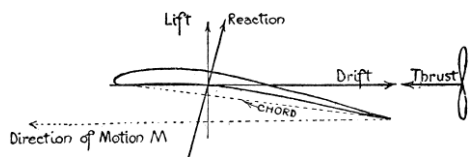


# Old School Demonstrations:

## Bernoulli's Principle (Demos)



### ➤ Lesson Plan: Bernoulli's Principle (Demos)

**Background:** Daniel Bernoulli was a Swiss mathematician during the eighteenth century. Bernoulli studied a physical phenomenon/relationship between the velocity of a fluid and pressure. His observations and applied mathematical explanations became known as Bernoulli's Principle. (Detailed explanation of Bernoulli's Principle below: Related Web Resource - Flight, Airfoils, Forces and Bernoulli's Principle)

Bernoulli's Principle describes a phenomenon in which the pressure (pressure is the amount of force applied over an area) of a fluid (gas or liquid) changes with a change in the velocity of the fluid. Bernoulli observed that an increase in the velocity of the fluid resulted in a decrease in the pressure of the fluid. Also, a decrease in the velocity of a fluid resulted in an increase in the pressure.

↑ - Velocity

↓ - Pressure

$(P = \text{Force} / \text{Area})$

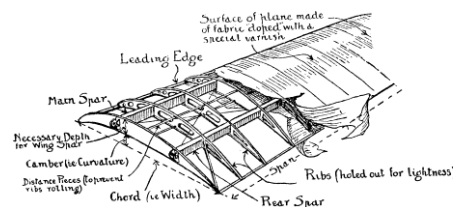
↓ - Velocity

↑ - Pressure

$(P = \text{Force} / \text{Area})$

This lab write-up includes many demonstrations that highlight Bernoulli's Principle. We will start with **flight/lift** and continue from there. Each section will include a small explanation and related video lesson.

Lift (airplane flight) is probably one of the most well known and controversial occurrences described by Bernoulli's Principle. Many times Bernoulli's Principle is used exclusively to describe the flight. In reality flight is a very complex integration of many factors including drag, Bernoulli's Principle, Newton's Third Law of Motion, gravity, etc. During this demonstration we will only consider Bernoulli's Principle when describing lift. I have included an extensive list of websites that describe additional mechanisms of flight/lift.



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# Bernoulli's Principle (Demos)

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## Materials: Flight/Lift

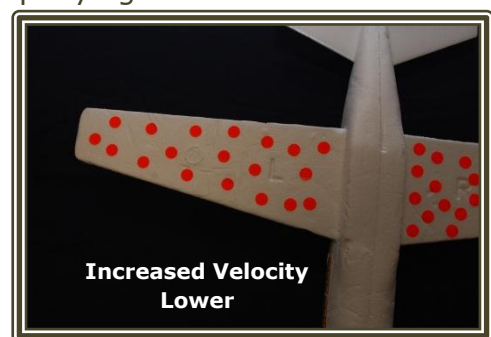
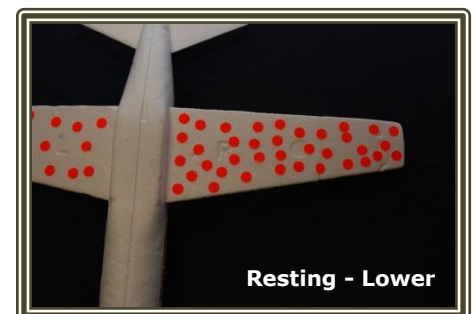
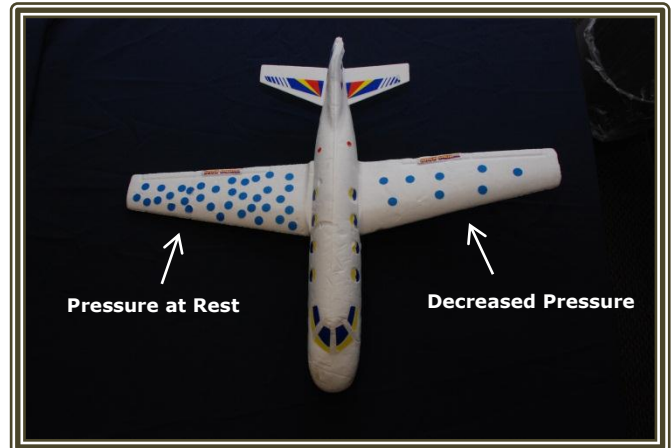
- Styrofoam plane
- Colored round stickers (2 colors)
- Classroom with student desks
- Paper (8.5"X11")
- Measuring tape
- Stopwatch (3-5)

