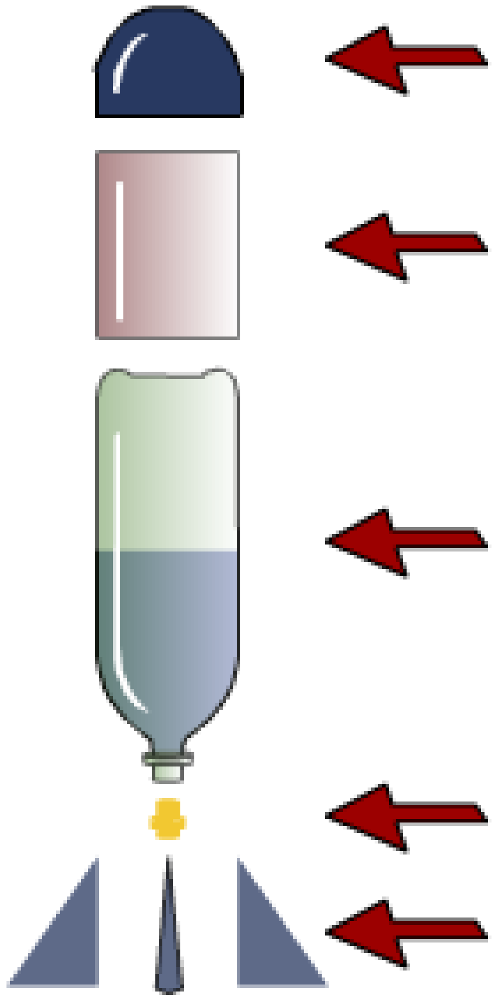
Stability
- High Center of Mass (CM)
- Low Center of Pressure (CP)
- Use of Launch Tube



