How To Build A Water Rocket

for SECME

DESIGN AND DEVELOPMENT

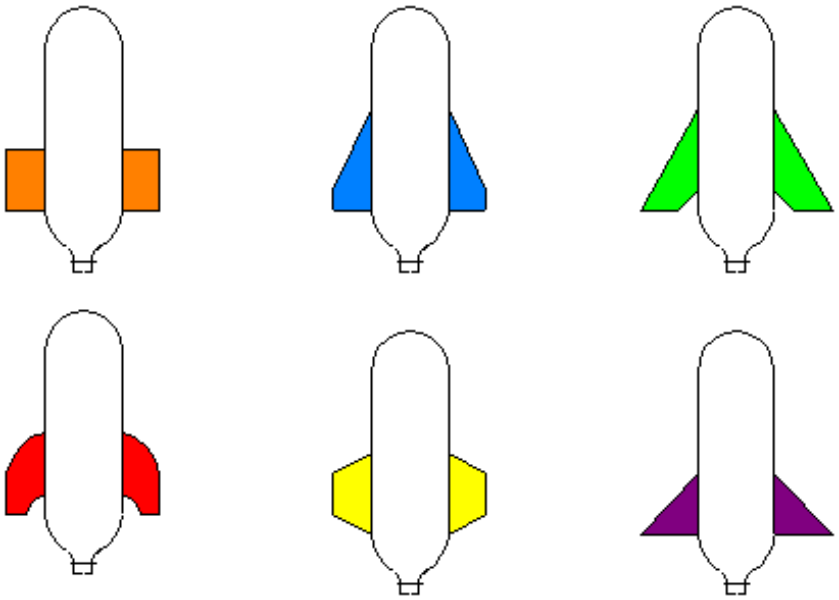
Brainstorm

The first step in the design of a water bottle rocket is brainstorming. Brainstorming is a problem-solving technique that involves the spontaneous contribution of ideas from all members of the group.

Design Possibilities

The following are illustrations of possible designs for the fins. Any variation of these suggested designs may be used and found to perform better than another when combined with various bottle designs.

!Stop! <u>All fins must be at least 10 cm from the throat exit plane of the bottle see diagram 1</u>. This schematic is provided solely to give examples of fin design. We encourage you to be creative.

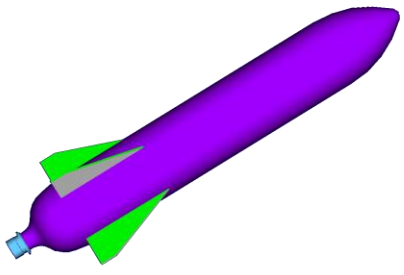


MATERIALS AND CONSTRUCTION

Off-limit Materials

The following list of materials should NOT be used in any form in the construction of the water rocket. They are dangerous and could cause harm to the operator and those in the presence of the water rocket launch.

- Metal
- Glass
- Spikes and Antennas of any kind.
- Hard Plastics/Rocks



Materials and Tools Needed

- Pressure Vessel (**Clear** 2-Liter Bottle)

***Note**:* Be certain that your clear, 2-liter bottle is free of scratches, nicks, dents, and discoloration.

- Adhesive (examples)
  - Foam mounting tape (approximately 1/16 thick, 2-sided adhesive)
  - Carpet tape (thin 2-sided adhesive)
  - Clear packing tape or strapping tape

- Use adhesive to bond fins, nose cone, and other allowed materials onto the water rocket

- Cutting utensils (Scissors, Hacksaw Blade, Utility Knife, etc.)

- Safety First: Children should be supervised **at all times** while constructing their Water Rockets

For Fin Construction:

- balsa and bass wood, cardboard, plastic, foam board, 1/4” to 1/2” thick styrofoam & etha foam, plastic plates, and plastic (2L) bottle