## Procedure:

During this lab/demonstration you will use a Styrofoam airplane to explain lift, and then the students will construct paper airplanes and compete in a paper airplane throwing contest.

### ➤ Setup/Process

1. Place 35-40 colored stickers on the upper and lower sides of one of the wings. On the second wing, place 20-25 colored stickers on the bottom and 8-10 on the top.
2. Describe the pressure on an airplane wing at rest. Wing (left) with 35-40 stickers on upper and lower sections. The pressure and force above and below the wing are the same. Atmospheric pressure at sea-level is approximately  $14.7 \text{ lbs./in.}^2$ .
3. Show the wing (airfoil) from the side – draw an airfoil on the board. The upper portion of the wing is a longer distance.
4. Compare the wing (airfoil) to the classroom. Race a student to the back of the room. Show how an increase in velocity occurs on top of the wing resulting in a decrease in pressure. Compare the decrease in pressure to high-fives at a BB game. Compare the high-fives at a game to the colored stickers on the wing of the plane (below) with 20-25 colored stickers on the bottom and 8-10 on the top. The demonstration is described in the accompanying video lesson.



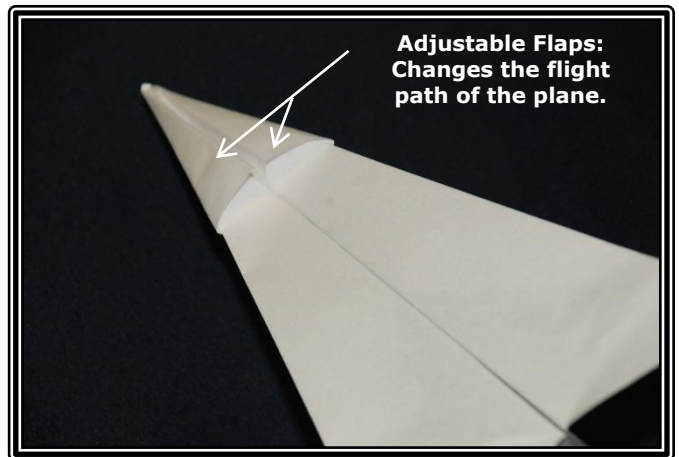
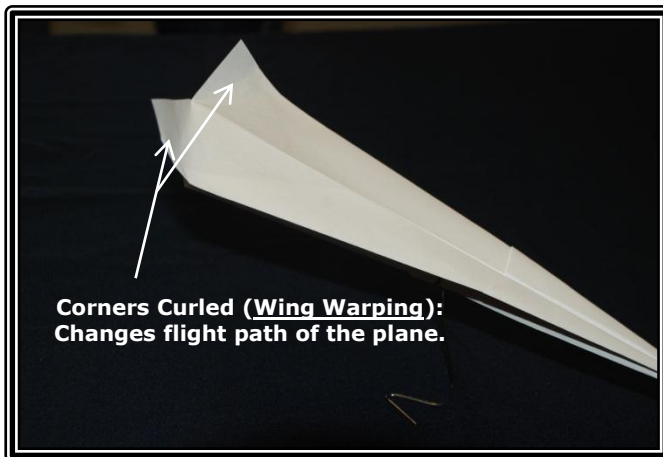
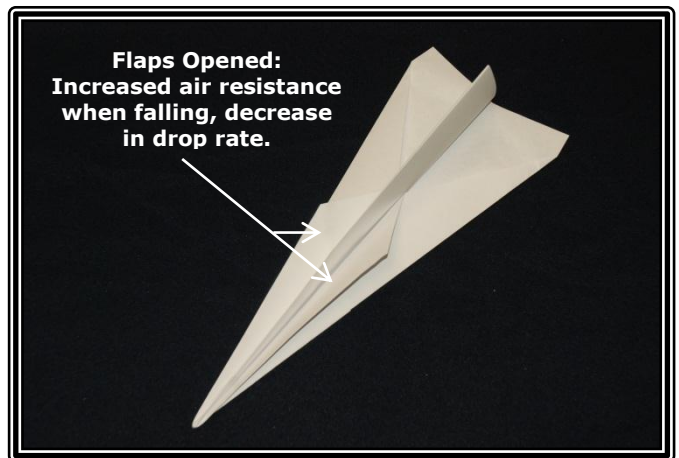
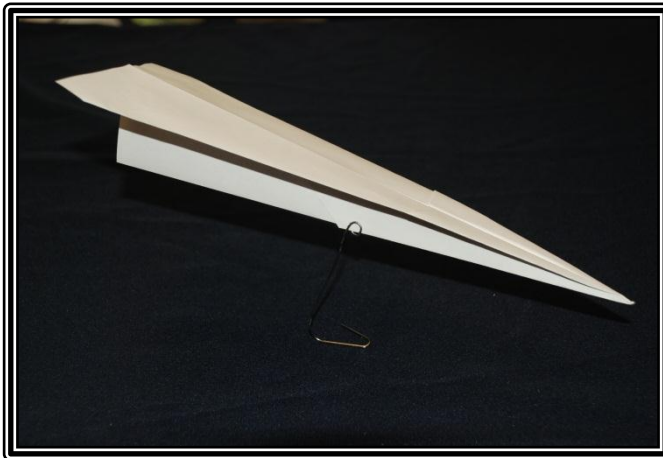
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# Bernoulli's Principle (Demos)

