611-0400 (40-520) Wind Tunnel

Introduction: Aerodynamic lift is a difficult concept to explain. It is clear that the principle works; anyone who has traveled in an airplane can vouch for it. Lift is the aerodynamic force which operates opposite to gravity, keeping a plane in the air. However, even 100 years after the Kitty Hawk made its first flight, the exact mechanics of lift are unclear. The principles of aerodynamics are easy to understand in theory, but very difficult to explain on small scales. For example, a butterfly's wings are simply too small to generate enough lift for the insect to fly, according to the general theories of aerodynamics. Of course, butterflies do indeed fly, by employing small scale techniques that are poorly understood.

The concept of lift is quite complex, and this manual will only provide a brief overview of the general principles. To visualize lift, consider the shape of an airplane wing. It is flat on the bottom, with a curved top. This curvature is by no means the same on all wings. In fact, airplanes have surfaces called *ailerons,* which move and change the curvature of the wing, thus changing the amount of lift generated. This allows planes to ascend and descend.

When air flows over a wing, the air flowing over the upper surface has to travel a longer path. This forces the air to speed up. It has been observed that the air moving over the top of a wing typically travels much faster than the air on the lower surface. This is because the air has less space to travel in, since the wing blocks it's path. View the air as a specific stream, with the air above keeping it in place. When the wing intrudes and partially blocks the path of the air, it is forced into a smaller space, which increases the velocity. According to Bernoulli's Principle, if a given volume of air increases its velocity, the pressure must decrease. Thus, the pressure on the top of the wing is lower than the pressure beneath it. This pressure differential creates a net force pointing upward.

Another way of looking at the same idea is to consider Newton's Third Law: any action produces an equal and opposite reaction. When air moves across the top of a wing, it gains a lower pressure and a higher velocity. The shape of the wing deflects this stream of air downward. When the stream passes the wing and hits the air beneath it, it imparts a force. Newton's third law dictates that this force is opposed by an equal force in the opposite direction. Thus, the wing creates a reactive force which pushes upward against it, generating lift.

Description: Your wind tunnel is an airfoil contained inside an acrylic tube. One end of this tube is open, while the other is occupied by a fan. Real wings operate by moving the airfoil through the air. This is impractical in the class room, so we use a fan to move air around the wing instead. The effects are the same.

To use your wind tunnel, you will need the following items: a low voltage power supply, a small digital scale, and a source of smoke.

For the first experiment, place your scale inside the housing, underneath the tube. The airfoil has a post running through it; place the lower end of this post on the center of your scale so that its weight is displayed. Record this value.

Next, attach the power supply to the jacks for the fan. The fan will run optimally at 12 V DC, but can run with as little as 2 V DC.

Activate the power supply, with a low voltage. You will notice that the weight of the wing decreases slightly. As you increase the voltage, the speed of the fan will increase, sending a greater volume of air at a higher velocity over the wing. This in turn generates greater lift. If you increase the voltage in stages, you can observe the weight of the wing decrease incrementally. In total, at maximum speed, the weight of the airfoil should decrease about 2.5g.

Since weight is due to gravity, it is possible to decrease an object's weight while leaving its mass intact. An airplane weighs nothing while it is flying, although it's mass can be quite considerable, such as the 300 ton Antonov An-225. Airplanes use large engines to propel the craft through the air fast enough that the wings generate sufficient lift to negate the plane's weight. In general, a faster plane requires less wing surface area to generate the same amount of lift. This is why fighter jets have smaller wings than cargo aircraft.

Our wind tunnel does not move air fast enough to generate enough lift to fully overcome the weight of the airfoil inside.

To further demonstrate the movement of air over a wing, hold a smoke generator outside the fan. The fan will pull the smoke in and pass it over the wing. This shows very clearly the fact that air travels in two paths around a wing.

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.