



# POW WOW 2004 - Rocket Fun

**Date:** January 24, 2004

**Course Session:** Sessions 1, 4

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**Objective:** Learn how to make safe, simple non-fuel type rockets (paper, pencil, water rockets) to incorporate in your den or pack program.

## On-line Resources:

- <http://quest.arc.nasa.gov/space/teachers/rockets>
- <http://www.grc.nasa.gov/WWW/K-12/airplane/bgmr.html>
- <http://edtech.kennesaw.edu/web/solar.html>
- <http://www.water-rockets.com/javasim/index.html>
- <http://homes.managesoft.com.au/~cjh/rockets/links.html>
- <http://mpassero.tripod.com/rocket/index.htm>

## Rocket Pop! Launch Pad:

- [http://www.everyoneslaser.com/rocketpop/rocketpop\\_sales.htm](http://www.everyoneslaser.com/rocketpop/rocketpop_sales.htm)

## Class Outline

- |   |       |
|---|-------|
| I. Introduction                             | (5')  |
| - Distribute Handouts                       |       |
| - Sign-in Sheet                             |       |
| - Brief history of Rockets                  |       |
| II. Rocket Principles                       | (3')  |
| - Newton's 3 Laws of Motion                 |       |
| - Rocket Pinwheel                           |       |
| III. Incorporating into Den or Pack Program | (5')  |
| - Wolf, Bear, Webelos Achievements          |       |
| - Space Theme                               |       |
| - Rocket Derby                              |       |
| - Rocket Derby Patches                      |       |
| IV. Rocket Safety                           | (2')  |
| V. Types of Rockets & Construction Tips     | (20') |
| A. Paper Rockets                            |       |
| B. Pencil Rockets                           |       |
| C. Alka-Seltzer Rockets                     |       |
| - Basic Film Canister                       |       |
| - Canister with Fins & Nosecone             |       |
| - Double canister                           |       |
| D. Water Rockets                            |       |
| - Basic Water bottle                        |       |
| - Water bottle with fins & nosecone         |       |
| - Paper Tube rockets                        |       |
| - Florescent Tube rocket                    |       |
| - Launch Pads                               |       |
| E. Rocket Car                               |       |
| VI. Rocket Construction                     | (15') |
| - Form in groups of 5 people each           |       |
| - Each group will build soda bottle rocket  |       |
| VII. Rocket Launch.                         | (10') |



## Den & Pack Activities with Rockets

### Den Activities:

|                       |   |
|-----------------------|---|
| Wolf Elective 5g:     | Make a model rocket.                          |
| Bear Achievement 21f: | Make a model of a rocket.                     |
| Elective 1d:          | Build a model of a rocket or space satellite. |
| Webelos Scientist 5:  | Show the effects of air pressure.             |
| 6:                    | Show the effects of water & air pressure.     |
| 7:                    | Build and launch a model rocket.              |

### Pack Activities:

- Space Theme
- Space Derby or Rocket Derby
- Pack picnic or barbecue
- Scout-O-Ramas
- Camporees

### Rocket Activities:

- Can be used in the den, the Pack or classroom.
- Can be incorporated in the Webelos Scientist badge.
- Can illustrate the effects of air pressure and water pressure
- Can be used to teach the scientific method. Experiment with different amounts of water and chart the launch times vs. water level. Experiment with different fin designs and see which ones give the best flight.
- Foster creativity and exploration. Give materials to the boys without any directions, and have them put together a rocket they think will fly the highest. Explore options for recovery systems such as parachutes.

## Rocket Safety Tips

### Construction Safety Precautions:

- Always use glue in a well-ventilated area.
- Cover the work area with paper or a cloth in case glue drips.

### Pressure Testing Water Rockets:

- Never use glass bottles for water rockets.
- Always fill rocket completely with water when pressure testing. This will reduce the explosive hazard of the compressed air.
- Pressurize slowly, and if possible open the air pressure valve so that the air bubbles slowly into the rocket. Then back away and wait for the pressure to stabilize in the rocket with no more bubble action.

### Launch Safety Precautions:

- Never launch a rocket over 400ft without FAA clearance.
- Never launch in a crowded area.
- Choose an open field that is clear of obstructions such as trees and wires.
- Never stand directly over the launch pad while setting rocket on pad or during launch.
- Have each student or student group set up their own rocket on the launch pad. Other students should stand back several meters. It will be easier to keep observers away by roping off the launch site.
- Only permit the students launching the rocket to retrieve it.
- The student pressurizing the rocket should put on eye protection (safety goggles).
- Launch under low pressure first.
- Launch under zero or gentle breeze conditions.
- Place the launcher in the center of the field and anchor it in place with the spikes or tent stakes.
- When pressurization is complete, all students should stand in back of the rope for the countdown. Launch the rocket when the recovery range is clear.