Water Rocket Plan

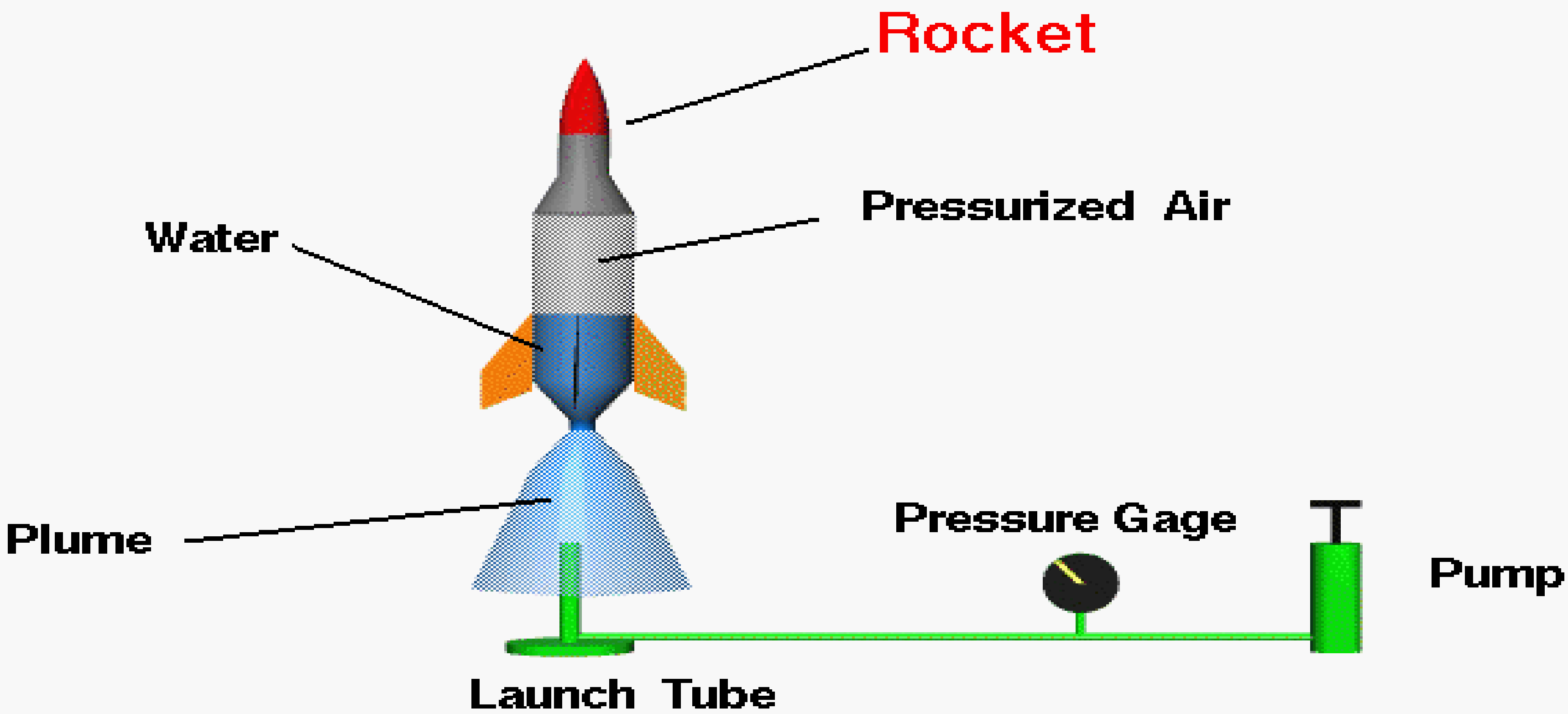
Name ______________________

What will you use to hold the parts together?____________________



Name of Component	*Materials Used*
________________________	____________________
________________________	____________________
BALLAST__________	____________________
________________________	____________________
________________________	____________________
________________________	____________________

Rocket Components



Center of Gravity/Center of Drag

Stability

*This bit is the same as in the 1½ litre 'Egglofter' rocket so, apart from the fact that this rocket requries 20 pence (70 grammes) in the nose, you can fix the weight in place and then skip onto the next part - **Water**.*

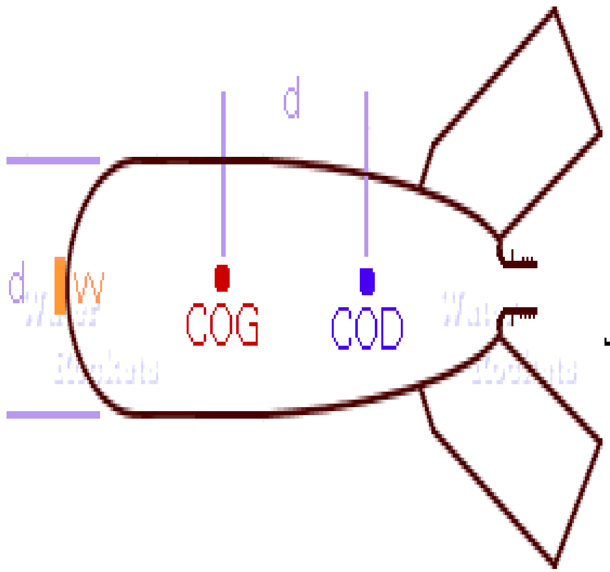
Ideally, you want the thing to fly straight as any deviation from this will reduce the rocket's performance. Once the thrust phase of the flight is out of the way, the rocket is essentially in free fall (*even though the first part of this free fall is upwards*). For it to maintain its attitude in the air, there are a few things that you will need to consider: the positions of the effective centre of drag (COD) and the centre of gravity (COG). With a small rocket such as a water rocket, it is fairly easy to find out where they are but you also need to know what to do with them. First, how to find them.

To find the COG, try to balance the rocket on its side so that you find a point that is reasonably stable. The COG is above this, on the axis of the rocket as in the diagram. (*If it is not on the axis, you have a problem*).

To find the COD, cut out a piece of cardboard the same shape as your rocket as viewed from the side and find its centre of gravity (*it need not be the same size as the real rocket as long as it is to scale and that you remember to scale it back when you have found it*). The centre of gravity of the cardboard model corresponds to the centre of drag.

Once you have put your fins on (*which you should have done before you started trying to find the COD*), the COD is going to remain almost in the same position, no matter what you are going to do with the rocket (*within reason*) wheras the COG may be moved by adding weight to the rocket. Ideally, the rocket should weigh as little as possible so you want to add only the barest minimum of extra weight.

