COMPRESSED AIR ROCKET

By Rick Schertle

PAPER, TAPE, COMPRESSED AIR ... LIFT-OFF!

Blow your friends away as you send this 25-cent rocket hundreds of feet in the air. You can build this easy launcher and rocket with common hardware store items in an afternoon.

All the parts for this simple but impressive air rocket and launcher are cheap and easy to find. Building it is a breeze and the modifications are endless. It's legal in a big city, reusable, clean, and can be launched even in high winds on a small field.

Believe me, folks are quite taken by the 200- to 300-foot flights fueled by 18 or so bicycle pumps of compressed air. Whether you're launching on your own or with a whole group of rocketeers, watch the crowds gather ... 3, 2, 1, and away!

CAUTION: DANGEROUS PROJECT

At normal temperatures, standard Schedule 40 PVC has a working pressure of around 150psi, but heat, sunlight, solvents, scratches, and time make the material lose strength, and even at the 75psi used for this project, it will eventually fail. When it fails, it will break into fragments that can be thrown with great force by the compressed air. For added safety, wear safety goggles and wrap PVC elements in several layers of duct tape (not shown) to minimize any possible shrapnel. For a bomb-proof model, you could also build the entire system out of galvanized steel pipe at a greater expense.

Photograph by Gabriela Hasbun

Set up: p.105 Make it: p.106 Use it: p.113

Rick Schertle (schertle@yahoo.com) is a master at the craft of teaching middle school in San Jose and a novice maker at home. His diverse interests include backyard chickens, adventure travel, veggie oil-fueled cars, and geocaching — all made more fun with the enthusiastic support of his wife and the crazy antics of his young son and daughter.

PUMP IT UP, UP, AND AWAY!

AIR ROCKET ANATOMY

1. **Bicycle pump**
2. **Tire valve** Allows PVC chamber to be pressurized.
3. **¾" inline electric sprinkler valve** Releases the pressure in an instant burst.
4. **Paired wires** Connect the battery button and sprinkler valve.
5. **Button** Triggers the sprinkler valve for the launch.
6. **R/C toy or power tool battery** Provides the juice necessary to trigger the valve under pressure.

My 5-year-old son demonstrated the physics of an air rocket recently at a hamburger joint when he shot the wrapper off his soda straw. That's basically how this air rocket works.

The launcher is made from PVC pipe, and has a chamber that's pressurized using a bicycle pump. The pressure is released in a split second through an electric sprinkler valve, sending the paper-and-tape rocket into the sky.

What's unique about this design (as opposed to a solid-fuel model rocket or soda-bottle water rocket) is that the force of the air propelling the rocket upward is applied all at once. It still blows my mind that just this initial blast of air can send the rocket so high.

If you want more info on the basic physics of the air rocket, this NASA link gives a nice simple description: makezine.com/go/airnasa. NASA's description of how air-powered rockets work also includes a nice Flash animation.