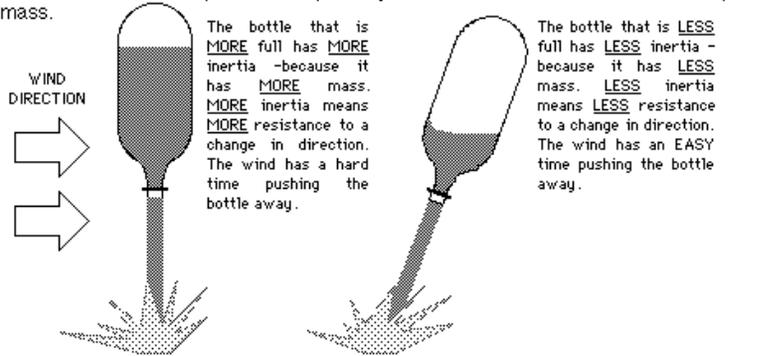
# Rocket Principles

## Newton's First Law

This law of motion is just an obvious statement of fact.

The **Law of Inertia** says, "An body in motion remains in motion, a body at rest remains at rest, until acted upon by an outside force."

**Inertia** is the tendency to resist any change in motion. It is associated with an object's mass.



## Newton's Second Law

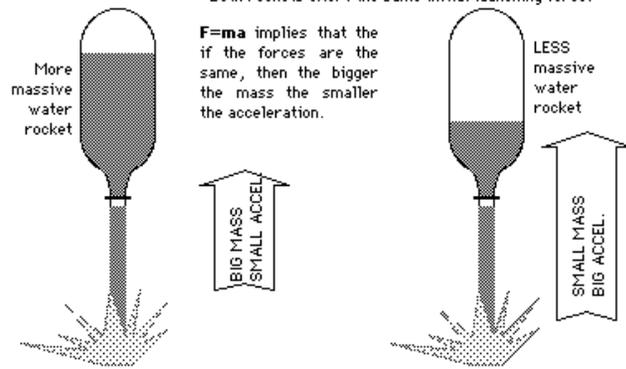
This law of motion is essentially a statement of a mathematical equation. The three parts of the equation are mass (m), acceleration (a), and force (f).

**Newton's 2nd Law** says: Force = (Mass)(Acceleration)

$$F = ma$$

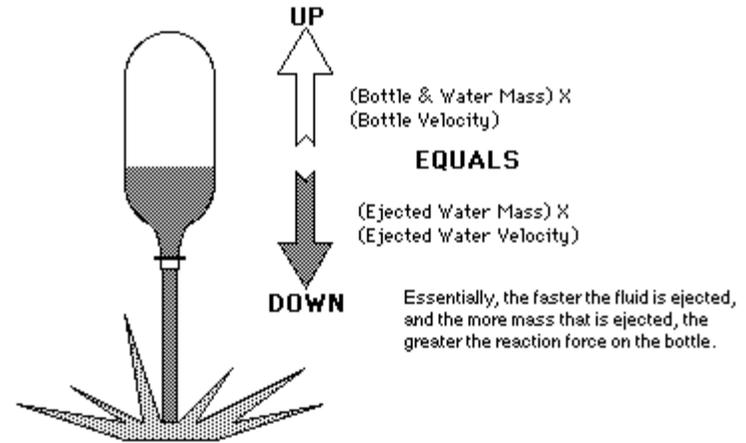
Both rockets exert the same initial launching force.

**F=ma** implies that the if the forces are the same, then the bigger the mass the smaller the acceleration.



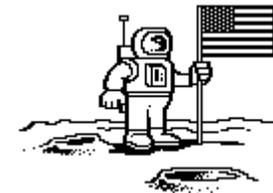
## Newton's Third Law

**Newton's 3rd Law** says "For every action, there is an equal and opposite re-action."



## Putting Newton's Laws of Motion Together

An unbalanced force must be exerted for a rocket to lift off from a launch pad or for a craft in space to change speed or direction (First Law). The amount of thrust (force) produced by a rocket engine will be determined by the rate at which the mass of the rocket fuel burns and the speed of the gas escaping the rocket (Second Law). The reaction, or motion, of the rocket is equal to and in the opposite direction of the action, or thrust, from the engine (Third Law).