BUILDING YOUR WATER ROCKET

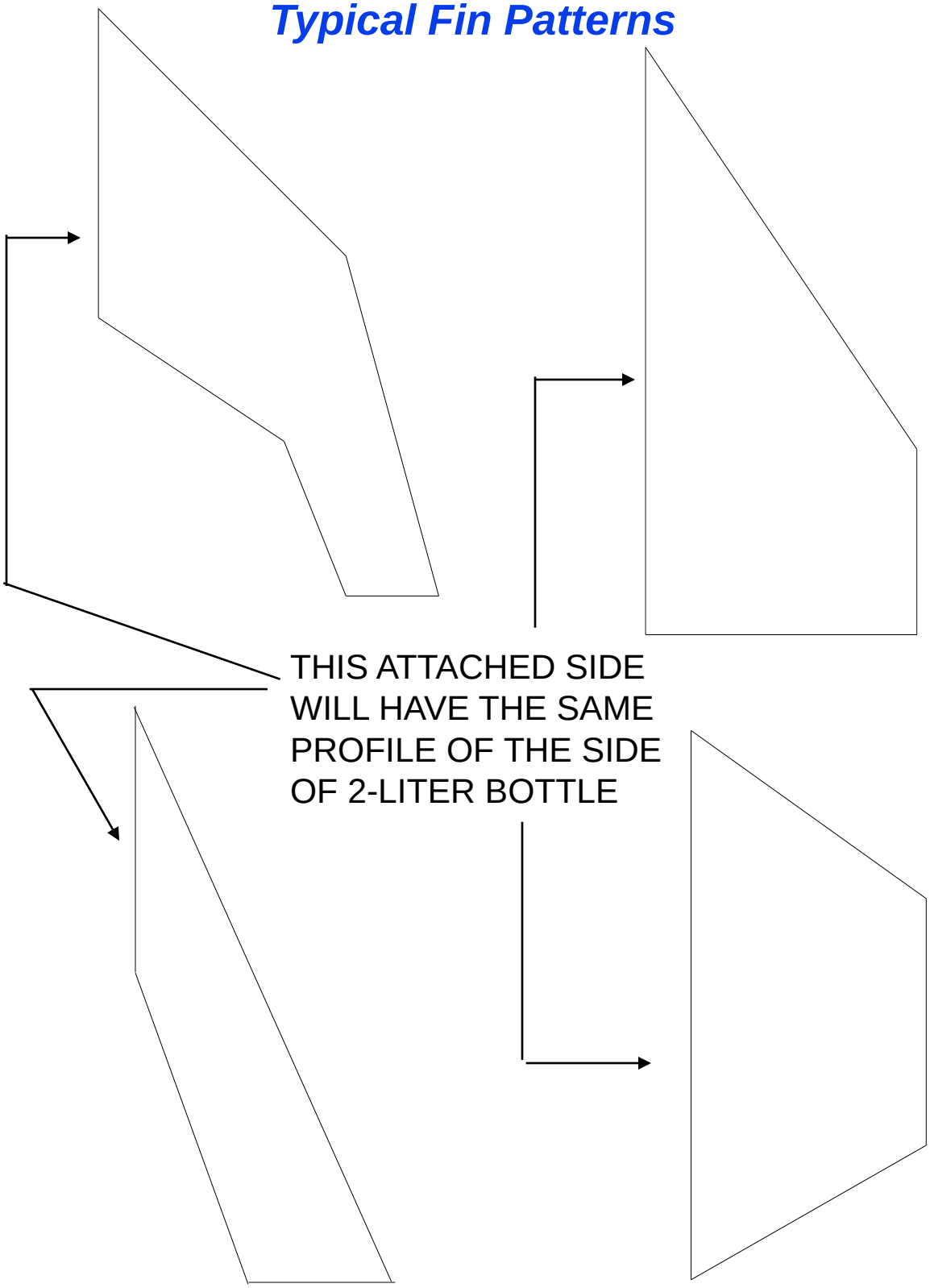
Fin Design and Construction

- Determine a fin pattern from your analytic design or trial and error.
- Use the recommended materials, however we encourage you to be creative. Keep in mind not to use the off-limit materials.
- Cut fins out of the material you choose.
- You can use no less than 3 fins on your rocket.
- Attach the fins to the lower section of the rocket using glue, Velcro, tape, or other adhesives.

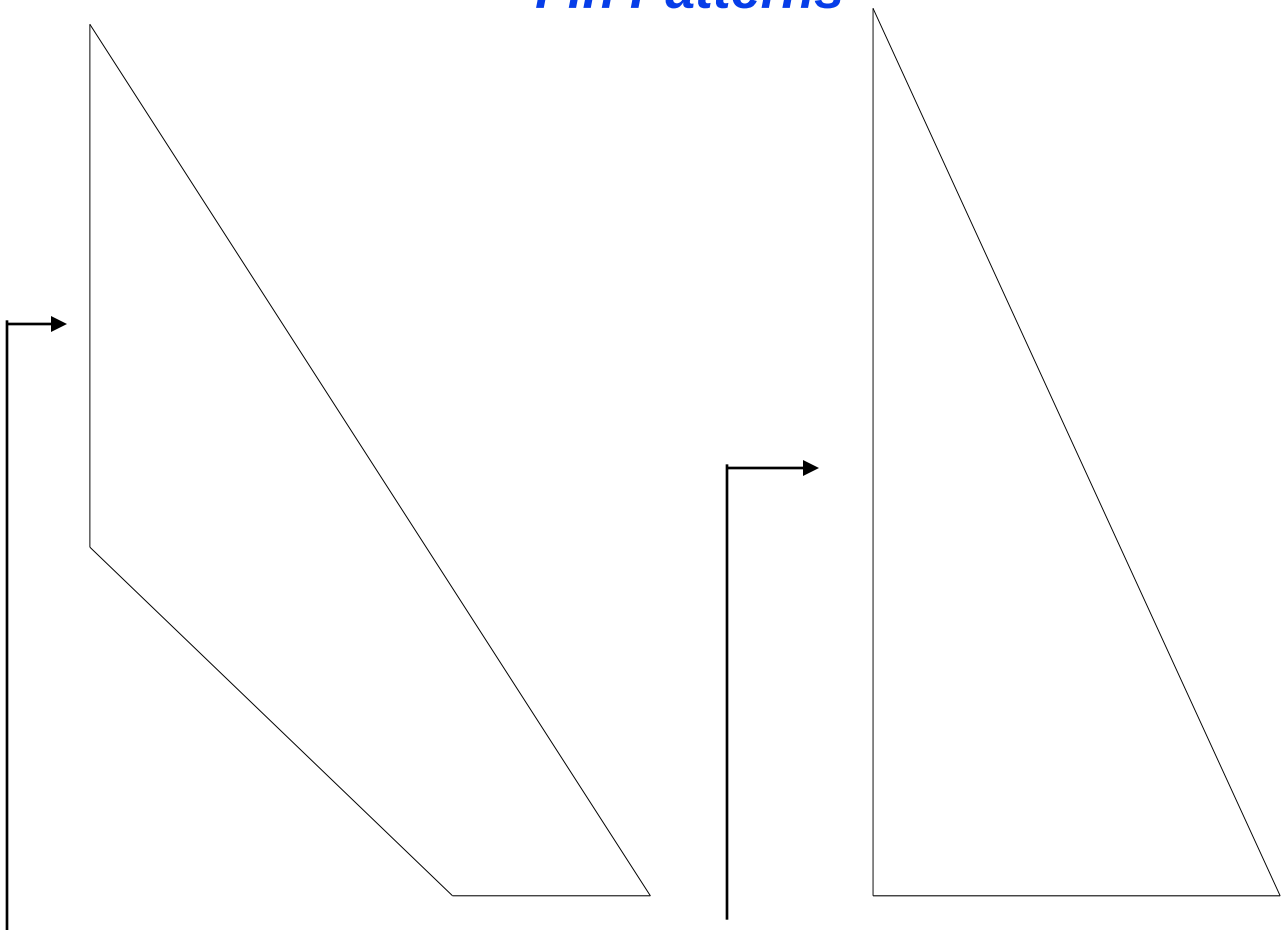
Tip: It is easier to attach fins to a bottle that is slightly pressurized. You can pressurize the bottle by placing the bottle with its top off in a freezer for 2-3 hours. Next, take it out of the freezer and put the top on very tight. Eventually, the air inside warms and the bottle will become slightly pressurized.