COG/COD Continued



So where does the COG want to be? The **COG** needs to be between 1 and 2 rocket body diameters (**d**) forward of the **COD** - in free flight, the COG effectively pulls the rocket forwards and the COD pulls it back - if they are between 1 and 2 rocket body diameters apart, they are able to exert enough of a couple (*a couple is a pair of equal and opposite forces that do not share the same axis and therefore tend to have a twisting effect*) to correct the rocket's attitude during flight.

To move the COG forwards, make a mark with a pen on the rocket where the COG needs to be and then tape coins to the front of the rocket (*at point **w***). Once you have found out how many you need, you can make a neat job of it with tape (*or glue*) so that the aerodynamic qualities that you have devoted so much of your time to are not lost.

I found that for the 4 litre bottle combination that I did this to, I needed 10 x 2p pieces. (*A UK 2 pence piece weighs approximately 7 grammes or ¼ ounce*).

Water Amount

We now have a water rocket that is aerodynamically sound. We know that we will be able to pump it up to a pressure of between 4 and 6 BarG (*between 60 and 90 psig*) and we can measure it. So, how do we know how much water to put in it?

We need to know its tare weight, volume, diameter and nozzle dimensions to be able to work out how much water it will need for a flight with the greatest height.

We can measure its nozzle, body diameter and weight it empty to get its tare weight but we have changed its volume so we don't know that any more - the volume of liquid it had when you bought it was not the same as its nominal volume either and in addition, there has to be a certain amount of ullage (*head space*) so as to take into account the expansion of the liquid when it gets hot so that the bottle doesn't burst in the shop. All we can do is measure it and the best way to do that is as follows. . .

Weigh the rocket empty (*you will need this for the computer model anyway*). Fill it to the top with water and weigh it again. Take the former from the latter and you have your volume (*close enough*) as, for the purposes of water rocketry, 1 gramme equals 1 cm^3.

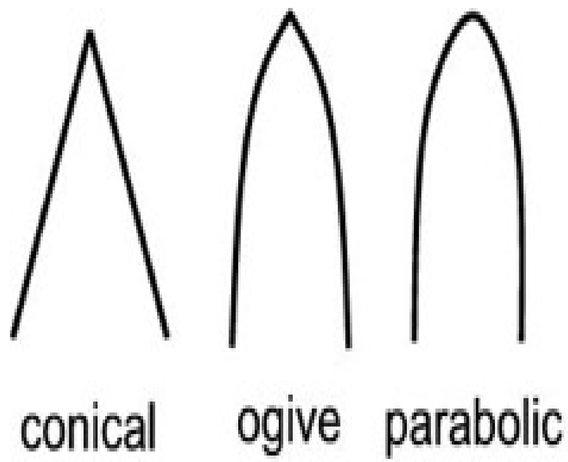
These figures were then fed into my computer model and the weights in the table below were calculated to be the optimum for the pressure range.

To put them into practice, put a piece of gaffer tape along the side of the rocket and weigh in the optimum amount of water. Mark on the gaffer tape where the water comes to, screw a top on, invert it and make another mark (*in such a way that you will not be confused - possibly using an arrow pointing upwards*). This will make life easier when in the field and you haven't got access to the scales.

If your rockets have tare weights or capacities that are different to these, you can use the above graph to work out roughly the right weight of water optimised for height - this assumes that the rocket capacity and diameter are roughly in proportion.

Nose Cones

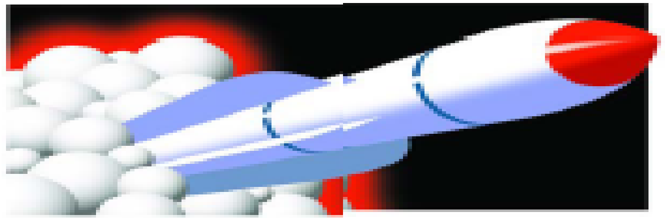
Nose cones, along with fins, are one of the most critical aerodynamic components of a rocket. A simple paper cone taped on top of the rocket is enough to significantly reduce the rocket's coefficient of friction, however more complex shapes may be used to further improve a rocket's performance (and some are surprisingly easy to make). There are three common shapes used for nose cones: conical, ogive and parabolic, as shown in the diagram below.