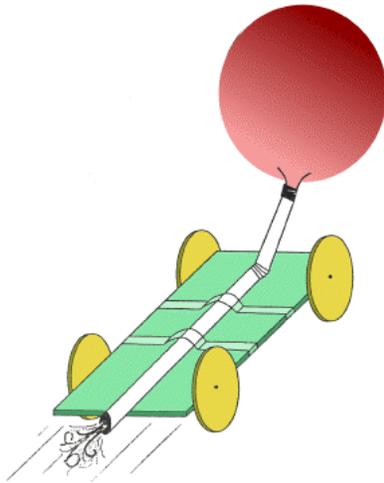


# Rocket Car

**TOPIC:** Newton's Third Law of Motion

**OBJECTIVE:** To construct a car to demonstrate how rockets move by means of action and reaction.

**DESCRIPTION:** A small car is propelled by the action/reaction force generated by a balloon.



## MATERIALS and TOOLS:

- 4 pins
- Styrofoam meat tray
- Cellophane tape
- Flexi-straw
- Scissors
- Drawing Compass
- Marker pen
- Small party balloon
- Ruler
- Emery Board

## PROCEDURE:

1. Using the ruler, marker, and drawing compass, draw a rectangle 3 by 7 inches and four circles 3 inches in diameter on the flat surface of the meat tray. Cut out each piece. Use an emery board to make the wheels as round as possible.
2. Push one pin into the center of each circle and then into the edge of the rectangle as shown in the picture. The pins become axles for the wheels. Do not push the pins in snugly because the wheels have to rotate freely. Test them to be sure they rotate freely. It is okay if the wheels wobble.
3. Inflate the balloon a few times to stretch it out a bit. Slip the nozzle over the end of the flexi-straw nearest the bend. Secure the nozzle to the straw with tape and seal it tight so that the balloon can be inflated by blowing through the straw.
4. Tape the straw to the car as shown in the picture.
5. Inflate the balloon and pinch the straw to hold in the air. Set the car on a smooth surface and release the straw.

**DISCUSSION:** The rocket car is propelled along the floor according to the principle stated in Isaac Newton's third law of motion. "For every action there is an opposite and equal reaction." The balloon pushes on the air and the air pushes back on the balloon. Because the balloon is attached to the car, the car is pulled along by the balloon.

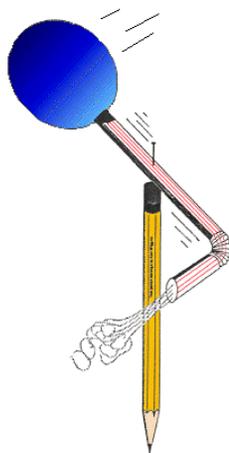




# Rocket Pinwheel

**TOPIC:** Action-Reaction Principle

**DESCRIPTION:** Construct a balloon- powered pinwheel.



## MATERIALS:

- Wooden pencil with an eraser on one end
- Sewing pin
- Round party balloon
- Flexible soda straw
- Plastic tape

## METHOD:

1. Inflate the balloon to stretch it out a bit.
2. Slip the nozzle end of the balloon over the end of the straw farthest away from the bend. Use a short piece of plastic tape to seal the balloon to the straw. The balloon should inflate when you blow through the straw.
3. Bend the opposite end of the straw at a right angle.

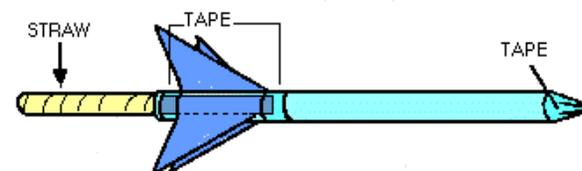
4. Lay the straw and balloon on an outstretched finger so that it balances and mark the balance point. Push the pin through the straw at the balance point and then continue pushing the pin into the eraser of the pencil and finally into the wood itself.
5. Spin the straw a few times to loosen up the hole the pin has made.
6. Blow in the straw to inflate the balloon and then let go of the straw.

**DISCUSSION:** The balloon-powered pinwheel spins because of the action-reaction principle described in Newton's Third Law of Motion. Stated simply, the law says every action is, accompanied by an opposite and equal reaction. In this case, the balloon produces an action by squeezing on the air inside causing it to rush out the straw. The air, traveling around the bend in the straw, imparts a reaction force at a right angle to the straw. The result is that the balloon and straw spins around the pin.

# Paper Rocket

**TOPIC:** Stability

**DESCRIPTION:** Small flying rockets to make out of paper and propel with air blown through a straw.



## MATERIALS:

- Scrap bond paper
- Cellophane tape



- Scissors
- Sharpened fat pencil
- Milkshake straw (slightly thinner than pencil)

## PROCEDURE:

1. Cut a narrow rectangular strip of paper about 5 inches long and roll it tightly around the fat pencil. Tape the cylinder and remove it from the pencil.
2. Cut crown points into one end of the cylinder and slip it back onto the pencil.
3. Slide the crown points to the pencil tip and squeeze the points together and tape them together to seal the end to form a nose cone (the pencil point provides support for taping). An alternative to the crown points is to just fold over one end of the tube and seal it with tape.
4. Remove the cylinder from the pencil and gently blow into the open end to check for leaks. If air easily escapes, use more tape to seal the leaks.
5. Cut out two sets of fins using the pattern and fold according to instructions. Tape the fins near the open end of the cylinder. The tabs make taping easy.

