Vacuum Cannon

Purpose: Demonstrates force, acceleration, and pressure.

No class, however hostile or sullen, will be bored with this demo. Normal air pressure is used to accelerate a ping pong ball to high speed. The acceleration is so large that the ball disappears, passes through two pop cans, and reappears embedded in the third.

Our cannon has evolved due to various catastrophes. The current (ca. Sept. 2006) cannon is shorter for ease of use (with little loss of power) and made of polycarbonate to avoid shock fractures (I hope).

Note: The fun comes from having a projectile with a very small mass (2.3 g). Assuming a pressure difference of 105 N/m^2 and an acceleration length of 1.83 m, one arrives at some remarkable figures:

Force on ball =	113 N 26 lb
Acceleration =	49,000 m/s^2 5,000 g
Muzzle velocity =	425 m/s 1,400 ft/s 950 m/hr
Muzzle energy =	208 J 153 ft lbs

Compare these figures with some data on common pistol ammunition taken from Remington's website:

Bullet	***v* (ft/s)**	***KE* (ft lbs)**
.25 pistol	760	64
.22 L.R.	1150	117
.38 S&W	685	150
9 mm	1155	341
.45 Colt	960	460
.357 Mag.	1350	506

So, in terms of muzzle energy, the ping-pong-ball cannon (in theory) is similar to a .38 special! However, the ping pong ball is a lot less destructive than a hand gun because of its large cross section in comparison with a bullet. Also, its actual speed is much less than this simple estimate† (See the theory page.) with an energy of perhaps 65 ft-lbs. Nonetheless, please be careful where you point it.

† *The Physics Teacher* (Vol. 43, Jan 2005) by Peterson, Pulford, and Stein: They measure final speeds on the order of 300 m/s. Also included in the article are some lovely 'photographs' of the ball in action, and some speculation on real world effects.

See the Vacuum Cannon theory

Cannon Setup

Dead Cans

Stop action photo of ball and cans (by Steven Boada).

Extra Equipment: Pump Cart. Also a heavy weight for a back stop is needed.

Location: The cannon is on top of the glass cabinets along with all the accessories. Tape and pop cans are in the GP shelves below.

Extra Directions and Notes:

Do not worry – it is easy. These are the details nobody will need (probably).

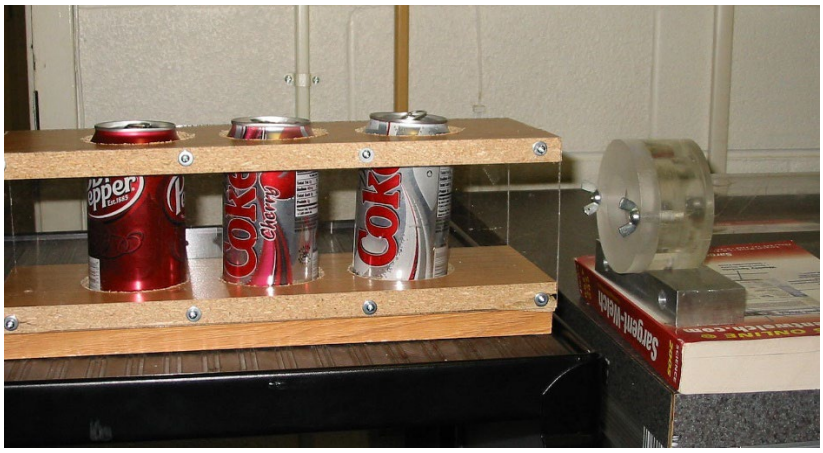
1. Connect the cannon to the vacuum pump: use the ½ in. hose and the ½ in pump barb.

2. Use 3 in. packing tape to seal each end. Remember to first insert the ping-pong ball into the barrel. Use the end opposite from the pump end. To keep the ball from rolling away from the end, I stick it to the sealing tape. See below for pictures.

3. Line up three (empty) pop cans in front of the barrel - or if you do not like the cans flying around use the plexi can-holder. You will probably need to adjust the height of the cannon (place some books underneath). Aim is important.

4. Pump down. With a good seal you should be able to get down to about 1.6 Torr. To pierce two cans you need to get down to the 2 Torr range.

