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Wind Tunnel
#WNDTNL

Warning:

- **Not a toy; use only in a laboratory or educational setting.**
- **California Proposition 65 Warning: This product can expose you to chemicals including ethyl acrylate, nickel, and lead, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.P65Warnings.ca.gov.**

Introduction

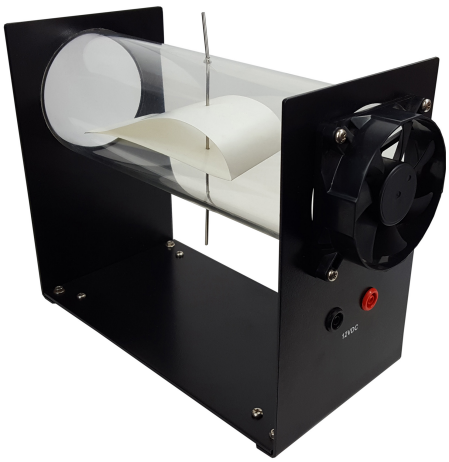
Wind tunnels are used to understand **aerodynamic lift,** or the force we manipulate to fly. Since **lift** is a force, it is a vector quantity with both a direction and a magnitude. It occurs when any solid object passes through a fluid. If the fluid is a liquid, **hydrodynamic lift** is created, and, if the fluid is a gas, **aerodynamic lift** is created.

As a solid object moves through a fluid, the force of the lift generated moves in a direction perpendicular to the flow of the fluid around the solid object. This rule applies if the fluid is flowing around an unmoving solid object or if the solid object is moving through a static fluid. For example, with an airplane, the shape of its wing causes the air traveling over its top to travel faster than the air passing below it. This difference in air velocity creates a pressure differential that causes lift to act in an upwards direction, counteracting gravity and allowing flight. In the case of this demonstration, it would be impractical to display lift in a confined classroom setting by moving a solid object through the air. Instead, wind tunnels like yours demonstrate the principle by moving the air with a fan around a stationary solid object.

Your wind tunnel consists of a mock-wing called an **airfoil** inside of a clear acrylic tube. This tube has a fan installed in one end to allow you to manipulate the flow of air. The other end of the tube is open for gas to escape and to allow you to manipulate the airfoil, if necessary. The airfoil is suspended inside on a movable metal bar. You can also create your own airfoil using the template provided in these instructions.

Below is a list of supplies that are not included with the demonstration that you will need:

Additional Supplies



You will need the following supplies to experiment with your device:

- 1 Power Supply, 12V DC
- 2 Connector Lead Cords, Banana-Plug Ends
- 1 Laboratory Balance, Gram Scale (Variable height)
- 1 Smoke Source (Punk Sticks, Incense Sticks, Wood Splints, etc... Find a source that works well for you.)

How to Use

Your wind tunnel has two primary functions: (1) to demonstrate lift, and (2) to demonstrate how air flows over a wing. You will need to set up the device first. After a quick set up, both demonstrations are easy to carry out.

Setting Up Your Wind Tunnel

1. Place your wind tunnel onto a flat surface, such as a table.
2. Gather together the additional supplies listed on the previous page (*i.e.* power supply, connector lead cords, and a smoke source).
3. Set up your power supply and connect your wind tunnel to it using your connector lead cords.

Lift Demonstration

1. Set up your wind tunnel.
2. Place a gram-scale inside your wind tunnel's housing below the acrylic tube and beneath the metal bar suspending the airfoil.
3. Adjust the height of your scale so that the metal bar suspending your airfoil can rest its entire weight onto it. **(Note:** You can use items like rubber stoppers or cardboard to change the height of your scale. Once it is adjusted and the scale is supporting the airfoil's weight, make sure that the airfoil is not rubbing against the sides of the acrylic tube or positioned too high within it. Do not rest the metal bar on the scale before turning it on.)
4. With the fan still off, take note of the weight of the airfoil displaying on your scale.
5. Turn on the fan of the wind tunnel by powering on your power supply.
6. Take note of the change in weight on the scale as the lift generated by the flow of the wind counteracts gravity and makes it appear to weigh less.