## FLYING THE PAPER ROCKET:

Slip the straw into the rocket's opening. Point the rocket towards a safe direction, sharply blow through the straw. The rocket will shoot away. Be careful not to aim the rocket towards anyone because the rocket could poke an eye.

**DISCUSSION:** Paper rockets demonstrate how rockets fly through the atmosphere and the importance of having fins for control. For experimental purposes, try building a rocket with no fins and one with the fins in the front to see how they will fly. Practice flying the rockets on a ballistic trajectory towards a target. Also try making a rocket with wings so that it will glide.

## Pencil Rocket

**TOPIC:** Rockets

**DESCRIPTION:** Rockets, using pencils for their bodies, are launched with a rubber band-powered launch platform.



## MATERIALS and TOOLS:

- 2 Pieces of wood 3'X4"X1" in size
- 2 Cup hooks
- 1 Wooden spring clothes pin
- 1 Small wood screw
- 1 Screw eye
- 2 Metal angle irons and screws
- 4 Feet of heavy string
- Iron bailing wire (18 gauge minimum)
- Several rubber bands
- Several wooden pencils (unsharpened)
- Several pencil cap erasers
- Cellophane or masking tap
- Heavy paper
- Saw
- Wood file
- Drill (3/16 inch diameter)
- Pliers



## PROCEDURE

### Launch Platform

1. Join the two pieces of wood as shown in the diagram to form the launch platform. Use a metal angle iron on each side to strengthen the structure.
2. Screw in the cup hooks and screw eye into the wood in the places indicated in figure 1.

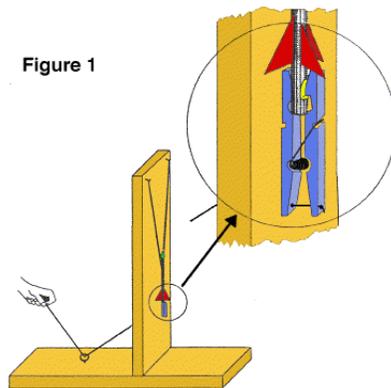


Figure 1

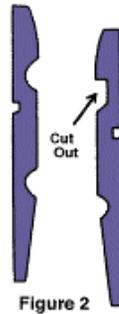


Figure 2

3. Temporarily separate the wooden pieces of the clothes pin and file the "jaw" of one piece square as shown in figure 2. Drill two holes through the other wood piece as shown. Drill one hole through the first wood piece as shown.
4. Drill a hole through the upright piece of the launch platform as shown and screw the clothes pin to it so that the lower hole in the pin lines up with the hole in the upright. Reassemble the clothes pin.
5. Tie a knot in one end of the string and feed it through the clothes pin as shown in figure 1, through the upright piece of the platform and then through the screw eye. When the free end of the string is pulled, the clothes pin will pen. The clothes pin has become a rocket hold-down and release device.

6. Loop four rubber bands together and loop their ends on the cup hooks. The launch platform is now complete.

### Rocket

1. Take a short piece of bailing wire and wrap it around the eraser end of the pencil about one inch from the end. Use pliers to twist the wire tightly so that it "bites" into the wood a bit. Next, bend the twisted ends into a hook as shown in figure 3.
2. Take a sharp knife and cut a notch in the other end of the pencil as shown in figure 3.
3. Cut out small paper rocket fins and tape them to the pencil just above the notch.
4. Place an eraser cap over the upper end of the rocket. This blunts the nose to make the rocket safer if it hits something.

**The rocket is now complete.**

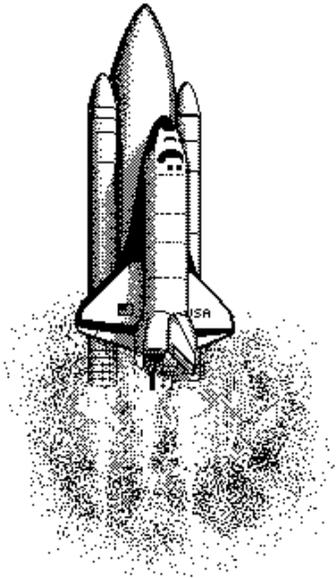
### **LAUNCHING PENCIL ROCKETS:**

1. Choose a wide-open outdoor area to launch the rockets.
2. Spread open the jaw of the clothes pin and place the notched end of the rocket in the jaws. Close the jaws and gently pull the pencil upward to insure the rocket is secure. If the rocket doesn't fit, change the shape of the notch slightly.
3. Pull the rubber bands down and loop them over the wire hook. Be sure not to look down over the rocket as you do this in case the rocket is prematurely released.
4. Stand at the other end of the launcher and step on the wood to provide additional support.



5. Make sure no one except yourself is standing next to the launch pad. Count down from 10 and pull the string. Step out of the way from the rocket as, it flies about 75 feet up in the air, gracefully turns upside down and returns to Earth.
6. The rocket's terminal altitude can be adjusted by increasing or decreasing the tension on the rubber bands.

