FEEL THE PRESSURE

High-Pressure Basketball

Everyone knows about the pressure that comes with taking that game winning shot, but the ball itself requires pressure, too.

HERE'S WHAT YOU'LL NEED

- Basketball
- Meter stick
- Paper
- Tape
- Air pump with pressure gauge and needle
- Stepladder
- Journal
- Markers
- Paper clip
- Balloon
- String
- Scissors

WARMUPS

Air is made up of matter. Actually, air is made up of lots of things. It is mostly nitrogen and oxygen with some other gases like carbon dioxide, argon and water vapor mixed in, but it's all matter. All that stuff takes up space.

We know that air is all around us but because it's invisible without an obvious size or shape, it is difficult to observe its properties and how it behaves.

If we can trap it inside of something flexible, like a balloon, its characteristics become much easier to see.

Let's get started.

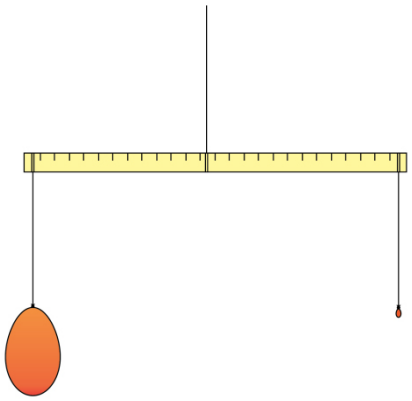
Blow up a balloon. Tie the end closed.

Now, tie the inflated balloon to about 30 cm of string. Tie an empty balloon to the end of another 30 cm length of string.

Use another piece of string and wrap it around the center of a meter stick. Tape the string to the meter stick to secure it.

At one end of the meter stick, tape the end of the string attached to the empty balloon.
Observe what happens to the meter stick.

Tape the end of the string attached to the inflated balloon to the other end of the meter stick.



How does this affect the position of the meter stick?

Use your fingers to pinch a section of the neck of the inflated balloon together. With scissors, cut a small notch in the balloon just above your fingers, but below the knot. Carefully release the balloon and observe. **What happens to the balloon and the position of the meter stick?**

In your journal, draw a model to explain how this activity demonstrates that air takes up space and has mass. Remember to label each part including the air.

When you cut the balloon and the air escaped, the action highlighted another important characteristic associated with air — pressure.

Air molecules are constantly bouncing off everything. As you blew air into the balloon the air molecules trapped inside compressed to fit the space. They were packed so tightly that they pushed against the interior surface, inflating the balloon. This gave the balloon its spherical shape. **What do you think would happen to the shape of the balloon if you squeezed it with both your hands?**

When the balloon was cut, it created an opening in the barrier holding the molecules inside allowing the air to escape. Instead of pushing the rubber of the balloon out uniformly, it pushed the balloon in the direction away from the cut.

GAME TIME

Just like the balloon in the previous experiment, basketballs and other sports balls are filled with air. The amount of air in the ball determines the amount of air pressure present.

Air pressure allows a basketball to keep its round shape while staying firm and bouncy. Basketballs, as well as volleyballs, soccer balls, and footballs, require a lot of force from air pressure to become and remain inflated.

Pick up your basketball and rotate it in your hands until you find the air hole. There are usually directions printed on the ball near the air hole recommending how much air to put into the ball. The amount of air is measured in pounds per square inch, which may be abbreviated as "lbs/in^2" or simply "psi." Your basketball will likely direct you to inflate the ball somewhere between 7 to 9 pounds per square inch.