Tip: Using a <u>low</u> melt glue gun is an excellent way to quickly bond fins. First clearly mark desired locations on the bottle prior to bonding. Try applying glue to a fin; then apply the fin to one of the marked locations on your bottle. This technique will aid in preventing your pressure vessel (i.e., bottle) from deforming due to the “initially” very warm temperature of the glue.

Typical Fin Patterns

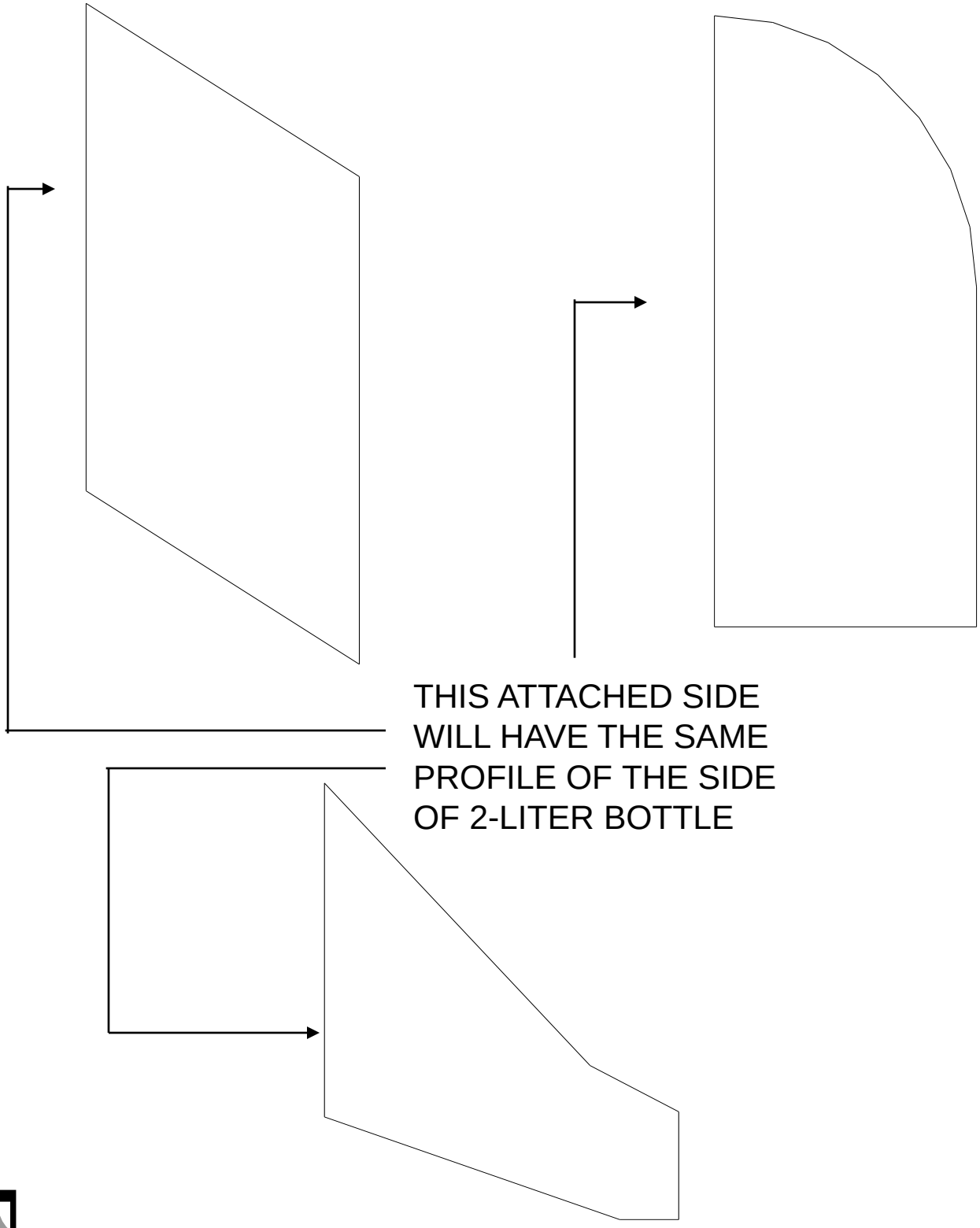


Fin Patterns



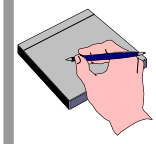
THIS ATTACHED SIDE
WILL HAVE THE SAME
PROFILE OF THE SIDE
OF 2-LITER BOTTLE

More Fin Patterns



Nose Cone Design and Construction:

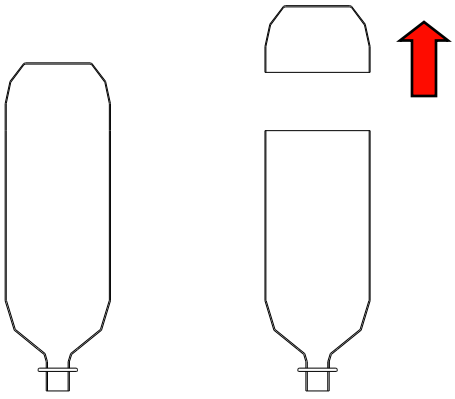
- Determine what material you want to use.
- Pattern the nose cone and cut it out.
- Attach the nose cone to the top of the rocket by using one of the recommended adhesives.



