HOW IN THE WORLD DID THEY DO IT?

A New Lesson in Rocketry

Adapted from "Industrial Strength Paper Rockets"

By Gregory Voght/NASA JSC

Description:

Students construct paper rockets, test rocket stability, and launch with an air pressure rocket launcher.

National Education Standards:

Science

Unifying Concepts

- Change, Constancy, and Measurement

Physical Sciences

- Motions and Forces
- Transfer of Energy

Science and Technology

- Abilities of Technological Design

Mathematics

- Patterns, Functions, and Algebra
- Geometry and Spatial Sense
- Measurement
- Data Analysis, Statistics, and Probability

Technology Education

- Design
  Engineering Design
  Troubleshooting, R& D, Invention, Innovation, and Experimentation
- Abilities for a Technological World
  Apply the Design Process
- The Designed World
  Energy and Power Technologies
  Transportation Technologies
  Manufacturing Technologies
  Construction Technologies

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Materials:

- Paper (variety of weights-copy paper, construction paper, cardstock, etc.)
- Cellophane tape
- Scissors
- Rulers
- Pencils
- String
- Cardboard
- Modeling clay
- Rocket forms (short lengths of ½ " PVC tubes)
- Fin and Nosecone patterns (Attachment #8)
- Posterboard
- Hot-Glue gun (to be used by teacher or adult volunteer)
- Launcher (See Attachment #9)
- Electric Air Compressor or Hand pump
- Safety glasses for the launch

Procedure:

- Choose a type of paper and roll it around the short lengths of ½" PVC tube. The tube serves as a form for constructing the body of the rocket. The paper should be snug on the form but able to slide easily.
- Use cellophane tape to secure paper roll.
- Choose a fin shape, trace on posterboard, and attach to body of rocket with tape. (After stability tests, fins should be attached with hot glue.)
- Trace nosecone, add modeling clay for weight if you wish, and attach to body of rocket with tape. (After the stability tests, the nosecone should be attached with hot glue.)
- Perform Rocket Stability Tests
    - Find the center of mass. This line on the rocket represents an average of the mass of the entire rocket. Demonstrate how to find this point by tying a string around the model rocket. Adjust the string so that the rocket will be parallel to the floor. This is the center of mass; use the ruler to measure where this line is located.
    - Conduct the swing test. Spin the sample rocket in a circle using the attached string. A well-designed rocket will spin with the nose cone facing forward without wobbling.

- Find the center of pressure. This line represents an average of the pressure exerted on a rocket during its flight. A simple way to calculate this is to trace and cut out a cardboard silhouette of the rocket. Show students an example, and show them how, by balancing this on a ruler, they can estimate the location of the center of pressure. Students should record the center of mass and the center of pressure on their scale drawing. The center of mass should be close to the nosecone and the center of pressure should be close to the fins. After the three tests, the trainees may wish to make modifications, so the groups should not permanently attach their nose cones/fins until the tests are complete.

Launch Procedure:

- Select a clear field for the launch. Although the rockets are made of paper, they can still cause injury if someone is struck by them.
- Set up the launcher and orient the base so that the launch tube can point straight upward. If the wind is blowing, you will want to aim the angle of the tube slightly into the wind.
- Connect the air compressor or hand pump to the tire valve on the launcher. With the valve closed, pump the launcher up to 30 pounds of pressure. Test fire a rocket and observe how far the rocket goes and in which direction. Make adjustments to the aiming and pump the launcher up to 50 pounds of pressure. Again, test fire a rocket and make any final aiming adjustments.
- Allow each student to load the rocket on the launch pad. (Student launching must wear safety goggles.) Clear the landing site from bystanders, perform countdown, and launch rocket.

Safety Rules:

- Do not pump the launcher up to a pressure grater than half the rated pressure of the weakest part. The PVC pipes and the valve come with pressure ratings. If the lowest rating is 150 PSI, do not pressurize the launcher to greater than 75 PSI. This provides a significant safety margin.
- Be careful in handling the launcher. PVC can crack if dropped or struck with sufficient force. Inspect the launcher before use. Discard a launcher that shows signs of cracking.
- Do not lean over the launch rod at any time.
- Do not place anything inside the launch rod.
- Wear eye protection for launches.