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## Procedure Continue (Flight/Lift):

5. Show the students an example of a paper airplane. Describe/show how small adjustments can change the lift/flight of the paper airplane.



6. The students will construct a paper airplane and compete in a paper airplane throwing contest.
- Airplane designs available online, example website listed under Related Web Resource.
  - Example airplane design available at SDPB. Found online next to the accompanying video lesson.
  - Possible categories for the contest (choose one or more categories)
    1. Longest distance
    2. Longest time in the air
    3. Longest distance in shortest amount of time
    4. Longest distance in longest period of time
    5. Etc.

**What to expect:** The students should observe that small changes or adjustments in the design of a plane can drastically change the flight of the plane. Students should understand that Bernoulli's Principle is one factor ([depending on the design of the wing](#)) that can affect lift.

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# Bernoulli's Principle (Demos)

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## Related Web Resource (Flight/Lift):

### Paper Airplanes

- Airplane designs  
<http://www.funpaperairplanes.com/index.html> ([Click](#))

### PBS Video Clips, Lessons and Interactives

- Dinosaur Train (PreK–Elementary lesson and video)  
<http://www.pbs.org/teachers/dinosaurtrain/lessonplans/pterosaurplane/> ([Click](#))
- Cyberchase Activity: Top Flight  
<http://www.pbs.org/parents/cyberchase/lessons/themes/mathandsports/educators.html> ([Click](#))
- Scientific American Frontiers: lessons and video clips  
<http://www.pbs.org/saf/1109/features/makeplane.htm> ([Click](#))
- NOVA: Technology and Engineering  
[http://www.pbs.org/wgbh/nova/teachers/resources/subj\\_13\\_03.html](http://www.pbs.org/wgbh/nova/teachers/resources/subj_13_03.html) ([Click](#))
- Dragonfly TV: Wing shape and stunts  
<http://pbskids.org/dragonflytv/show/modelairplanes.html> ([Click](#))
- Wright Brothers KCET  
<http://www.pbs.org/kcet/chasingthesun/planes/wrightfly.html> ([Click](#))
- NOVA Deadliest Plane Crash (watch online)  
<http://video.pbs.org/video/1214003495/> ([Click](#))
- NOVA: Lift and Drag  
<http://www.pbs.org/wgbh/nova/space/lift-drag.html> ([Click](#))
- The Physics of Sailing (video and guide)  
<http://science.kqed.org/quest/video/the-physics-of-sailing> ([Click](#))