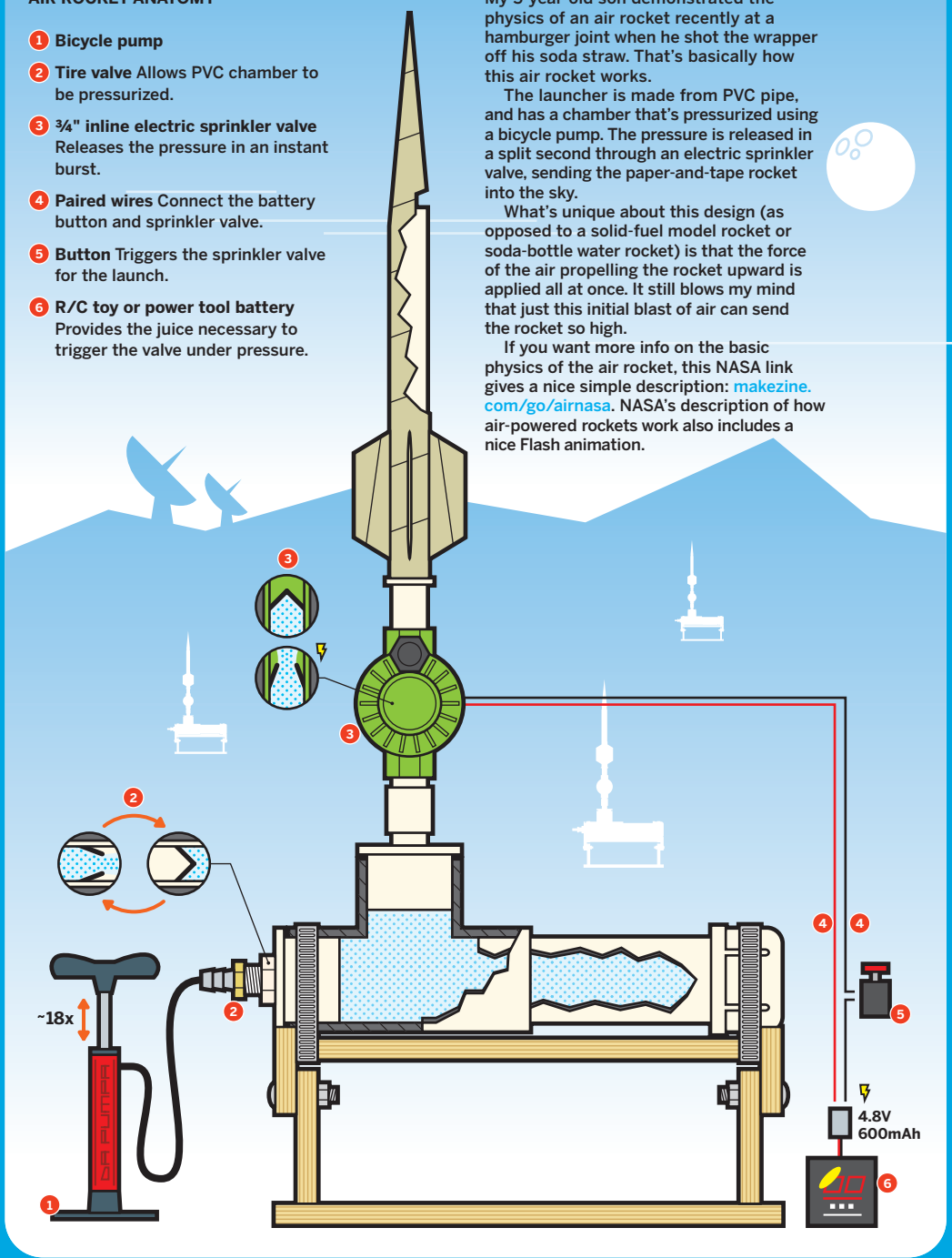
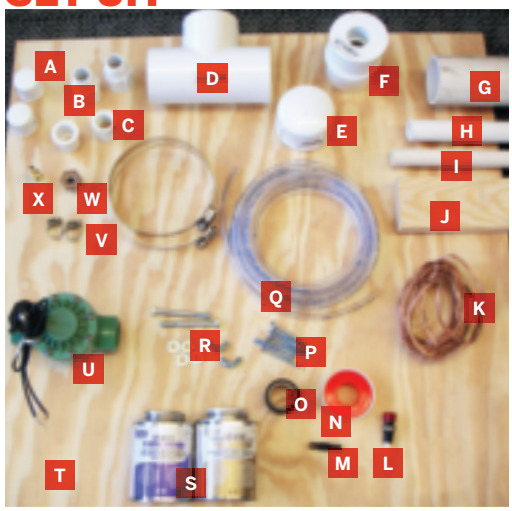
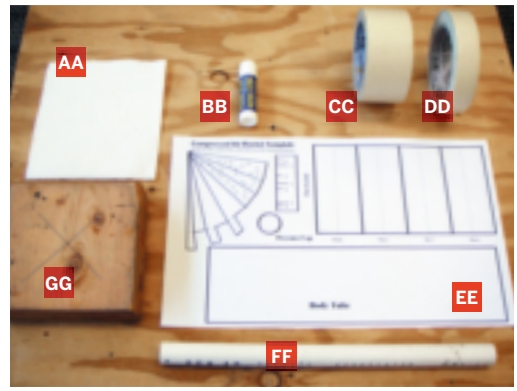


Illustration by Nik Schulz

SET UP.





MATERIALS

[A] ¾" PVC slip end caps (2) see below

[B] ¾" PVC adapters, ¾" male threaded × ¾" female slip (2)

[C] ¾" PVC reducers: ¾" male slip × ½" female threaded and ½" female slip × ¾" male slip

[D] 2" PVC slip tee

[E] 2" PVC slip end cap

[F] 2" PVC reducer bushings, male slip × ¾" female slip (2)

[G] 2" PVC pipe, 10" length

[H] ¾" PVC pipe, 3" and 4" lengths

[I] ½" PVC pipe, 16" length for launch tube

[J] 48" length of 1×3 pine board to be cut to various sizes for the launch tower

[K] 10' length of paired wire I used speaker wire.