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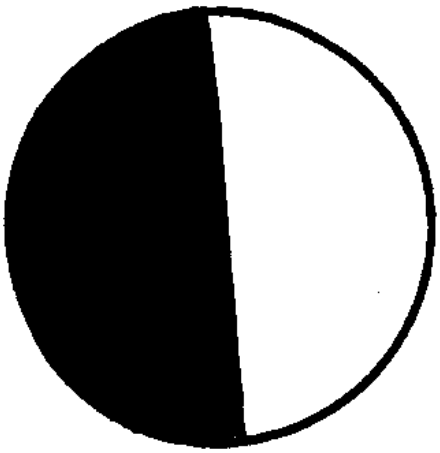
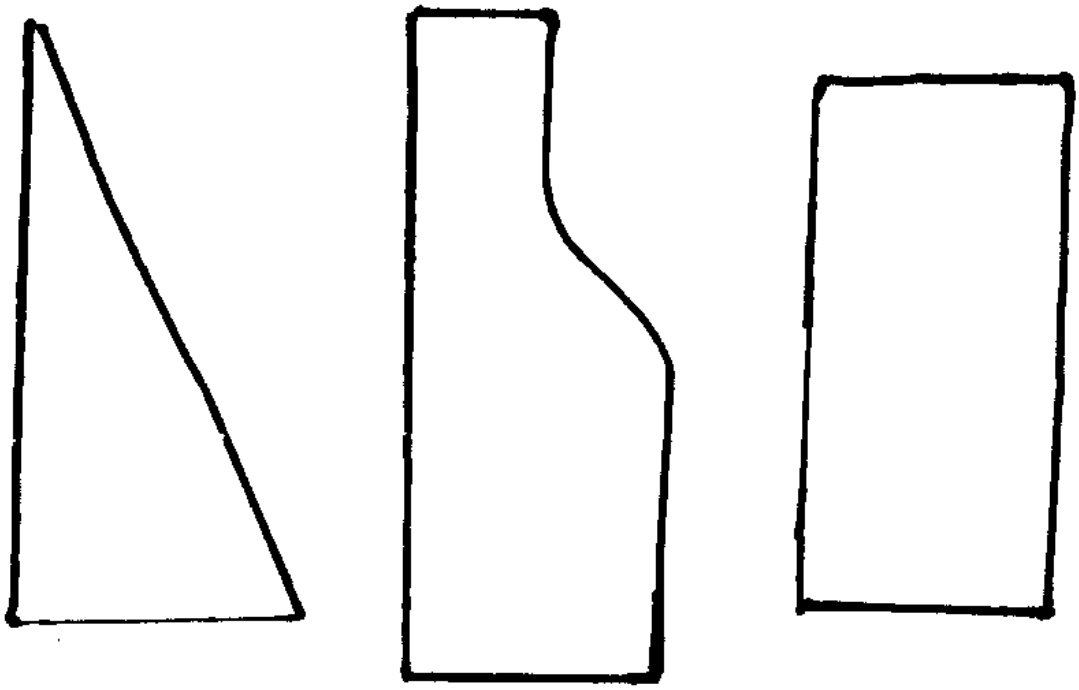
Nosecone



Using half of the circle, curl to form a nosecone.

Fin Shapes



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Constructing the Air Pressure Launcher

The air pressure launcher is made from Schedule 40 PVC plumbing parts available at most hardware stores. Refer to the diagrams for the specific parts needed. Clerks at the hardware store can help select the parts for you from the diagrams. Be sure to get pressure pipes for the 3", 3/4", and 1/2" tubing.

Using a saw, cut three pieces from the 3" pipe. The pieces should be 17, 6, and 5 inches long. PVC cuts very easily. Remove any burrs from the cut and clean the pipe if it is dirty.

Using a drill and bit, drill a hole into the center of the 3" end cap. The size of the hole will depend upon the diameter of the tire valve stem. The hole should be just smaller than the diameter of the rubber stem so that the stem seals itself to the cap when it is pushed through the hole from the inside out

Join the end cap to the 17-inch long 3" pipe segment with PVC cement. First clean both joining surfaces with PVC Purple Primer Cleaner. Make sure you are working in a well ventilated area away from open flame. When dry, coat the surfaces with PVC Cement and push the parts together immediately. Following the same cementing procedure, join one elbow to the other end of the pipe. Next, join the 5-inch long 3" pipe to the elbow. Join the remaining large elbow to the other end of this pipe segment. Be sure that both elbows are aimed in the same direction. The large tubes will serve as the launcher base and the pieces must not be twisted or the launcher will rock when it is being used. To insure proper alignment, set the base on the floor before the glue has set and press the second elbow until it is properly aligned.