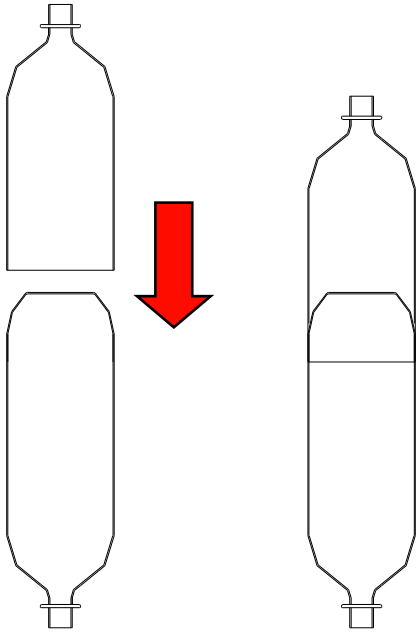
Note: Remember use only the material recommended and maintain a nose radius of **0.5 inch or greater**.

Tip: Add ballast (weight) to nose cone (e.g., Styrofoam-peanuts, shredded paper, etc.) to shift the water rocket's center of mass forward and increase its flight stability. Smaller amounts of more dense materials such as clay, sand, water, etc. may also be used as ballast. Remember not to use the Off-Limit materials.

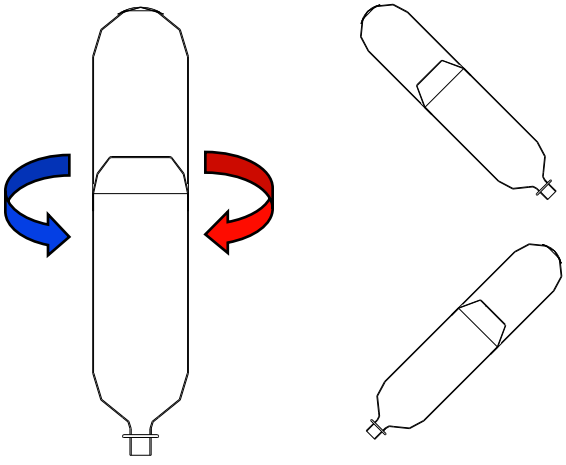
Preferred Nose Cone Construction- Water Rocket Assembly Method



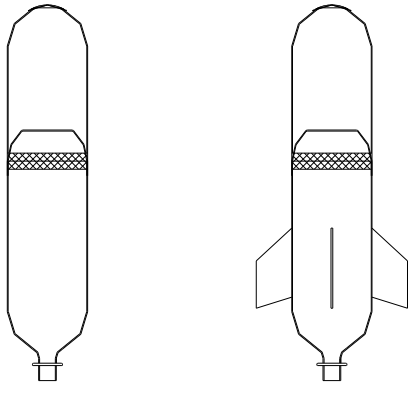
Step 1: Cut the bottom off of a 2L Bottle (discard bottom).



Step 2: Carefully align top portion of bottle on the 2L bottle to be used for the pressure vessel.

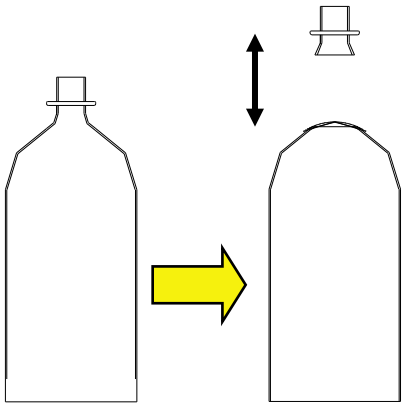


Step 3: Rotate and observe your water rocket from several angles to ensure good alignment.



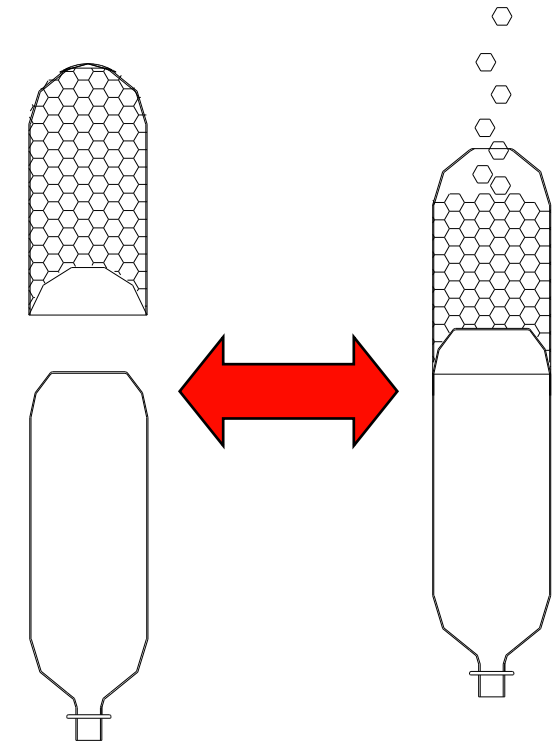
Step 4: Tape/secure the joint between the nose cone stage and the pressure vessel**.**

Tips: - Remember to add ballast to your nose cone stage.
- The pressure vessel should be in <u>good</u> condition <u>free of</u> scratches and dents.