**DISCUSSION:** Like the flight of Robert Goddard's first liquid fuel rocket in 1926, the pencil rocket gets its upward thrust from its nose end rather than its tail. Regardless, the rocket's fins still provide stability, guiding the rocket upward for a smooth flight. If a steady wind is blowing during flight, the fins will steer the rocket towards the wind in a process called 'weather cocking.' On NASA rockets, active controls steer during flight to prevent weather cocking and to aim them on the right trajectory. Active controls include tilting nozzles and various forms of fins and vanes.



## Alka-Seltzer Rockets

(By Mike Passerotti)

### Purpose

To design a paper rocket propelled by Alka-Seltzer and water to demonstrate Newton's third law of motion.

### Background

The paper rocket in this activity is propelled according to the principle stated in Isaac Newton's third law of motion: "For every action there is an opposite and equal reaction." Gas pressure builds inside the film canister due to the mixing of Alka-Seltzer and water. This action continues until enough pressure builds to blow apart the canister from its lid. The reaction is the launch of the rocket.

### Materials

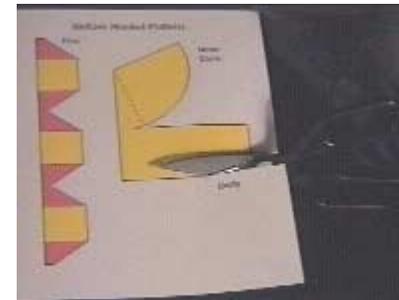
[card stock printed pattern](#); empty film canister with lid that snaps inside; markers, crayons, or colored pencils; tape; glue; scissors; Alka-Seltzer tablets; water; metric tape measure or meter sticks; straw; (Optional launch pad: wood block, coat hanger or other stiff wire)

### Preparation

Review and prepare materials. It is most important to use film canisters with lids that snap inside. Do not use lids that close around the outside of the canister.

### Construction

1. Cut the fins out. Cut the nose cone and body out as one piece.





2. Tape the body onto the film canister, roll the paper around the side, and tape the end down. The lid end of the film canister goes down.



3. Roll the nose cone around in the shape of a cone and tape it together. Straighten the nose cone point to the center of the rocket and tape it to the sides.



4. Fold the fins so that the colored side is out. Tape or glue the fin halves together to form a complete circle.



5. Fold the fins so that the colored side is out. Tape or glue the fin halves together to form a complete circle.



6. Cut a 1-inch piece of straw and tape it to the body.

### Launch Time

This is an outdoor activity. If gusty winds are a problem, then place a quarter in the canister to keep the rocket from falling over. Launching near a wall where a metric tape has been hung or where meter sticks have been stacked may make it easier to judge how high the rocket goes. You may want to wear safety glasses during this experiment as a general safety precaution. Everyone should stand away from loaded rockets when they are on the launch pad. It may take 15 to 20 seconds to build up enough pressure to launch, so a loaded rocket should not be approached prematurely. These rockets can shoot 5 meters or more into the air. No sharp objects should be placed on top of the nose cone or elsewhere on the rocket.

Make a launch pad with a block of wood and a straight piece of wire. Drill a hole for the wire and insert the wire straight up to guide the rocket at lift off.

### Wrap-up

One way to record the results of different "fuel" mixtures is to make a simple graph of height vs. amount of water. Such a graph gives a clear, visual record of the observations and can be used as evidence to support interpretations.

Design and launch other rockets powered by two, three or more film canisters.

Design a two-stage rocket.





# Soda Bottle Rockets

## Materials

2 soda bottles; card stock printed pattern; markers, crayons, or colored pencils; tape; glue; scissors; water; wood block approximately 4" long piece of "2 by 4" lumber; one wood screw; one rubber automotive valve stem; bicycle tire pump.

## Preparation

Review and prepare materials. Build the launch pad by cutting 2 1/2" off the cap end of the bottle. Cut a 3/8" slot down one side of the bottle for the tire pump hose. Drill or punch a hole in the bottom of the bottle. Screw the bottle to the block of wood.

## Construction

1. [Print the patterns. Cut the fins out. Cut the nose cone out.](#)
2. Roll and tape the nose cone. Tape the nose cone to the bottom of the whole soda bottle.
3. Fold the fins at all the dotted lines. Glue or tape two of the fins together. Wrap the fins around the middle of the whole soda bottle and glue or tape the last fin together.

## Launch Time

This is an outdoor activity. If gusty winds are a problem, then abort the launch. Everyone should stand away from rockets when they are on the launch pad. These rockets can shoot 100 feet or more into the air. No sharp objects should be placed on top of the nose cone or elsewhere on the rocket.