A common misconception is that the most aerodynamis is the conical shaped nose cone. This probably comes from the fact that frequently space-going vehicles have nose cones this shape (for example the space shuttle's solid rocket boosters). However this shape is only suitable for supersonic flights (above the speed of sound). For water rockets, which only achieve a speed of about 1/4 to 1/3 the speed of sound, a parabolic shape turns out to be the most efficient. Similarly, you often see model rockets (the pyrotechnic type) with parabolic nose cones as well. Several methods exist to construct nose cones of this shape. The simplest and quickest is to use the top of another bottle cut off and taped or glued (or attached some other way) to the top of the rocket. Another technique that is used is guppying. This involves heating the bottom of a pressurised bottle so that it expands into a rounded shape. While this method does give very good results, it takes a lot of practice to get right.

Build An Air-Powered Bottle Rocket

GRADE: High school



PURPOSE

3…2…1…Get ready to blast off into a highflying and even higher excitement activity. Your students are going to design, build, and launch an air-powered rocket. This will be an exciting way for students to learn about aerospace engineering.

KEY TERMS

Newton's First Law – Objects at rest tend to stay at rest, and objects in motion tend to stay in motion at a constant speed in a straight line unless acted upon by an unbalanced force.

Newton's Second Law – The net force acting on an object in a given direction is equal to the mass of the object multiplied by the acceleration of the object in the same direction as the net force.

Newton's Third Law – The force of one object (object 1) acting on another object (object 2) is equal in magnitude and opposite in direction to the force of the second object acting upon the first.

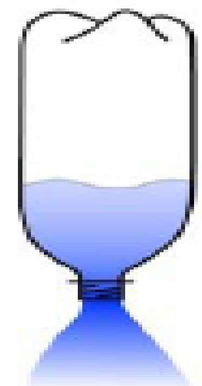
Center of Gravity (CoM) - The point at which the entire weight of a body may be considered as concentrated so that if supported at this point the body would remain in equilibrium in any position. (O). Same location as center of mass.

Center of Pressure (CoP) - The point on a body where the sum of the total pressure acts. Pressure acting on a surface causes a force. The point at which the sum of these forces, from the various surfaces of the body is the CoP.

EQUIPMENT

- 3 Altitrak altitude finders
  http://www.sciencekit.com/category.asp_Q_c_E_756062
- 1 three bottle rocket launcher
  http://www.sciencekit.com/category.asp_Q_c_E_439894
- 1 1/2 liter PET bottle (one per student with extras)
  http://www.sciencekit.com/category.asp_Q_c_E_439894
- Bicycle Pump with Gauge
  http://www.sciencekit.com/category.asp_Q_c_E_439894
- Duct Tape – One roll per 10 students
- Ghostline Poster Kit (Walmart) With 1/2"Grid Pattern
- Coroplast (Corrugated Plastic Sheets)
- Markers and Decals
- Duct Tape
- Glue sticks
- Low-temperature glue gun
- Water
- Clay
- Plastic garbage bags
- String
- Safety glasses
- Graph Paper

PROCEDURE



1. Form groups.
2. Introduce the bottle rocket activity.
3. Sketch preliminary rocket designs.
4. Talk about safety.
5. Give students materials to begin construction.
6. Demonstrate how to find center of mass (CM) and center of pressure (CP).