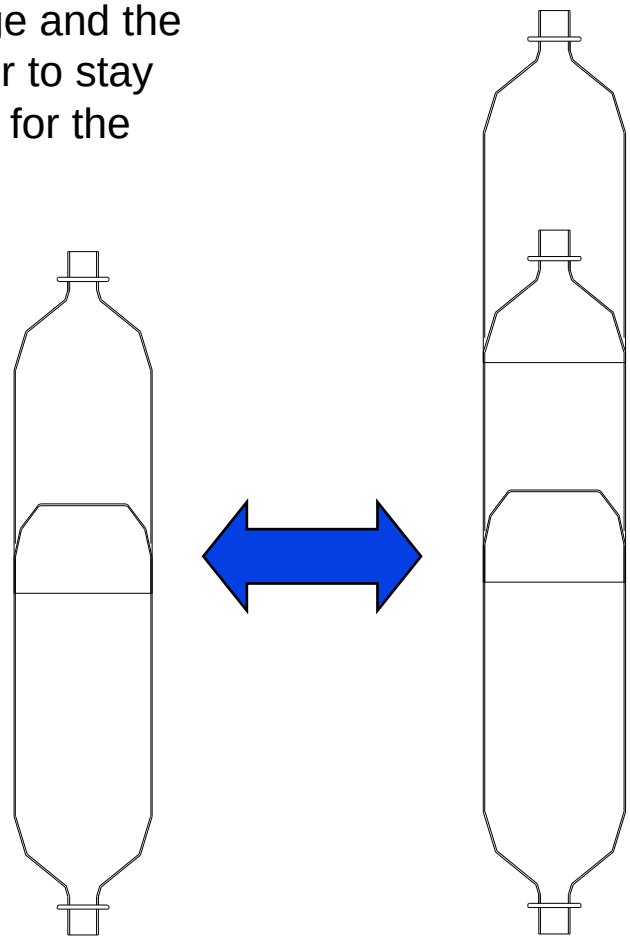
Option 1: A) The neck can be cut off of the top of the nose cone as shown in Step 4. This will slightly improve the aerodynamics of the rocket. **B)** The resulting hole can simply be covered with tape. (Use a hack saw blade for cutting through the thicker material at the neck of bottle. Utility and other knives are NOT recommended for this process.)

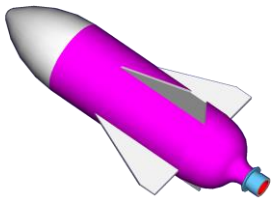
Option 2: Ballast can be added before or after you permanently affix the nose cone to the pressure vessel.



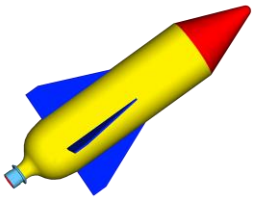
BEFORE **AFTER**

Option 3: The length of the Rocket can be increased by adding another bottle between the nose cone stage and the pressure vessel. Remember to stay within the dimensional limits for the competition.

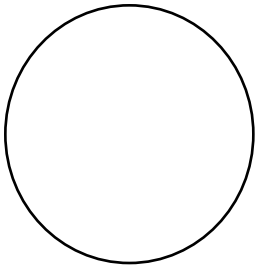




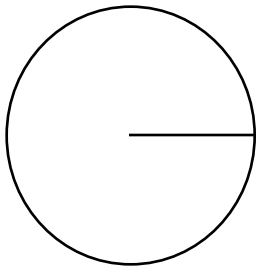
Note: Taller rockets will <u>not necessarily</u> perform better than shorter ones. Try to keep your construction/assembly process as simple as possible.



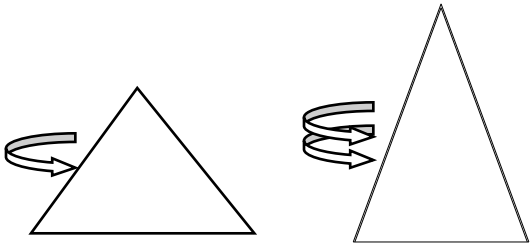
Alternative Example of Nose Cone Construction



Step 1: Cut a circle out of thick stock paper or thin poster material (Using 16” or larger diameter).

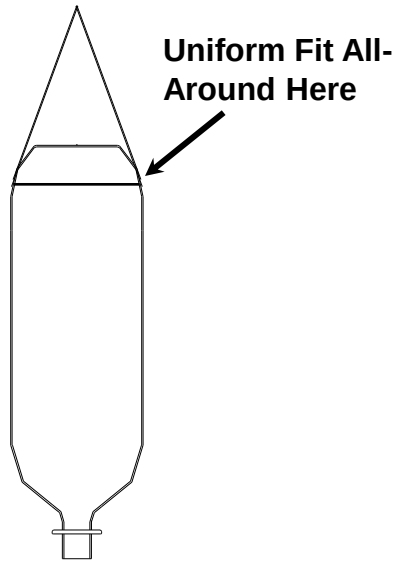


Step 2: Cut a line along the radius as shown.

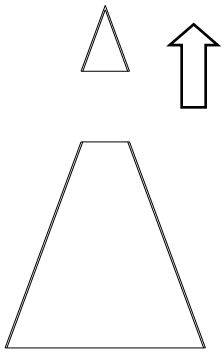


Step 3: Rotate the paper into a cone. Next tape or glue the seam to maintain the cone’s shape. You can adjust the angle of the cone with more rotation.

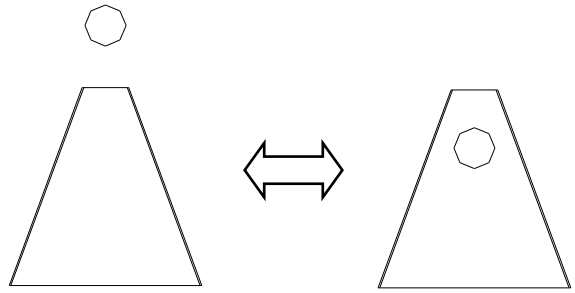
(Keep in mind that the base of your cone needs to be large enough to fit around the top of the pressure vessel.)



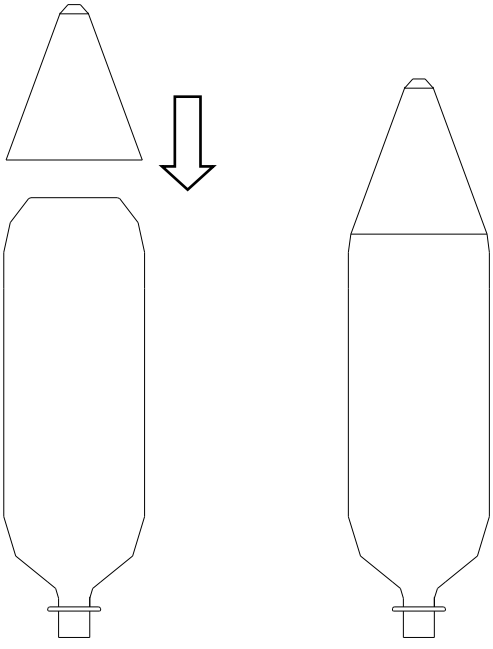
Step 4: If needed, trim the base of cone as required so that it has a uniform fit with the diameter of a 2L bottle**.**



Step 6: Uniformly trim top of paper nose cone to accept a craft foam or styrofoam ball or cone.