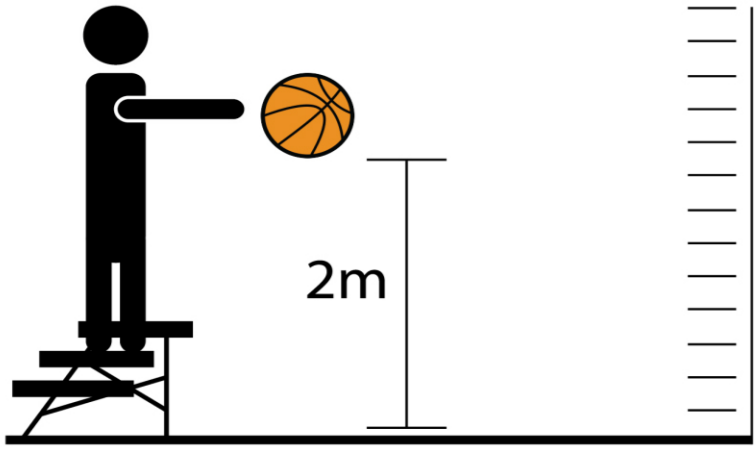
In this activity we will attempt to discover how much air pressure is needed to produce the best basketball bounce.

Before you begin you will need to create a table to record your results and observations. Read through the activity overview below to help you determine what type of table you will need.

- You will be inflating a ball to different psi levels.
- At each level, you will drop the ball from the same height and record how high it initially bounces back.
- Scientists use multiple data points, so repeating each trial drop at least three times will help ensure you get accurate results.
- You will need a place to calculate to the average bounce height, as well.

To set up a testing area, find an open space near a vertical wall. Use a vertical strip of paper or several meter sticks taped to a wall to mark and measure the height of each bounce. In this experiment, the bottom of the ball will be at a height of 2 meters each time that it is dropped, so keep this in mind when deciding at what height you should stop making your measurements.

Because you are dropping the ball from such a height, you may find it helpful to use a step ladder.



Now it is time to prep the ball for your first trial.

Start by using an air pump with a pressure gauge to check the air pressure of the basketball.

For the initial trial, the ball will need to have a pressure of 4 pounds per square inch. If your ball has less than that, use the pump to increase the pressure until the dial indicates 4 psi. If your ball has more than 4 psi, you will have to reduce the air pressure. To do this, straighten a plastic-covered paper clip. Moisten the air hole on the ball with a bit of water and wedge the tip of the paper clip into the air hole, moving the paper clip until the air hole is temporarily widened enough to let the air out.

Pro tip: You can use petroleum jelly to lubricate the paperclip, reducing the chance of tearing the air hole.

You can use the gauge on the air pump to check the air pressure in the ball. If you release too much air, pump more air until you reach 4 psi.

Carefully climb up the step ladder and hold the basketball so that the bottom of the ball is 2 m from the ground. With a friend watching and checking the height, drop the basketball. Your friend should watch carefully and note the height reached by the top of the basketball on its first bounce. Mark the spot on the paper taped to the wall. Measure and record the height in the corresponding space in in your graph.

Pro tip: If marking heights on the wall, use markers of various colors to keep track of which trial you are recording. For example, red for 4 psi, orange for 5 psi, yellow for 6 psi, etc.

Repeat this step at least three more times, remembering that each time the ball is dropped, the bottom of the ball should be 2 m from the ground. When you record the measurement, be sure to mark the greatest height reached by the top of be ball on its first bounce.

Now that you have completed this first trial, use the air pump to increase the air pressure in the ball to 5 psi. Repeat the trial as you have done before. Remember, to ensure accurate results a good scientist repeats trials over and over to get multiple data points.

Use the air pump again increasing the air pressure to 6 psi, repeat the trial, and record your results.

Use the air pump again increasing the air pressure to 7 psi. Based on your results so far make a prediction of how high you think the ball will bounce. Test to find out. Don't forget to repeat the trial and record your results.

Use the air pump again, this time increasing the air pressure to 8 psi (this is likely the recommended amount

suggested by the ball manufacturer.) Repeat the trial as before and record the results.

Use the air pump again increasing the air pressure to 9 psi, repeat the trial, and record your results.

Repeat the trial once more but this time increase the air pressure to 10 psi. Record your results.

You may choose to continue increasing the air pressure in the ball, but remember the air you are inserting into the ball is creating pressure that is pushing on the outside of the ball.

Now that you have completed four trial drops for each psi level and recorded the bounce results in your table, you can use the data points to calculate the average bounce height for each pressure level.