### Flight, Airfoils, Forces and Bernoulli's Principle

- Guide: lessons and experiments, explanation of flight (NASA)  
[http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The\\_Courage\\_to\\_Soar.html](http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Courage_to_Soar.html) ([Click](#))
- Explanation of flight (NASA)  
<http://virtualskies.arc.nasa.gov/aeronautics/1.html> ([Click](#))
- Bernoulli and Newton (NASA)  
<http://www.grc.nasa.gov/WWW/k-12/airplane/bernnew.html> ([Click](#))
- Airfoil and Bernoulli's (University of Minnesota)  
<http://www.lcse.umn.edu/~bruff/bernoulli.html> ([Click](#))
- Airfoil and Bernoulli's (MIT Dept. of Aeronautics and Astronautics)  
<http://web.mit.edu/16.00/www/aec/flight.html> ([Click](#)/ [Flight of Birds PP](#))
- The Bernoulli Theory of Flight Q&A (Dept. of Physics U. of Illinois)  
<http://van.physics.illinois.edu/qa/listing.php?id=2103> ([Click](#))

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# Bernoulli's Principle (Demos)

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**Bernoulli's Ball Video Demonstration** This is a twist on the classic Ping-Pong ball/hairdryer demonstration used to show Bernoulli's Principle. A leaf blower replaces the hairdryer and a beach ball replaces the Ping-Pong ball. This is amazing to watch.

## Materials: Bernoulli's Ball

- Hairdryer (cool option works best)
- Ping-Pong ball
- Extension Cord
- Leaf blower
- Assortment of balls (various sizes and weights)
- Large room (gym works well)

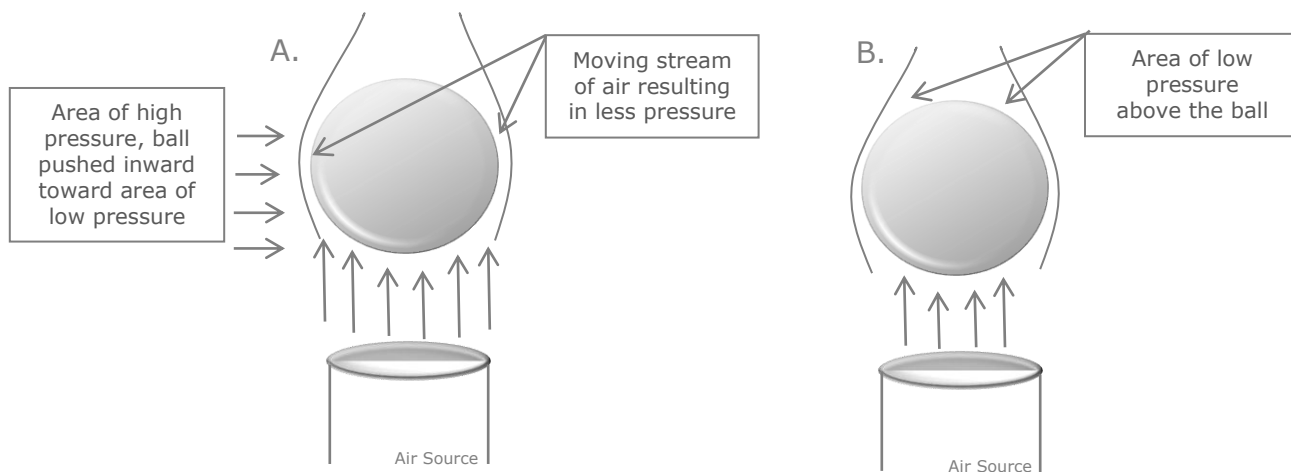
**Procedure:** During this demonstration a hairdryer will be used to float a Ping-Pong ball, and then a leaf blower will be used to float a beach ball.