Step 7: Add the foam ball or cone to create a 0.5” or larger nose cone radius.

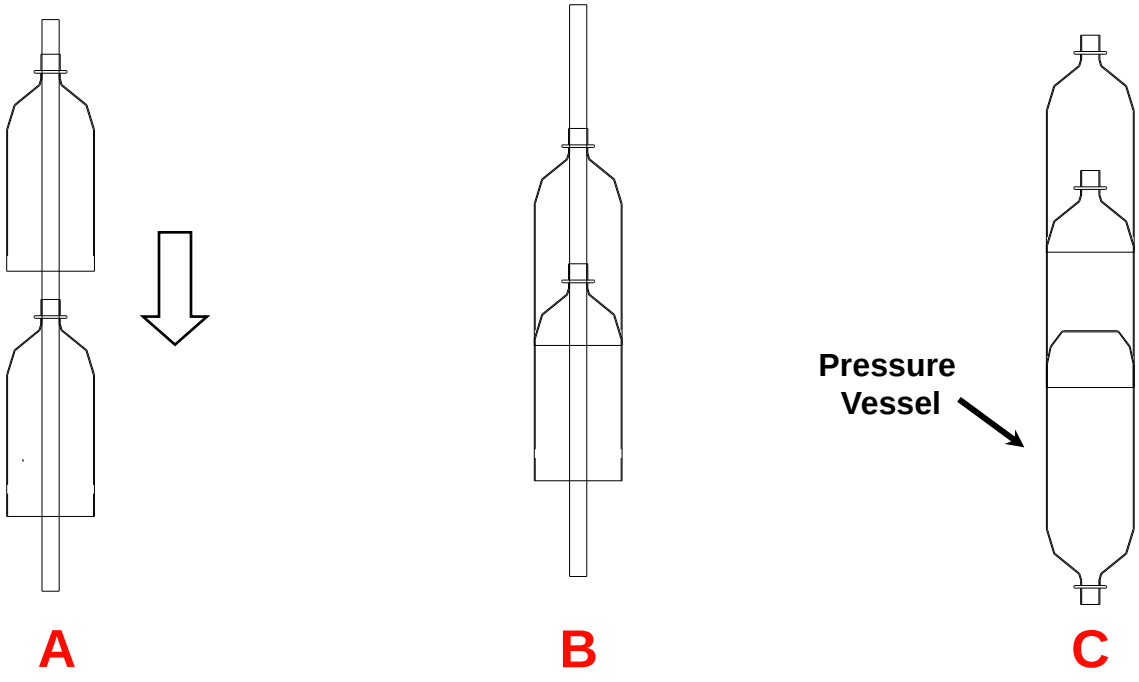


Step 8: Secure the resulting nose cone to the pressure vessel using an adhesive like tape, glue, velcro, etc.

Be certain to use some form of ballast (weight) to shift your rocket’s center of mass forward.

Other Tips

More on Water Rocket Construction:



A **B** **C**

A) For lengthened rockets (Option 3) A piece of 1/2” PVC pipe can be used to align the nose cone to a second bottle prior to assembly with the main pressure vessel bottle.

B) Join the bottles together, on the PVC shaft and tape the joint between bottles securely. (Make certain tape lays flat on the bottle’s surface.)

C) Now, remove the PVC shaft and join upper nose cone stage to the pressure vessel. Carefully align the the stages.

(Note: you will <u>NOT</u> be able to use the PVC shaft to align the nose cone and attached bottle to the pressure Vessel.)

Tips on Fin Design

FINS: Whether your fins are wide or thin, the primary "assembly" objectives/considerations should be:

1) Make certain fins are aligned with center axis of rocket**.**

2) Be sure fins are well affixed to bottle to prevent separation or deflection/movement during flight.

3) Wider fins (1/4"-1/2" thick) provide a larger attachment/ contact surface. They can be securely attached using tape only and are useful for quick assembly.

4)Thinner fins (3/16" or less) are excellent for reducing the effects of drag, however, more effort is usually involved with securely attaching them to your water rocket. Thin fins must be very stiff once mounted to prevent movement during flight.

Tips on Fin Design

5) A minimum of three fins are recommend for stable flight (4 fins are a good choice as well).

6) All fins should be spaced equally apart regardless of the number (e.g., 3 fins-120^{o} apart, 4 fins-90^{o} apart, and so on).

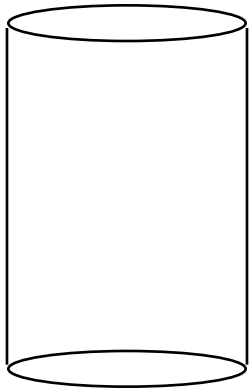
Note: Aligned fins are recommended, particularly when competing. Tilting fins will cause rockets to spin. This action <u>may</u> slightly increase flight stability but will likely make it more difficult to "calculate" how far the rocket will travel. In case fins are tilted to cause "spin":

- **They must ALL be tilted in the same direction.**
- **They should only be tilted slightly (e.g., 2^{o} to 10^{o}).**
- **The fins should be equally spaced.**
- **It is strongly suggested that you try the aligned fin approach first!!!**