[L] Button momentary switch RadioShack part #275-609

[M] Tire air valve

[N] Teflon tape

[O] Electrical tape

[P] Wood screws, size #6×1½" or similar (8)

[Q] 10' length of 5⁄16" (outside diameter) × 3⁄16" (inside diameter) flexible vinyl tubing

[R] ¼" hex bolts, 2" long (2), wing nuts (2), and washers (4)

[S] PVC cement and primer

[T] 24"×24" piece of ½" plywood as a base for the launch tower

[U] ¾" inline 24V electric sprinkler valve Cheap is fine, just make sure you get an inline one.

[V] Hose clamps: size #4, 7⁄16"–11⁄16" (2) and size #72, 3½"–5" (2)

[W] ½" male threaded × ⅛" female threaded brass reducer bushing

[X] 3⁄16" hose barb × ⅛" male threaded brass fitting

[NOT SHOWN] Battery connector Connectors can be the standard R/C toy type used for rechargeable batteries, or a generic bullet type.

Power tool or R/C toy battery to trigger the sprinkler valve. Under pressure, the valve requires higher amperage: a power tool or R/C toy battery will work, minimum 4.8V, 600mAh.

Bicycle pump and pressure gauge Use a pump with a built-in gauge, or just use an ordinary pen-type tire pressure gauge.

ROCKET BUILDING MATERIALS

[AA] Paper napkin

[BB] Glue stick

[CC] 2"-wide masking tape

[DD] ¾"-wide masking tape

[EE] Printed rocket template Download it from makezine.com/15/airrocket and print on 8½"×14" paper.

[FF] 13" length of ½" PVC pipe for rocket-building stand

[GG] 5½" length of scrap 2×6 lumber

TOOLS

[NOT SHOWN] Hacksaw or PVC cutter A cheap PVC cutter is a super handy tool for cutting hose, PVC pipe, etc.

Fine sandpaper

Rubber mallet

Utility knife

Screwdrivers

Drill and bits: 3⁄32", ¼", ½", 13⁄16"

Saw for cutting lumber to various sizes

Soldering iron and solder (optional)

Socket set (optional)

Scissors

Wire cutters

Adjustable wrench

Channel-lock pliers

Large C-clamp

Please note: Only Schedule 40 PVC should be used.

Photography by Rick Schertle

MAKE IT.

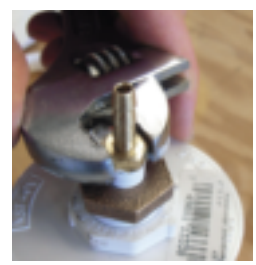
BUILD YOUR AIR ROCKET LAUNCHER AND ROCKETS

START **Time: An Afternoon Complexity: Easy**

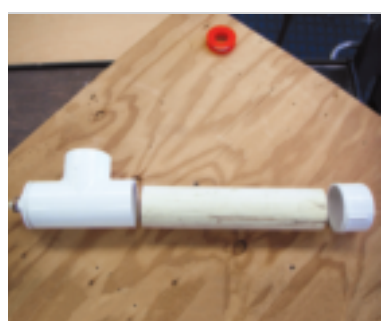
1. ASSEMBLE THE PRESSURE CHAMBER

1a. Use PVC primer, then cement, to glue the 2" male slip × ¾" female slip PVC reducer bushing into the 2" slip tee. Next, prime and glue the ¾" male slip × ½" female threaded PVC reducer into the 2" male slip × ¾" female slip PVC reducer bushing.

1b. Apply teflon tape to the threads of both brass fittings. Screw the brass barbed fitting to the brass ½"×⅛" reducer bushing. Screw the ½"×⅛" brass reducer bushing into the ¾" male slip × ½" female threaded PVC reducer. Tighten all connections with an adjustable wrench.



1c. To complete the pressure chamber assembly, prime and glue the 2" end cap onto the 10" length of 2" PVC pipe. Next, glue the 10" piece of 2" pipe into the other end of the 2" tee as shown.