Cement the 6-inch long 3" pipe to the elbow. Attach the 3" X 2" Coupling and the 2" X 3/4" Flush Bushing with cement to the other end of the tube.

Cut two 2" long pieces of 3/4" tube and prepare them for cementing. Join one to the flush bushing on one end and to the valve on the other end. Cement the second tube to the other end of the valve.

Cement the 3/4" elbow (with outside threads on one end) to the end of the second small tube. Screw the second elbow on to the first. Do not cement this elbow. It needs to be able to be rotated.

Cement the 3/4" X 1/2" Flush Bushing into the open end of the second elbow.

Cut an 18" long piece of 1/2" pipe and push it into the elbow. It can be cemented if you wish. This is the launch tube.

For extra strength, you can wrap the tubes with nylon filament tape. This is optional but recommended.

Tip: To make it easier to slip rockets on to the launch tube, use a file or sand paper to taper the upper end of the launch tube.

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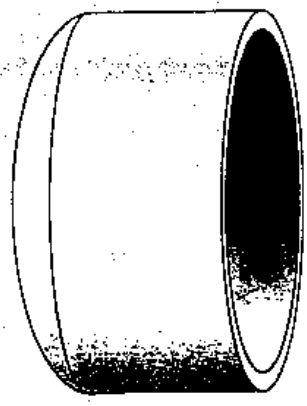
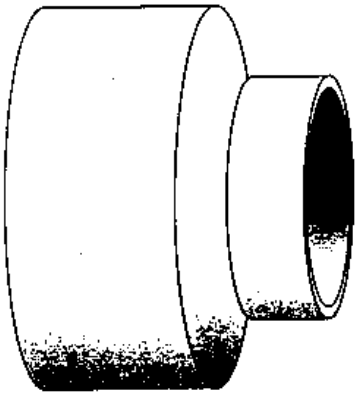
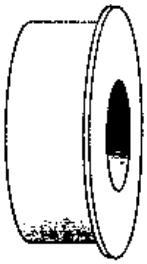
Air Pressure Rocket launcher Parts



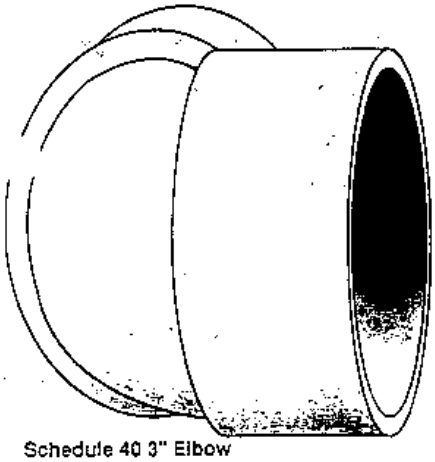
Schedule 40 3" Cap



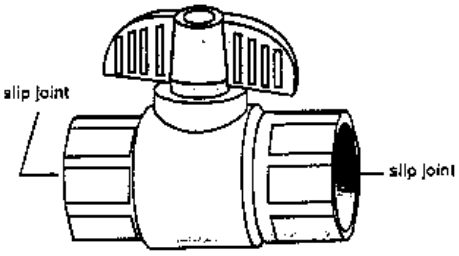
Schedule 40 3" X 2" Coupling



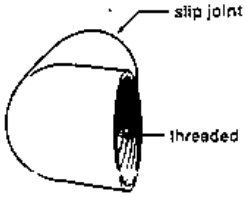
Schedule 40 Flush Bushing
2" X 3/4"



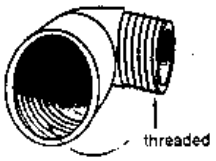
Schedule 40 3" Elbow



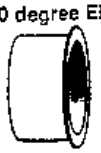
Schedule 40 Compact 3/4" Ball Valve



Schedule 40
3/4" 90 degree Elbow



Schedule 40
3/4" 90 degree Elbow



Schedule 40 Flush Bushing
3/4" X 1/2"

Snap-in Tubeless Tire Valve
TR418 or similar
(from auto supply store)