### ➤ Setup/Process

1. Ask the students if they have ever seen a display in a store in which a beach ball is floating above a fan.
2. Place a Ping-Pong ball above the hairdryer; ask the students how the Pong-Pong ball is able to float above the ball without falling. Turn off the dryer.
3. Ask the students whether the ball is being pushed up or pulled up.
4. Turn on the dryer and slowly turn the hairdryer from 90 degrees to 45 degrees. The ball should not fall.
5. A student should place their hand above the ball. The ball should drop. This represents turbulence above an airplane wing.
6. Perform the demonstration using a larger ball(s) and a leaf blower.



**What to expect:** This is a classic demonstration of Bernoulli's Principle. There are two primary explanations for this demonstration. A.) There is a moving stream of air traveling around the ball resulting in an area of less pressure. The ball is prevented from falling out of the moving stream of air because it is pushed in by the higher pressured air adjacent to the moving steam of air. B.) The air travels around the ball and is moving at the greatest velocity at the top of the ball, resulting in an area of low pressure above the ball. The ball is drawn toward the area of low pressure. This area of low pressure can be disturbed by placing a hand above the ball. I have seen explanation B used more often.



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# Bernoulli's Principle (Demos)

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## Materials: Bernoulli's Bag

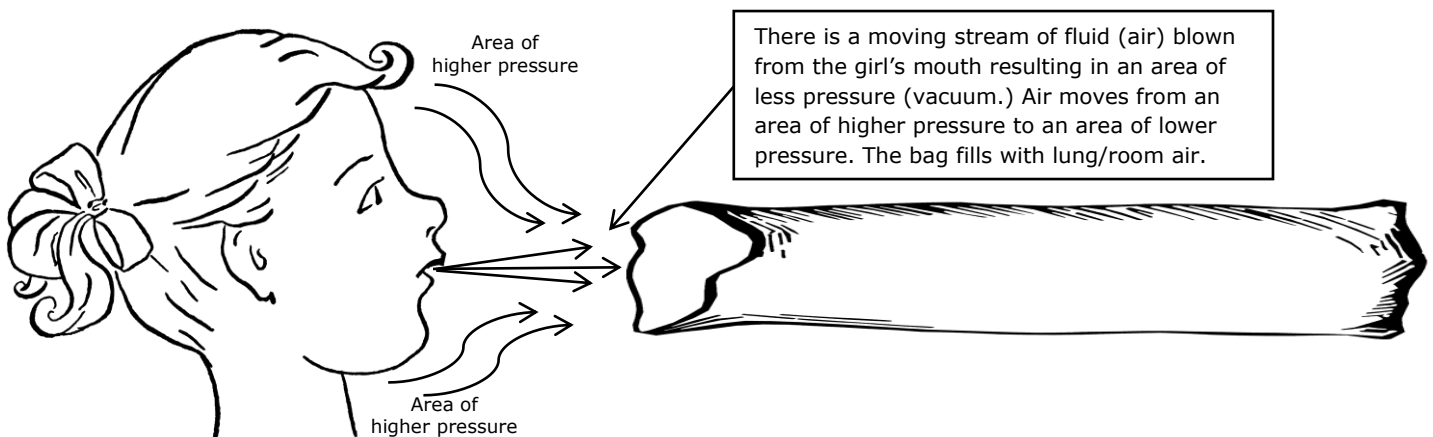
- Long plastic tube(s)
  - Different names, depending on supplier (Bernoulli's bag, WindTube, Bernoulli' tube)
    - One supplier (<http://www.teachersource.com/product/windtubes/air-pressure>)
    - A garbage bag also works, but the demo is not as effective.