Fill the soda bottle a little less than half way with water. Shove the large end of the tire valve stem into the neck of the bottle. Attach the bicycle pump hose to the valve stem. Lower the bottle into the launch pad so that the hose slides down into the slot, the valve stem points down and the bottle rests on top of the cut bottle.

Pump up the bottle until it pops off the valve stem and flies to new heights.

## Wrap-up

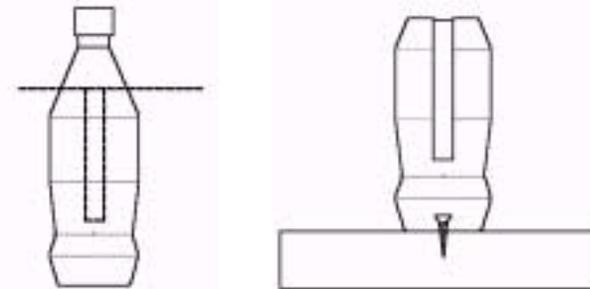
One way to record the results of different "fuel" mixtures is to make a simple graph of height vs. amount of water. Such a graph gives a clear, visual record of the observations and can be used as evidence to support interpretations.

Design and launch other rockets. Design a two-stage rocket. Design recovery mechanisms such as parachute, ribbon or propeller.

# Soda Bottle Launch Pad

You can use a bicycle pump, soda bottle, one screw, a piece of 2x4 scrap and an automotive tire valve stem to create a launch pad.

1. Take an empty soda bottle and cut it as shown below (left), cut the top off and cut a slot wide enough for the bicycle pump hose and deep enough to slide in the rocket, valve stem and bicycle pump hose fitting (the rocket should rest on the cut end of the soda bottle launch pad:



2. Screw the soda bottle to a scrap piece of 2x4 as shown above (right).
3. Shove the tire valve stem into the neck of your soda bottle rocket (Fig. 3).
4. Attach the bicycle pump to the valve stem.
5. Slide the soda bottle rocket with hose attached into the launch pad. See the finished pad ready to launch (Fig. 4).



Fig. 3

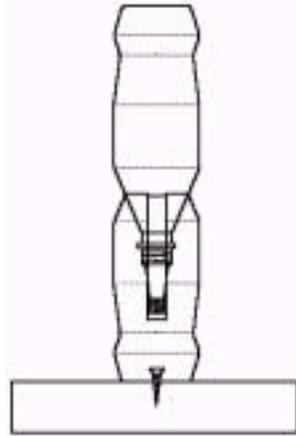


Fig. 4

6. Pump it up until it pops!

## Rocket Derby Rockets

### Rocket Kit:

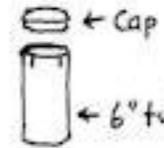
Each rocket kit shall contain the following items:

- 12" cardboard tube
- 6" cardboard tube, with 3 marks for placement of fins
- 1 White tube cap
- 20 oz. plastic soda bottle (empty)
- 1 strip of Fun Foam
- 1 fan-shaped cardboard piece for nose cone
- 3 fins
- Color paper, stickers and markers can also be provided for decorating the rocket.

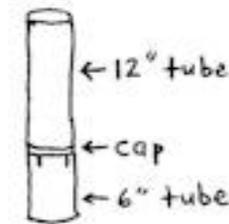
In addition to the above materials, you will also need lots of scissors and rolls of 2" wide clear packing tape.

### Rocket Construction:

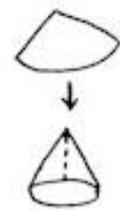
① Insert Cap



② Tape tubes together



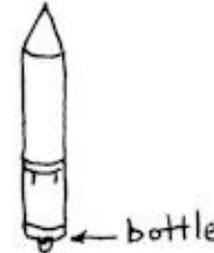
③ Fold Cone & Tape



④ Center Cone & Tape to tube



⑤ Insert Bottle

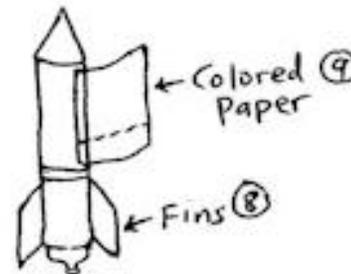


⑥ Wrap foam strip around bottle & shove in tube



⑦ Seal Bottle in tube w/ tape

⑧ Attach fins at fin guides



⑨ Tape color paper to tube, wrap tube & tape

⑩ Attach Rocket ID sticker below cone. Decorate rocket!



These rockets are great for water rocket derbies. They are inexpensive to make, easy to construct and are quite durable. They are capable of reaching over 100 feet in height.