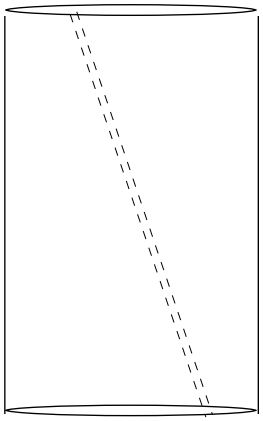
APPENDIX

Building Fins From 2-Liter Bottles

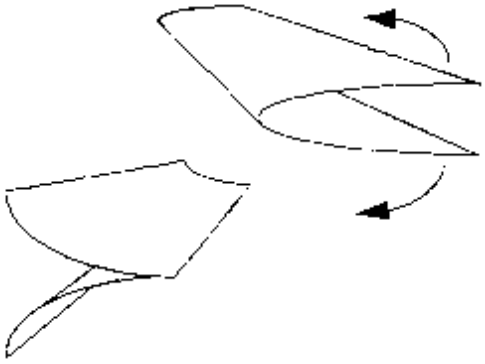
1. Cut Top and Bottom Off



2. Flatten and Cut



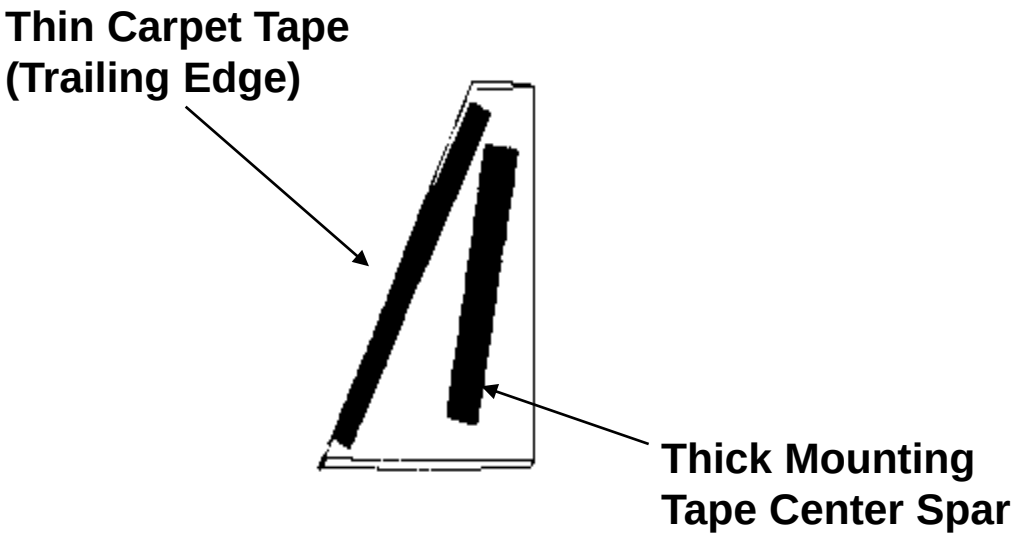
3. Reverse the Fold and Recrease



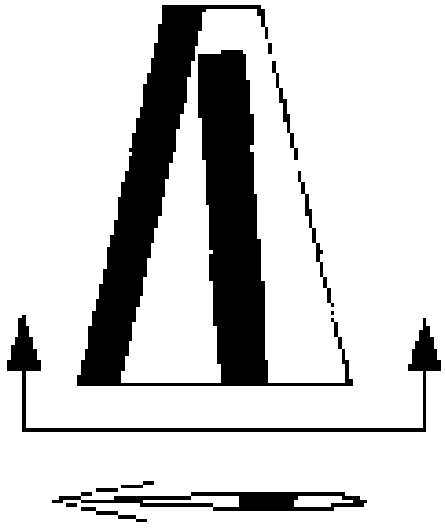
Note: The method of design and construction shown here is only an example. Use your imagination to create new designs using the recommended materials.

An Example Only:
Building Fins From 2-Liter Bottles

4. Add double sided tape



5. Trim to desired sweep, add clear packing tape over trailing edge.



Note: Adding clear packing tape keeps the leading edge from curling up and mounting tape adds strength and stiffness to the fin.

Tip: Add a smooth film of glue around the base of each fin.