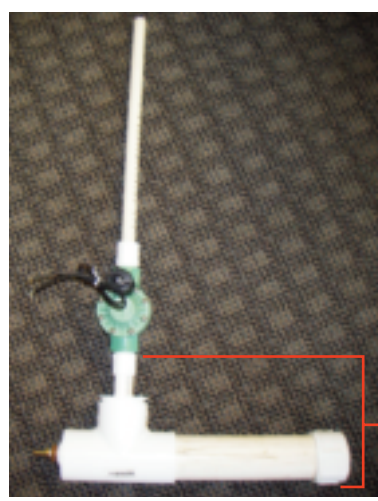
2. BUILD THE LAUNCH SYSTEM

2a. Wrap teflon tape around each of the ¾" male threaded × ¾" female slip PVC adapters. Thread the adapters onto the ¾" inline 24V electric sprinkler valve and tighten with channel-lock pliers.

2b. Cut a 3" length of ¾" PVC and a 16" length of ½" PVC. Glue the 3" piece into the "In" side of the sprinkler valve. Glue the ¾" male slip × ½" female slip reducer and the 16" length of ½" PVC into the "Out" side of the valve.

2c. Glue the 2" male slip × ¾" female slip PVC reducer bushing into the tee on the pressure chamber.

2d. Glue the completed launch assembly into the pressure chamber. Your air launch system is complete.



WARNING: Wrap the pressure chamber with several layers of duct tape (not shown) to prevent injury in case the chamber shatters under pressure.

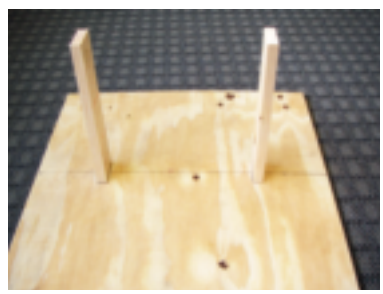
3. BUILD THE LAUNCH TOWER AND ATTACH THE LAUNCH SYSTEM

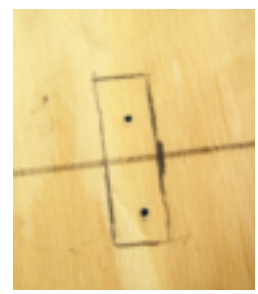
3a. Cut your ¾"×3" lumber to the following lengths: 15" (1), 3½" (2), and 12" (2).

3b. Clamp a 3½" length to the 15" length as shown. Pre-drill 2 holes with the 3/32" bit and then screw in the 1½" screws using a drill/driver. A bit of wood glue would be good too, if available. Repeat with the other 3½" length on the other side.

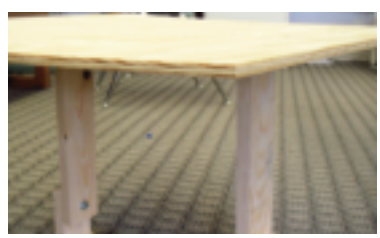
3c. Mark a 3½" piece 1" from the bottom, mark a 12" piece 2" from the top, line them up, and sandwich them together using a C-clamp. Drill a ¼" hole through both pieces, then slip a ¼" hex bolt through, with washers on both sides and a wing nut on the outside. Repeat on the other side.

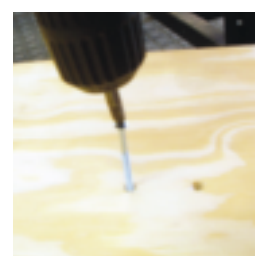
3d. The 24"×24" piece of plywood will provide a sturdy base for the launch tower. Measure and mark a line down the center of the plywood, 12" in from either side. On your centerline, measure and mark 4½" in from both ends. Place the legs of the launch tower with their edges on the inside of the marks, then trace a line around each leg. Drill two 3/32" holes in each traced area.





3e. Turn the whole thing upside down, line up the launch tower on the marks, and then finish drilling pilot holes into the launch tower legs, through the existing holes in the plywood. Screw into place.





3f. Once your base is secure, attach the pressure chamber/launch system to the horizontal board using the 2 large hose clamps. Your launch tower is complete.

4. MAKE AND WIRE THE LAUNCH BUTTON

4a. Drill a ¼" hole in the middle of one ¾" PVC slip end cap, and drill a ½" hole in the middle of the other to accommodate the button switch.