**Procedure:** This classic science demonstration shows Bernoulli's Principle. A moving stream of air produces an area of low pressure (vacuum.) Air moves from high pressure to low pressure filling the bag with air.

- Setup/Process
  1. Have 3-4 students come to the front of the room and face the class.
  2. Challenge the students: each person, including the teacher, will get 5 breaths to see who can fill up the bag with the most air.
  3. Have each student, one at a time, blow 5 breaths into the bag.
  4. Order the students from most air in bag to least air in bag.
  5. Then the teacher (Bernoulli's Principle) will fill the bag with one breath.
    - Hold the bag open, removing folds, and place it 6" - 12" from your mouth.
    - Blow one large breath into the bag as you step back.

**What to expect:** Most students will do one of the following: A.) They will blow one breath into the bag and not remove their mouth from the bag. They will rebreathe the same breath over and over again. The amount of air in the bag represents one forced exhalation. B.) A second group of students will exhale 5 separate breaths into the bag.

The bag can be easily filled with one breath using Bernoulli's Principle. The moving stream of air exhaled is moving faster than the air around it. This creates an area of low pressure (vacuum.) This area of low pressure draws air from the area of high pressure around it, because fluid moves from an area of high pressure to an area of low pressure. The bag is filled with a small amount of air from the lungs and a large amount from the room. See diagram below.



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# Bernoulli's Principle (Demos)

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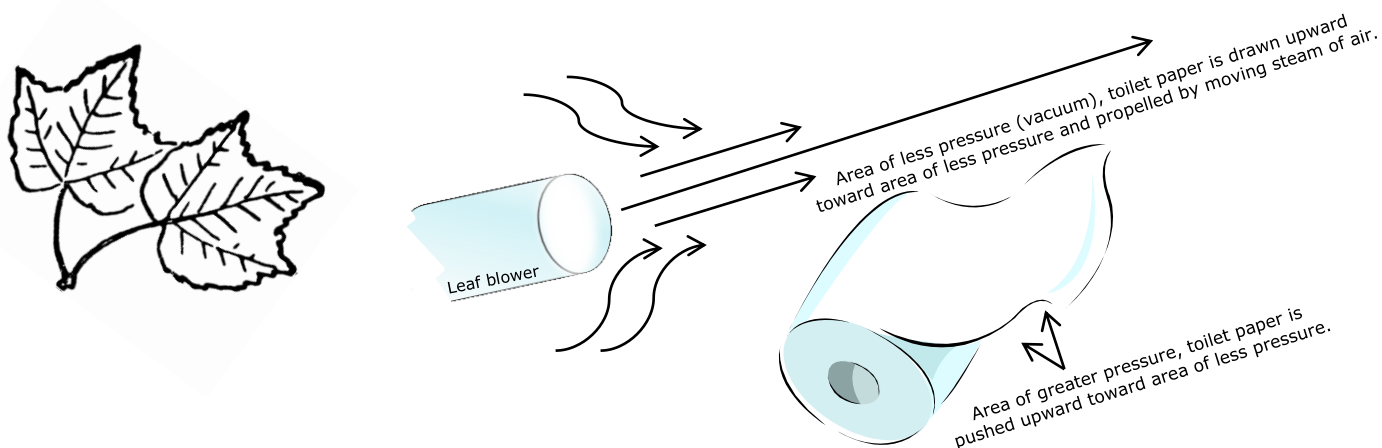
## Materials: Bernoulli's TP

- Leaf blower
- Extension Cord
- Dowel rod (normally sold in 4' lengths)
- Toilet paper (inexpensive)
- Paper (8.5" X 11")

**Procedure:** During this classic science demonstration a leaf blower is used to propel toilet paper into the air using Bernoulli's Principle. A moving stream of air produces an area of low pressure. Air moves from high pressure to low pressure.