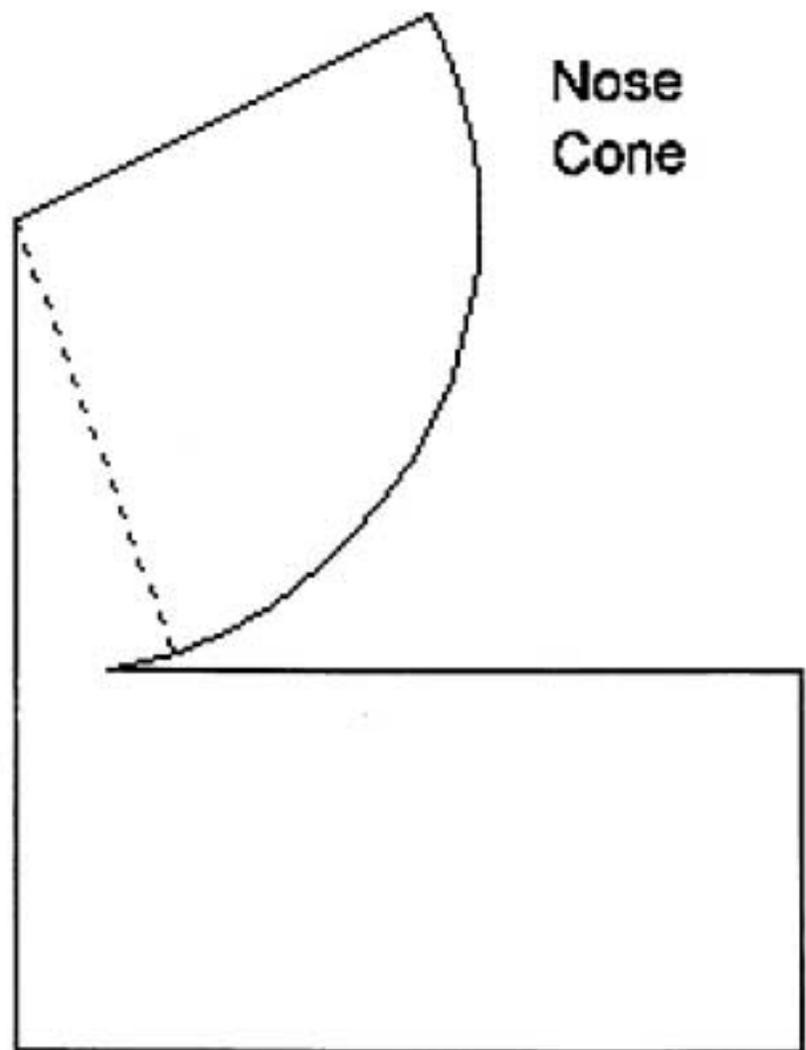
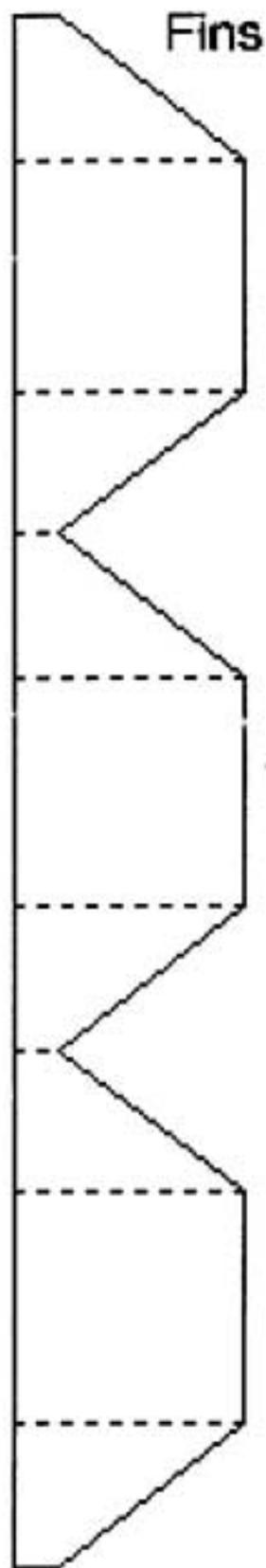
## NOTES:

1. Insert the tube cap onto the end of the 6" tube, which has 3 marks for the fin guides.
2. Stack 12" tube onto capped end of short tube. Tape the tubes together.
3. Shape the fan-shaped cardboard into a nosecone and tape together, making sure that the opening fits onto the cardboard tube.
4. Center the nosecone onto the end of the 12" tube, and tape the nosecone onto the tube. Completely cover the nosecone with tape.
5. Insert the plastic soda bottle into the 6" tube, with the opening sticking out.
6. Wrap the strip of fun foam around the top of the bottle, and shove it into the cardboard tube. The fun foam keeps the bottle from moving around in the tube.
7. Seal the bottle in tube with tape.
8. Place each fin onto a fin guide on the 6" tube. The fin point should be pointing toward the nosecone. Tape fins SECURELY onto tube, and cover completely with tape.
9. Wrap the rocket body with 1-1/2 sheets of color paper (will be provided), and tape onto the rocket. Tape the color paper to the tube before wrapping around tube.
10. Attach Rocket ID Sticker below nosecone. Decorate rocket with markers, stickers, etc.

