

## **Title: “Under Pressure”**

**Andrew Fotta, Connecticut Science Center, Hartford, CT**

**Demonstrates the power of air pressure by using vacuum cannon to propel an object at speeds high enough to penetrate a board or destroy a watermelon.**

“Hello, I’m Andrew, a STEM educator here at the Connecticut Science Center. Today we’re going to talk about air pressure.”

“A quick show of hands, how many people have been swimming? And when you’ve been swimming, how many of you have gone underwater and had your ears hurt?”

“Anyone know why that is?” (call on volunteer). “That’s right, it’s because the farther down you go, the more water there is above you, pushing down. As you know, water has weight, it has mass, and due to gravity, it exerts force.”

“The same thing is happening in our atmosphere. Air is all around us and above us it goes up for many miles – essentially, we live at the bottom of an ocean of air.”

“So, like water, the farther down into our atmosphere you go, the more air there is above you, pushing down.”

“Down here at sea level, that equals 14.7lbs per sq in.!”

“To demonstrate this, I have a rubber mat, and I need a volunteer to help me out.”

“Great, so what would you say this mat weighs? (1/2 lb?)”

“Ok, so I’m just going to put the mat down, and ask you to pick it up. Sounds easy, right?”

(Put mat down on table) “Ok, so just pick it up by this convenient hook that has been provided for you.”

(They can’t)

“So, what’s the problem? Why weren’t you able to pick the mat up? Did you not eat your Wheaties this morning?”

**“Now, this mat is 10.5 X10.5 inches square, which means it has a surface area of about 110 square inches.”**

**“Now, does anyone remember how much air pressure there is at sea level? (14.7 lbs/sq in.)”**

**“This means that the air above the mat is pushing down with about 1,620 lbs of force!”**

**“Now, when I’m holding the mat in my hands, there is not only air pressure pushing down on the mat, but also up on the mat, and on all other sides at the same time. Because of this, the pressure equals out and I don’t feel it in anyone one direction more than the other.”**

**“But, when I place the mat down on a flat surface, there is little to no air underneath the mat to counter act the air pressure pushing down on it.”**

**“Which means, unless my volunteer can lift a large horse, they will not be able to pick this mat up.”**

**Thank volunteer, send them back.**

**“Now, we’re going to use the properties we just talked about to propel something.”**

**Hold ping pong ball in one hand, board in another.**

**“Can we throw this ball hard enough to break this board?”**

**Show vacuum tube. “We will put the ping pong ball in and seal the ends. Then we will remove the air from within. That means there is about 28lbs of pressure pushing in on the sides. Since there is no air inside, there is nothing pushing back.”**

**“When we puncture the foil, the air outside will go rushing in, pushing our ball through the tube and out the other side at around 200 MPH into this board.”**

**“Ready? Let’s countdown from 3....”**

**Countdown**

**Puncture tube/break board.**

**“Wow! That was spectacular!”**

**“Now, what would happen if we had a bigger surface for the air to push on?”**

**“We’d have more force!”**

**“So....”**

**Bring out big cannon, all ready to go**

**Show end cap – “This is what is inside this tube. We will remove the air from inside, but because the ends are so much bigger, (3 in diameter) there will now be 103 lbs of air pressure pushing in, therefore creating a bigger force.”**

**Volunteer? Countdown – blow up watermelon.**

**Materials:**

1 air pressure mat:

<https://www.arborsci.com/atmospheric-mat.html>

**2 vacuum cannons:**

**Small one:**

-10 ft. clear pvc with a hole drilled in one end and fitted with a male valve for vacuum pump to attach to.

-2 end tubes that fit snugly over the ends of the pipe. (PVC pipe works well)

-Mylar space blanket pieces.

-Ping pong ball.

-Vacuum pump

-Hose to go from pump to tube

-Acrylic shield to place the target in

Vice to hold the target (1/8<sup>th</sup> inch MDF board in our case, but may use eggs, empty soda cans, etc., anything that will be destroyed by the ping pong ball!)

**Large cannon:**

-10 ft 3 in. diameter pvc pipe with a hole drilled in one end and fitted with a male valve for vacuum pump to attach to.

-Projectile: needs to be something that fits in the tube the same diameter as the tube, but moves freely. (ours is a PVC end cap).

-2 end tubes that fit snugly over the ends of the pipe. (PVC pipe works well)

-Mylar space blanket pieces. (we used 4 layers)

-Vacuum pump

-Hose to go from pump to tube

-Some sort of protection/backdrop to prevent the projectile from going too far.

-We made wooden cradles to hold the cannon on either end as well.

### **Directions to ready cannon to fire:**

1. Place projectile in the tube.
2. Place the mylar sheet(s) over end of the tube, then push on end tubes to hold mylar in place. (Ends should fit over tube snugly but have nothing over hanging end of tube so projectile can exit freely.
3. Once both ends have been sealed with mylar, turn on vacuum pump.
4. When pump has pulled all the air from the tube, quickly puncture the back end with scissors or something sharp.
5. Projectile will exit the opposite end of tube.
6. Be sure to not stand directly behind tube as you puncture it, in case of misfire!

