Two Large-Scale Devices for Demonstrating a Bernoulli Effect

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An object placed in a moving fluid experiences a net force when the speed of the fluid is greater on one side of the object than on the other. This is due to a difference in pressure on the two sides of the object and is known as the Bernoulli effect. A number of demonstrations of this Bernoulli effect have appeared in the physics teaching literature. In this article, we describe two such demonstrations that are quite dramatic and suitable for showing to large classes.

Airstream Past Two Bowling Balls

One of our devices consists of two 9-lb bowling balls suspended from a frame by chains of equal length as shown in Fig. 1(a). An airstream is created using the Electric Power Sweep Blower manufactured by Toro Co. (model #51586). This blower is advertised to produce an airstream with a speed of 140 mph. The blower was purchased at Home Depot for less than $35. For this apparatus, the optimum space between the balls before directing the airstream between them is approximately the width of an adult’s hand.

When the airstream from the blower is directed between the bowling balls, there is a reduction of the air pressure in the region between the balls created by the airflow, and they are drawn together as shown in Fig. 1(b). Our experience has been that students most often anticipate that the balls will be pushed apart by the airstream. With that initial lack of understanding, this apparatus provides a dramatic demonstration of the Bernoulli effect.

An Airfoil

The other device we have constructed for demonstrating the Bernoulli effect is an airplane wing (an airfoil) mounted on a base. The airstream across the wing gives it a lift, causing it to rise. The apparatus is shown in Figs. 2(a) and 2(b). We use an airfoil called...
a CLARK-Y wing. It is a classic airfoil shape that is familiar to those who are knowledgeable about wing design. This airfoil was chosen based on the experience one of the authors (D.H.) has with model airplanes.\textsuperscript{7} Our airfoil was cut from a block of polystyrene at a local hobby shop at a cost of only a few dollars.

The leading and trailing edges of the wing are made of light, smooth balsa wood glued to the polystyrene. Such edges are necessary to eliminate much of the turbulence created by rough polystyrene edges. Our wing is 30.5 cm long with a surface area of 600 cm\(^2\). It has a mass of 45 g.

As can be seen in Fig. 2, the wing is constrained to slide on two thin rods. One rod passes through the center of mass, which is located approximately 30\% of the distance from the leading edge of the wing. The other rod passes through a guide attached to one end of the wing. After experimenting with several designs, we have found that this arrangement minimizes the frictional forces between the rods and the wing.

In order to achieve lift, it is essential that the front edge of any wing be tilted upward at some small angle (called the “attack angle”) so as to present a small cross section of the underside of the wing to the airstream. We find that the best results are obtained for our wing when the attack angle is approximately 2\(^\circ\), and the blower is held horizontally, approximately 6 in from the front edge of the wing. The wing should rest about 4 in above the base of the frame in order to allow substantial airflow around both surfaces of the wing. If the wing rests on the base of the apparatus, a partial vacuum is formed under the wing and no lift is achieved.

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**References**


5. Devices similar to those described in this paper can be seen at the Discovery Science Center in Santa Ana, Calif.

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