### Tips for Running a Rocket Derby

- Plan event well in advance, set date and location (Park with large field).
- Prepare rocket kits in advance. Conduct workshop before event for assembling rockets, or build during a den or pack meeting.
- For competition, judge rockets for flight time (from lift-off to landing).
- Get volunteers (parents) for:
  - Event Coordinator
  - Time keeper (with stopwatch)
  - Water fillers (to fill rockets)
  - Launch crew (to operate the launch pads)
- Compress rockets to a maximum of 85 psi for competition (vary pressure based on wind and environment).
- Always following safety precautions!

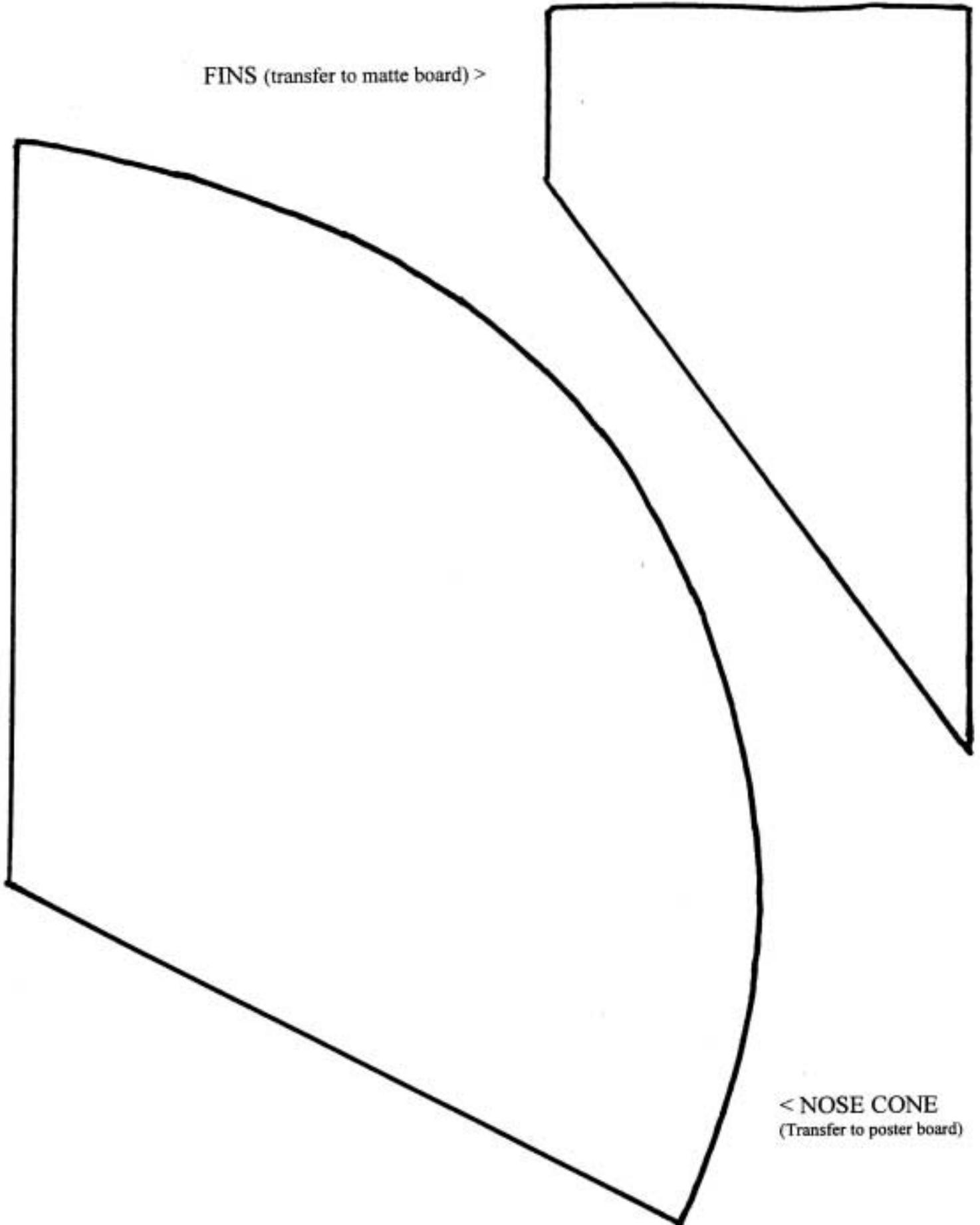
# Seltzer Rocket Pattern



Body

# TUBE ROCKET PATTERNS

FINS (transfer to matte board) >



< NOSE CONE  
(Transfer to poster board)