Diagram 1

Rocket Identification

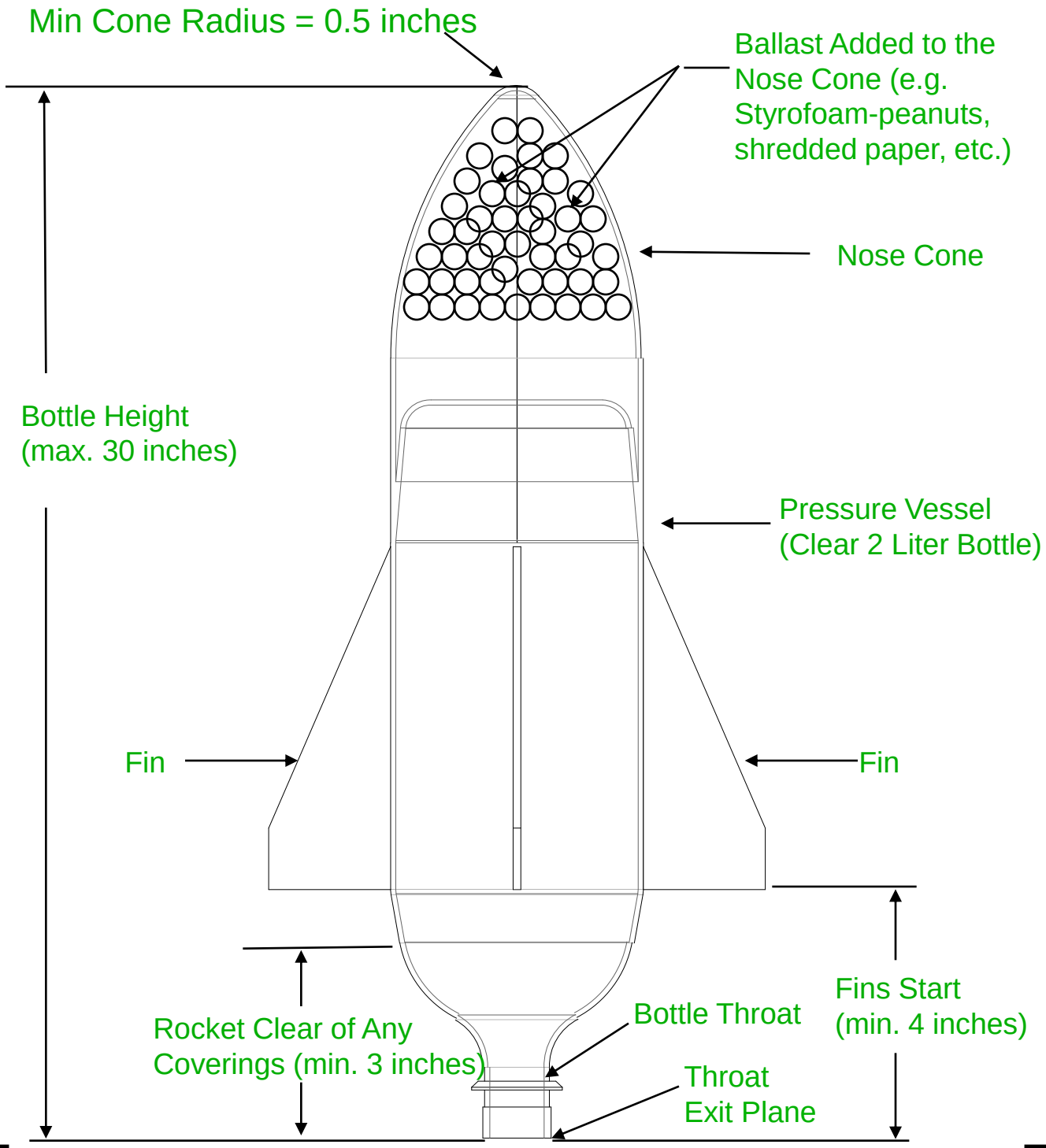
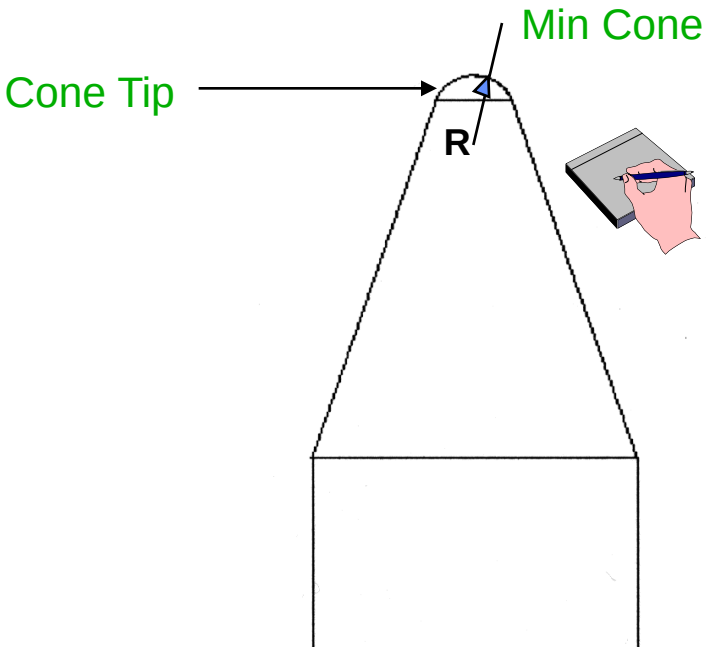


Diagram 2

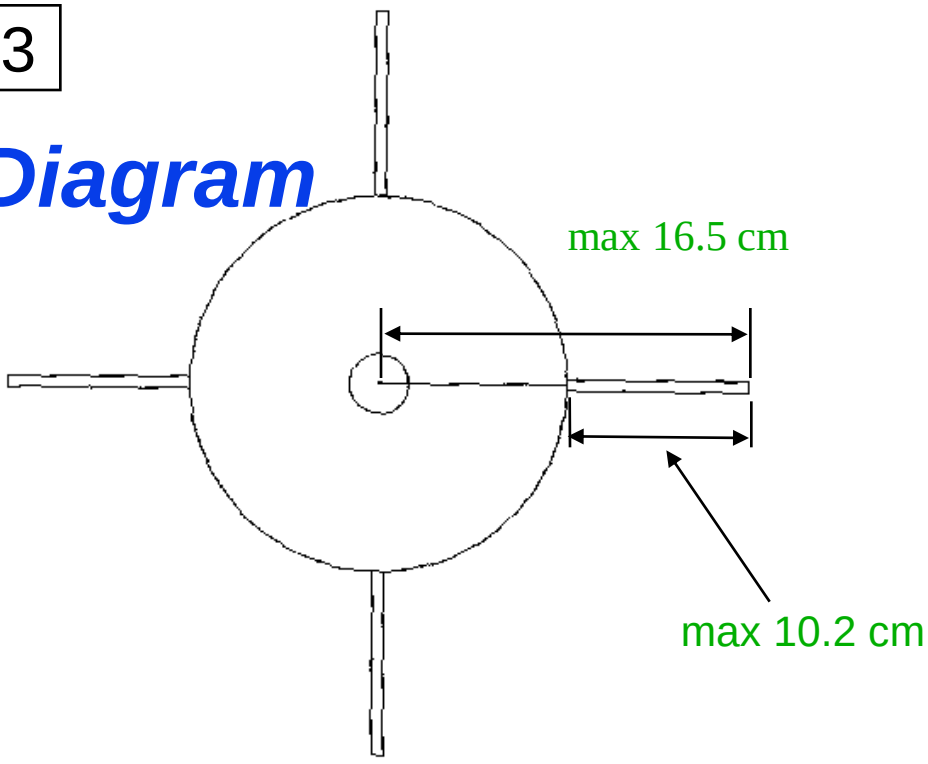
Nose Cone Diagram



Note: Make certain to construct the tip of the nose cone per the minimum cone radius (0.5 inches) for safe operation.

Diagram 3

Fin Diagram



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