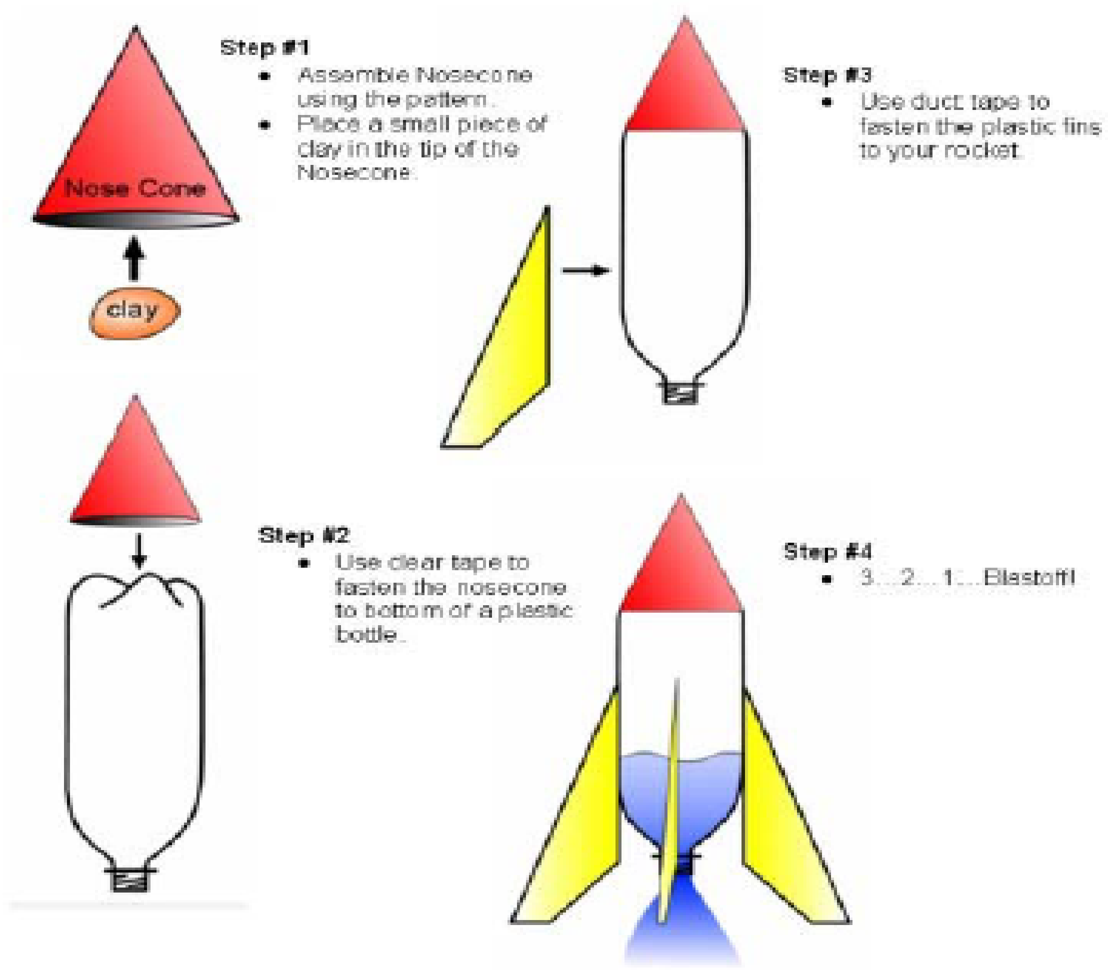
- The Center of Mass (CM) can be found by locating the balancing point of the rocket.
- The Center of Pressure (CP) can be found by tying a string around the rocket body so that it does not slip. Have the students stand in a wide open area and swing their rocket in a circle. If the rocket points in the direction they are swinging, it is stable. If not, have the students add more clay to the nosecone or replace their fins with larger ones. This test should be repeated until the rocket points in the direction they are swinging.
- The CM should be closer to the nose cone than the CP.

7. Discuss launching safety.
8. Demonstrate the correct use of the Altitrak to measure the height of rockets at apogee.
9. Complete post launch documentation.

SAFETY GUIDE

- Following these safety procedures will ensure all students safely enjoy this activity.
- Only plastic drink bottles should be used for rockets. No Glass!!
- Bottles should be retired from use after 15 launches.
- Supervise students closely when they are using rockets.

- Launch rockets in an open grassy field or athletic field away from buildings. If it is a windy day, place the launcher closer to the windward side of the field.
- As you set up your rocket on the launch pad, observers should stand back several meters. It is recommended that you rope off the launch site.
- Do not point your water rocket at another person, animal, or object. Water rockets take off with a good deal of force from the air pressure and weight from the water.
- The team member responsible for pumping air into the rocket should wear eye protection. The bottle rocket should be pumped no higher than about 50 pounds of pressure per square inch, but never above 90 psi. Before launching, consult the following table.
- When pressurization is complete, everyone should stand in back of the roped off area for the countdown. Two-liter bottles can weaken and will explode. Bottles should be retired from use after 10-15 launches.
- Continue to count down and launch the rocket only when the recovery range is clear.
- If you do not experience successful liftoff, remember that the bottle is pressurized and may blast off when you touch it. Be careful; do not let it hit you. Never stand over the rocket.



Nose Cone Template