5. Pop the end window with something sharp. Once the shot is fired, be sure to turn the pump off (or close the valve).

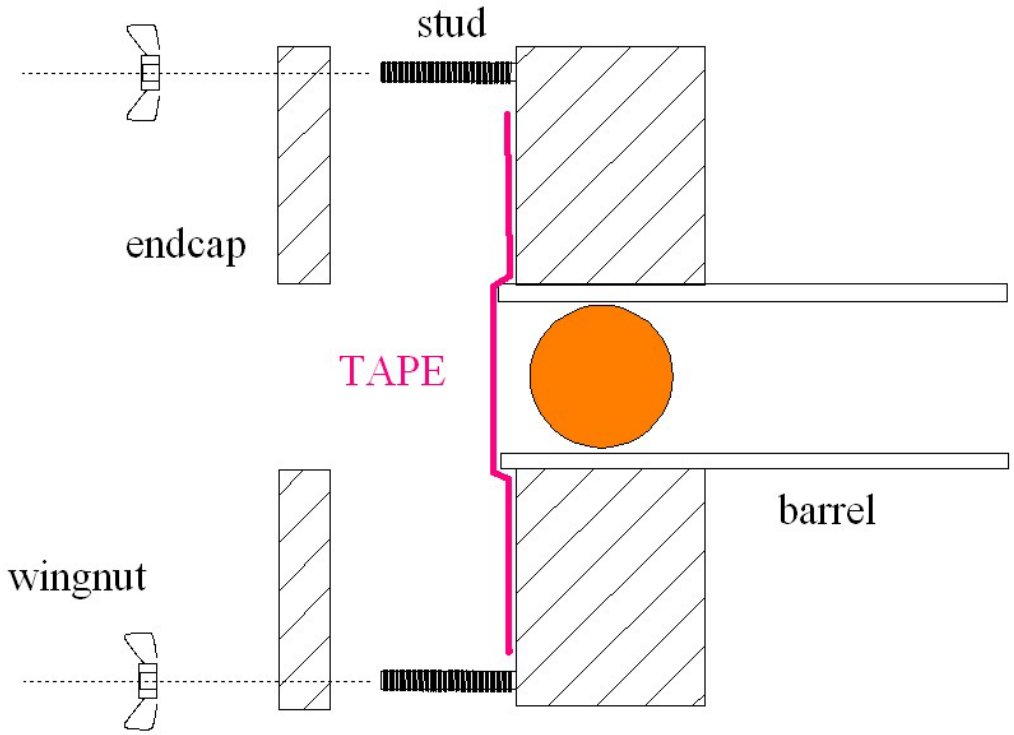


Can holder

Cans lined up

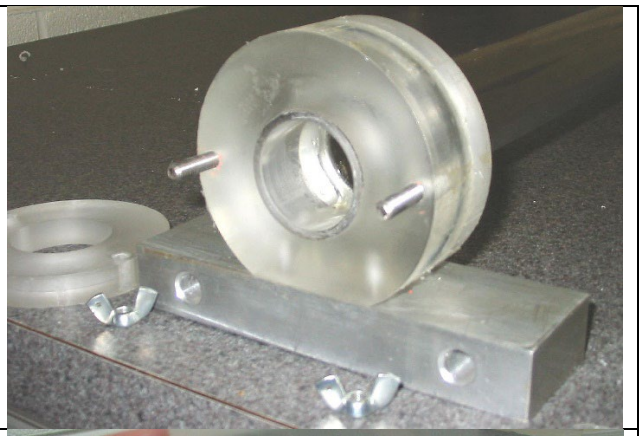
Sealing the end with tape:

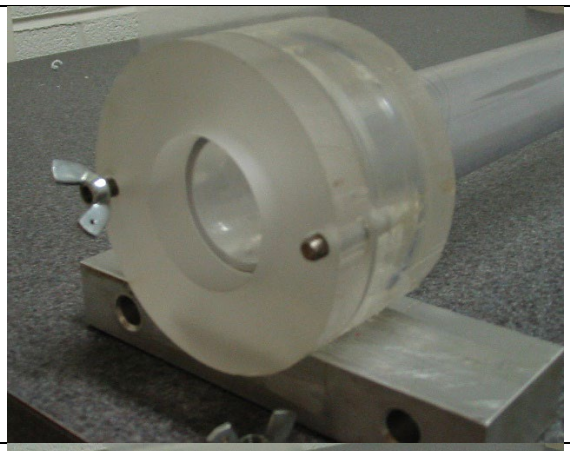
In earlier versions of the cannon, the packing-tape-to-endpiece seal worked pretty well. The problem was that the tape would creep and, sooner or later, suck into the barrel. To alleviate the problem, the new scheme uses endcaps that are bolted down over the tape.



The current endcap scheme.

With this scheme, you can pump down and not worry about how long the tape will last.

1. Start with the end cap off.	
2. Place a piece of 3” packing tape over the muzzle end. Smooth the tape over the sealing surface with your thumb. Make a good seal!	
3. With your thumb nail, crease the tape around the outside of the muzzle – it protrudes slightly beyond the sealing surface.	

4. Put on the end cap over the studs, start the thumb nuts, and tighten. The nuts should be snug but not forced too tight.	
5. That is it. It should work!