- Setup/Process
  1. Ask the students if a piece of paper will go up or down if air is blown across the top of it.
  2. Have all of the students blow air across the top of a piece of paper.
  3. Ask the students why the paper moves in the upward direction.
  4. Explain why the paper moves in an upward direction.
  5. Ask the students what they think will happen if air is blown across the top of a roll of toilet paper suspended on a dowel rod.
  6. Blow air across the top of a roll of toilet paper. (roll should be suspended to unroll away from the blower, it works best if it unrolls from the top)
  7. Explain why the toilet paper is propelled into the air.

**What to expect:** The moving stream of air from the leaf blower is moving faster than the air around it. This creates an area of low pressure (vacuum.) This area of low pressure draws air from the area of high pressure around it, because fluid moves from an area of high pressure to an area of low pressure. The toilet paper is pushed upward by the higher pressure below it and is propelled by the moving stream of air.



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# Bernoulli's Principle (Demos)

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## Materials: Bernoulli's (air) Tube

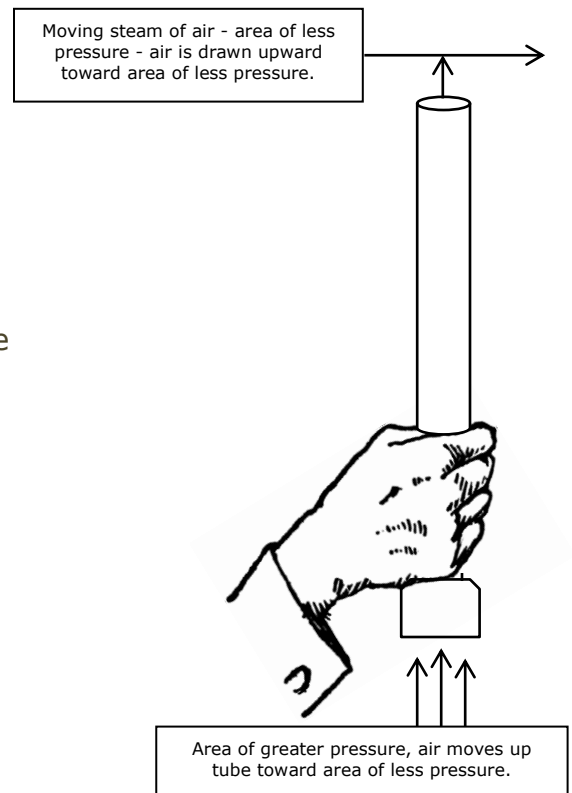
- Plastic tube
  - Different names, depending on supplier (Bernoulli's Tube, Sound Tube, Resonance Tube)
    - One supplier
      - <http://www.teachersource.com/product/sound-tubes/sound-resonance>
- Confetti (three hole punch paper)
- Water may be used instead of confetti (outside)
- Paper cup to hold confetti

**Procedure:** During this classic science demonstration a plastic tube is spun resulting in a high pitched sound being produced.

- Setup/Process
  1. Hold the large end of the tube and spin the tube above your head.
  2. Different pitches can be produced by varying how fast the tube is spun.
  3. Tell the students that air is traveling through the inside of the tube producing the sound.
  4. Ask the students if the air is traveling up the tube or down the tube.
  5. Place your hand on the bottom of the tube as you spin it, the sound goes away.
  6. Place the larger end of the tube in a cup of confetti or water. The confetti\water will be pulled from the cup and propelled out the end of the tube.

**What to expect:** The distal end of the tube is moving through the air faster than the end that is being held. This creates an area of low pressure (vacuum.) This area of low pressure draws air from the area of high pressure at the opposite end of the tube. The inside of the tube is corrugated; the air molecules hit the ridges inside of the tube causing them to tumble creating vortices/vibrations. Sound is produced by these vibrations. The sound is intense because it is vibrating at one of the tubes natural frequencies - acoustic [resonance](#).

In addition to Bernoulli's Principle, air is forced out of the tube by the motion (centrifugal force) of the tube. The tube is held by the hand (centripetal force), but the air inside it is not. The tube would also fly outward if it was released by the hand.



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