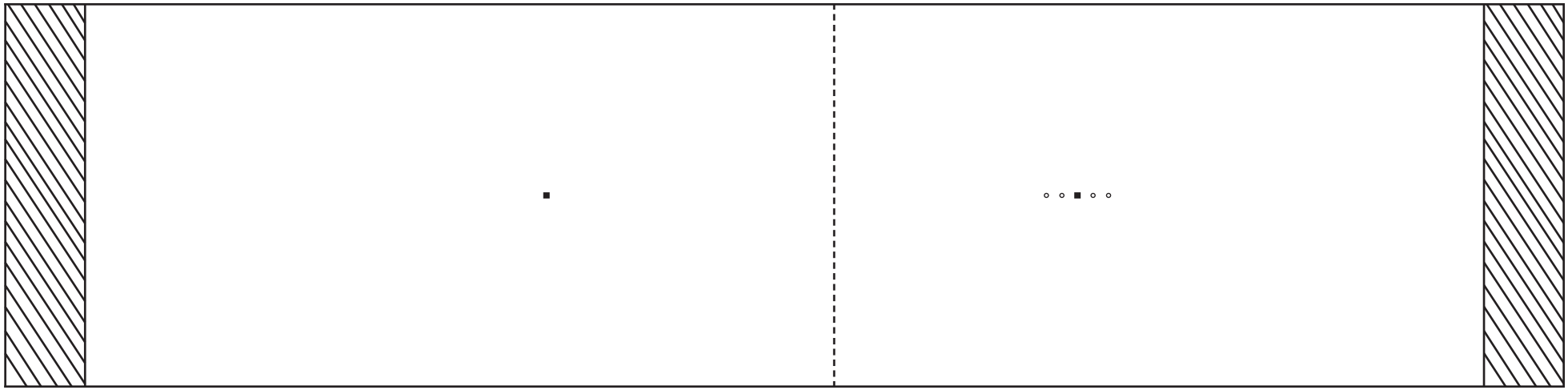
Airflow Demonstration

1. Set up your wind tunnel.
2. Turn on the fan of the wind tunnel by powering on your power supply.
3. Using a flame, ignite a smoke source of your choosing that can provide a thick, sustained stream of smoke.
4. Place your smoke source in front of the fan to your wind tunnel.
5. Watch the smoke get sucked into the wind tunnel and travel around the airfoil. You should notice the curved path of the smoke as it travels over the top of the airfoil. Contrast this curved path with the straight path of the smoke traveling below the airfoil.

Creating Your Own Airfoil

1. Use the template on the following page as a guide to make an airfoil of your own. Experiment with different materials: paper, cardstock, aluminum foil, etc...
2. Once you select your material, trace the template onto it and cut it out along the border.
3. Bend sharply along the dotted line near the middle.
4. Glue (or tape) the lower and upper halves together so that they touch in the areas filled with tightly-packed parallel lines.
5. Punch two holes in your new airfoil for your metal bar to go through – one in the top half and one in the lower. Use the dots in the middle of each half as your guides. Using both filled-in squares as your guides will emulate the airfoil provided with your wind tunnel. By selecting one of the empty circles in the lower half as your guide, you can experiment with different angles for your airfoil. You may also experiment with hole placements entirely different than the ones on our template.
6. Perform the lift and airflow demonstrations above with your new airfoil. Take note of any differences you notice between it and the one that came with your wind tunnel. **(Note:** Depending on how large and smooth you make your holes in step 5, your airfoil may not grip the metal bar tightly enough to move it. It might float with the wind up and down on the bar, making measurements with your scale impossible. The provided rubber O-rings can help prevent this sliding along the bar if you wish to still observe lift with your scale.**)**

Airfoil Template



Top Half of Airfoil

Lower Half of Airfoil