Other Materials:
- Pipe: 3" pressure*
  3/4" pressure*
  1/2" pressure*
- PVC Purple Primer
- PVC Cement

Tools: Saw for 3" pipe
(optional) PVC cutter for 3/4" and 1/2" pipe
Drill and bit for tire valve hole

* Comes in 10 foot lengths

Gregory Vogt 2/2000

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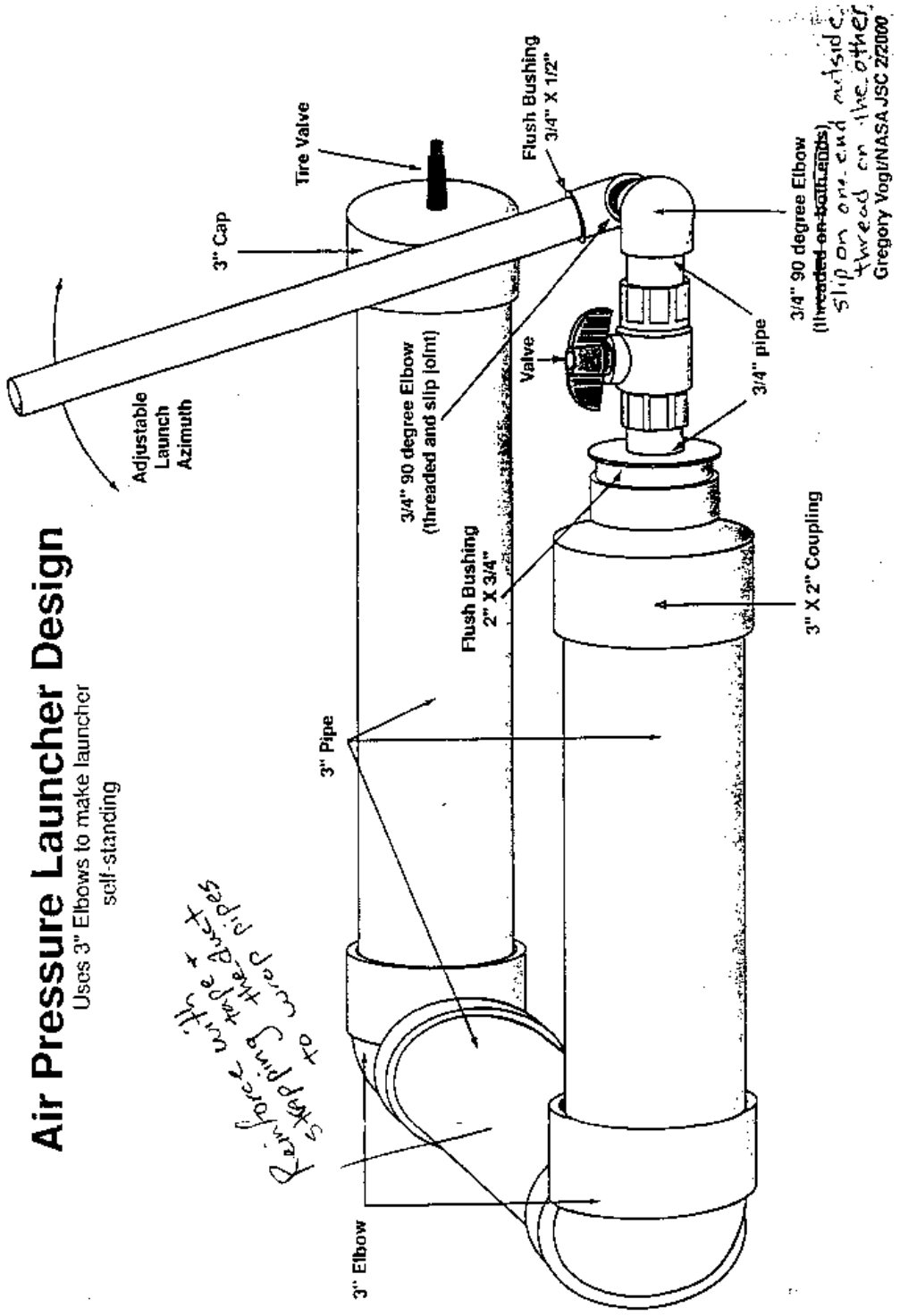

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