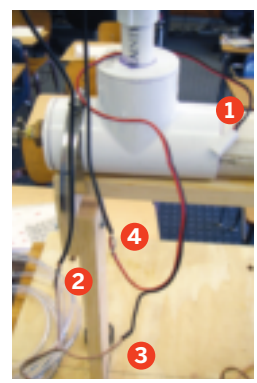
4b. Thread the paired wire through the end cap with the smaller hole, from the outside, and tie a knot about 8" from the end, so the knot is inside the cap. Now thread the end of the wire in the following order — through the 4" piece of ¾" PVC, through the nut and washer for the button, then through the ½" hole in the other ¾" end cap, from the inside.

4c. Solder the wire ends to the leads on the bottom of the button. Slip the washer and nut over the button, inside the PVC cap, and tighten the nut using a pair of needlenose pliers. This can be a bit tricky.

4d. Push everything together to complete the button assembly. Don't glue it, in case you need to make repairs to your button later.

4e. Connect the wiring. Solder connections when possible, and insulate them with electrical tape.

1. Use bullet connectors or something similar to connect the battery leads to the button and the electric valve.
2. Connect 1 wire from the button to 1 lead on the sprinkler valve. Twist, then solder and/or tape.
3. Connect the other wire from the button to one of the bullet connectors on the battery leads (red or black, it doesn't matter).
4. Connect the remaining battery connector to the remaining lead on the sprinkler valve.



4f. Tape the wire for the button to the vertical support of the launch tower. Test your launch button. When you press the button, you should hear the sprinkler valve click open and closed. You'll do more testing later when the system is under pressure.

5. MAKE THE AIR HOSE AND TEST THE LAUNCH SYSTEM

5a. Now we're going to assemble and attach the air hose to the launcher. First, strip the rubber off the tire valve. You can use fine sandpaper to clean off the valve so it's shiny.

5b. Slip the tiny hose clamp over the hose and insert the tire valve into the hose. Push it in as far as you can. Tighten the hose clamp over the tube and valve using a socket or screwdriver. This connection was the Achilles' heel in my prototype launcher. Granted, it was exciting to have the hose explode off at 75psi, hissing wildly like a snake, but, for the sake of reliability, I've strengthened it by using the mini hose clamps.

Slip the second mini hose clamp over the other end of the hose, and push the hose end onto the 3⁄16" hose barb. Tighten the clamp over the hose and barb. If you find the clamp too big and you're not able to get it really tight, wrap the barb in rubber from a bike inner tube and then tighten the clamp over that.

5c. Attach the bicycle pump to the tire valve and pressurize the system to about 75psi. Keep an eye on the gauge and listen for any hissing. The pressure should stay at 75psi. If you find leaks, fix them and try again.

Release the pressure by pressing the launch button (with the battery connected). **Be careful when you do this — wear eye protection and stand clear of the pressure chamber.**

If the pressure doesn't release when you press the button, tighten down the solenoid (the black thing with the wires coming out) on the sprinkler valve. You may also need a larger battery (one with more amps) to trigger the solenoid under pressure.

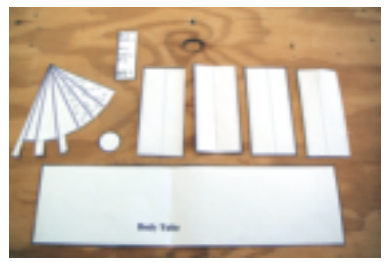
If you're still having problems with your electrical system, most valves have a manual trigger you can flip to release the pressure. If you're up this close to the valve you may want hearing protection as well. **Be very careful that your head is away from the launch tube.**

6. BUILD THE ROCKET ASSEMBLY STAND

Mark the center of a 5½" scrap of 2×6 lumber. Drill a 13⁄16" hole 1" deep in the center. This is where a drill press is really handy. Then twist a 13" length of ½" PVC pipe into the hole. Add masking tape to the base of the pipe, if needed, to get a snug fit.

7. BUILD THE ROCKETS

7a. Download the rocket template from makezine.com/15/airrocket and print it out on 8½"×14" paper. Cut out all the pieces on the solid lines as shown.

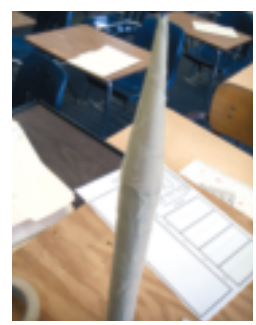


7b. Wrap the body tube around the assembly stand and tape it in 5 places with the ¾" masking tape. The smoother your tape, the more aerodynamic your rocket will be. Now wrap the body tube with 2" masking tape, working your way down. Slide the body tube to the top of the PVC stand. Tape the pressure cap on top of the body tube by crisscrossing ¾" tape over the top, and smooth it down.