Using the equation below, calculate and record the average bounce height for balls inflated to the same air pressure.

$$\text{Average Bounce Height (cm)} = \frac{\text{Sum of all bounce heights (cm)}}{\text{Number of bounces}}$$

ANALYZE THE REPLAY
What happened?

Review all of the information you have collected through your trials and observations.

- At which amount of air pressure did the ball bounce the highest?
- At which amount of air pressure did the ball bounce the least?
- At which amount of air pressure did the ball bounce as you would expect it?
- Did changing the amount of air pressure inside the ball cause changes that you expected?
- Why do you think changing the air pressure in the ball caused these changes?
- How much air pressure would you want in a basketball if you were playing? Why?
- Why do you think the manufacturer of the basketball suggests inflating the ball to 7 to 9 psi, or similar measurements?
- Can you imagine a situation when it would be advantageous to have more or less air pressure in the ball than the recommended standard?
- Using what you have discovered from this basketball bounce activity, how do you think the inflated balloon in the previous activity would have acted if it had higher air pressure? What if it had lower air pressure?

OVERTIME
Let's take it further

In this activity we changed the amount of air inside the basketball, causing the ball to react differently when it hit the ground. Changing the amount of air inside the ball is not the only way we can use air pressure to change how the ball behaves.

You have probably seen a hot air balloon rise and float across the sky. As air is warmed the air molecules become more excited and move faster. Warm air molecules move faster and bump into each other, because of this the same amount of air molecules will take up more space if they are warm than they will if they are cool. If these fast-moving warm air molecules are trapped in a balloon, that balloon will rise when surrounded by cooler air.

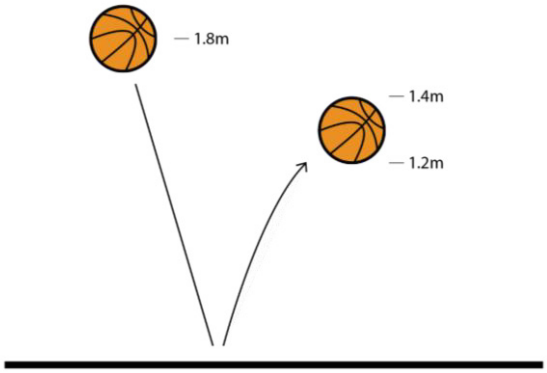
Using what you have learned, create your own experiment testing how a ball's bounce is affected by warmer and cooler temperatures.

Altitude also affects air pressure; can you design an experiment that measures how a ball bounces when an experiment is performed at different heights above the earth's surface?

An NBA regulation ball is inflated to between 7.5 and 8.5 psi. By regulating a basketball's air pressure, the NBA can ensure fair playing conditions. As this activity illustrated, the ball's internal air pressure determines how it bounces. This can be explained using Newton's laws of motion. As the ball hits a surface, the ball's internal pressure applies a force to that surface, causing an equal force to repel it in the opposite direction.

If the ball has the right amount of internal air pressure, a basketball player can effectively dribble the ball. If the air pressure is too low, the ball will lack the force necessary to get it back to the needed height. If the ball is overinflated, it may apply too great of a force and bounce too high.

Because you may not always have an air pressure gauge handy and because some surfaces will cause a basketball to bounce differently anyway, here is a simple test you can use to find if your basketball has the right amount of air pressure. Drop the ball from about 1.8 m. If the ball bounces up between 1.2 and 1.4 m, it has the proper amount of internal air pressure.



DO YOU WANT TO LEARN MORE?

Research: Newton's Third Law, altitude, temperature, barometer

OKLAHOMA ACADEMIC STANDARDS: SCIENCE

Mathmatics	4TH GRADE	5th Grade
N 1.1 Numbers and Operations		●
N 1.4 Numbers and Operations		●
N 1.5 Numbers and Operations	●	
A 1.1 Algebraic Reasoning and Algebra	●	
GM 2.4 Geometry and Measurements	●	
GM 2.5 Geometry and Measurements	●	●
GM 3.4 - Geometry and Measurement		
D 1.1 Data Analysis	●	●
Science		
PS 3.2 Energy	●	
PS 1.1 Matter and Its Interactions		●
PS 2.1 Motion and Stability		●