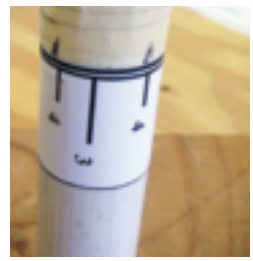
NOTE: Make sure to overlap the tape, making it about 2 layers thick everywhere. If you miss a spot, you'll have a dramatic blowout!

7c. Curl the nose cone around to overlap the dotted section, and tape it in place. Stuff the nose cone tightly with the napkin. A full napkin should fit in. Use a pencil to pack it tightly.

7d. Place the nose cone on top of the body tube, tape around the tabs, then cover the nose cone in tape.



7e. Wrap the fin guide around the PVC pipe at the base of the body tube and mark on the 3s for a 3-fin model or the 4s for 4 fins.

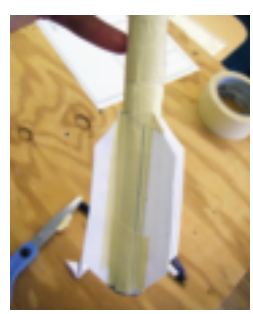


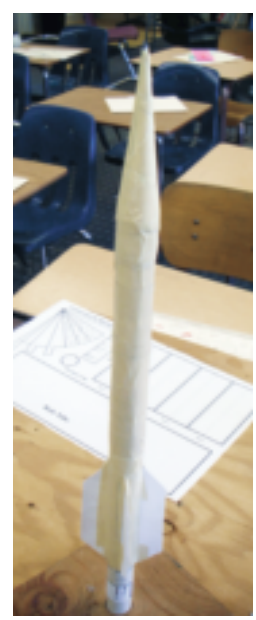
7f. Fold the fins on the dashed lines, then stack them together and trim the tops and bottoms at an angle.

7g. Glue the fins together with a glue stick, and pinch them to adhere them. Make sure you don't glue the tabs that will be used to attach the fins to the rocket.

7h. Line up the fins with the marks on the bottom of the body tube. Tape all fins securely in place.

Your rocket is now complete and ready to launch. The great thing about these rockets is that no matter how they're built, they will fly! Some of course will fly better than others, but they all will fly to some degree.

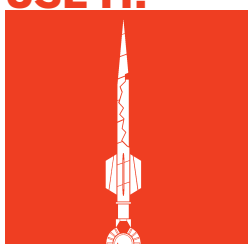




FINISH X

NOW GO USE IT »

USE IT.



ROCKET SAFETY, SITE SELECTION, OPERATION, AND CONTESTS

SAFETY

As with any air-powered device, you have to use caution. Eye injuries are your biggest danger. Safety goggles for you and any spectators are required.

SITE SELECTION

Because these air rockets have no recovery system, you can launch them in a fairly small area even with wind. They will go very high but then come right back down.

A small field would be an ideal launch site. The rockets are light and soft, so while it's not ideal for them to land on cars, the chance of damage is slight.

OPERATION

Set the launcher on the ground and lay out the air hose and launch button wire away from the launcher.

Slide the rocket down the launch tube until it stops at the pressure cap. This is a tight fit and you may need to smooth down the inside bottom of the rocket with your fingers to get it on. You may also bevel the top of the PVC launch tube with a file to make it easier.

Connect the air pump to the hose and pump up to about 75psi. If you go above 75psi, you may blow out the side of your rocket.

Count down and then launch! With a good launch, the rocket will go nearly out of sight and then free-fall to the ground.

The rocket will get crumpled as it hits the ground, but can simply be pinched back into shape and launched again and again.

If for some reason it does not launch, follow the pressure testing instructions in Step 5c.

CAUTION: When placing the rocket on the launcher, make sure your head is never over the launch tube. Wear safety goggles. Make sure everyone is clear from the area before launching, and do a countdown once everyone is at a safe distance.

CONTESTS

» Tilt the launch tower, then place a trash can 100yds away and see who can get the closest.

» Build a simple clinometer (wikihow.com/Make-a-Clinometer) and have contests to see whose rocket can get the highest.

OTHER RESOURCES

If this MAKE project really grabs you, here's a great article on air rockets and some more sophisticated setups, by two professors at Southern Illinois University: makezine.com/go/airrocket.