South Gwinnett High School

Technology Education

TE 336 – Engineering II – Transportation/Dynamics

Unit 5 – Introduction to Dynamics-Notes

This supplemental information is taken from Applied Technologies, Aerodynamics Module. This information has been developed exclusively for South Gwinnett High School.

1. **Statics**.
2. **Aerodynamics**
3. **Hydrodynamics**
4. Which substance can be compressed, air or water?
5. What causes the shape of sand dunes?
6. What causes air pressure?
7. Is air denser in higher altitudes of lower altitudes? Why?
8. What causes wind?

Although extensive research has been done for hundreds of years, we still know very little about why water reacts the way it does under certain circumstances. With the introduction of flight, *air* became the *fluid* that most needed researching. Early physicists discovered that, for the most part, air responds almost identically to water. Much of the data acquired for water was helpful in the study of air. Like water, air was discovered to have a few characteristics that could not be explained, plus one unique difference-- *air can be compressed and water cannot*. Let us concentrate on studying how air flows over and around objects and how objects move as they travel through the air.

Let's begin by discussing the effects of natural air movement (wind) on the planet in which we live. Wind can cause many disturbances to the face of the earth. Sand dunes at the beach or in the desert are good examples of how wind can alter the shape of the surface of our planet. As air moves along, it picks up and pushes grains of sand in the direction of its movement. Typically the sand will move until it meets with some kind of resistance or until the air stops moving. In some cases, something as small as a blade of grass can begin the reaction resulting in a sand dune. Once sand starts to accumulate, the wind will continue to push more and more grains up the side of the dune forming a shape resulting in an aerodynamic phenomenon **(see figure 1-1)**. As the dune gets larger, the air's reaction becomes more pronounced and the dune's shape will become more and more dramatic. The wind will continue to push the sand on the windward side over the top of the dune, causing the dune to gradually move.

Desert sands have been known to overtake entire villages, consuming them as they go. Because of shifting sands, it is very easy to get lost in a desert. The tracks you leave may very well be gone tomorrow. Another effect that the wind has on the face of the earth is erosion. You are probably familiar with how water can erode the land when it rains. Air can have the same effect. The wind can pick up dust and particles of sand, hurling them into mountainsides, slowly eroding away the rock and dirt. Wind erosion is a very slow process, but it can still be extremely devastating to man-made structures as well.

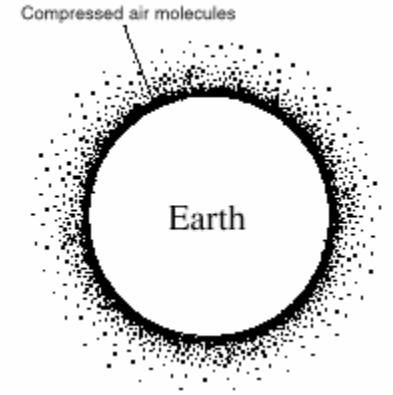
Wind is also the typical cause of waves on large bodies of water. As the wind passes over the water, small ripples form. The moving air behind the ripple causes the ripple to grow larger and larger. Eventually, depending on the intensity of the wind, the ripple

becomes a wave. Waves can be quite destructive to shorelines as well as to boats. Small waves can slowly erode the shoreline, while large waves caused by high winds can be one of the most destructive forces of nature. Consider incidences of large waves sinking boats, toppling seaside buildings, and flooding coastal cities. Hurricanes, cyclones, gales and tornadoes cause extensive damages every year. These high winds have been known to level entire cities and destroy thousands of acres of forest.

How could air do such damage? Does air have mass? Air is not a solid, is it? Does air have weight? Air seems so harmless, almost like it doesn't exist. What makes moving air so powerful that it could lift a roof off a building and carry it hundreds of yards? What causes the wind?

THE AIR IS REALLY THERE

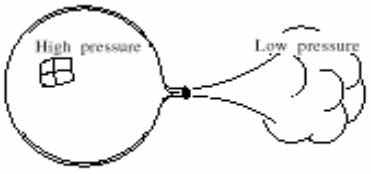
Air is really there. It has weight. It is made up of mostly nitrogen and oxygen molecules, which are zipping around, bouncing off each other and the objects they surround. These molecules are constantly being pulled toward the earth by gravity, but because they are bouncing in all different directions, including out and up, they will not freely fall to the earth's surface. Air molecules extend over 200 miles from the ground. All of these air molecules being pulled toward the earth by gravity give an incredible amount of weight to the air.



Imagine a column of air 1-inch by 1 inch extending 200 miles into the air from an altitude equal to sea level. If you could place a scale beneath that column of air and measure its weight, it would weigh almost 15 pounds. If you were to weigh the air at an elevation of 18,000 feet (approximately 3.4 miles), it would weigh half as much. That means that the air above 3.4 miles contains no more air molecules than the air below 18,000 feet. The reason for this irregularity is that air molecules compress when under pressure; therefore, the closer you get to the earth's surface, the denser the air gets because of this compression. Air is not typically measured by its weight but rather the pressure created by the weight. Besides altitude, there are other factors, which affect air pressure such as temperature and moisture content.

THE WIND

Wind is caused when one area has a higher pressure than another. For example, when you fill a balloon with air, the pressure inside the balloon is much greater than the pressure outside the balloon. If you release the air from the the balloon, a small wind is developed. What actually causes the wind is the higher-pressure area pushing the air into the lower pressure area.



In the earth's environment, pressures typically vary by temperature. Warming air causes its molecules to become more active, which increases pressure. Cooling air causes the molecules to become less active, which makes the air contract, resulting in less pressure. Wind is created when warm, high pressure air pushes into cooler, low-pressure air. Air temperatures are constantly changing because of the sun, sea and ground. Wind directions, for the most part, are determined by the locations of high and low-pressure areas and the earth's rotation. The size of high and low-pressure areas as well as the differences of their temperatures and moisture content determines the wind's intensity. The same air pressures that occur naturally are also created when a body moves through the air. Typically the four forces acting on any body in motion are thrust, drag, lift and gravity. These four principle forces can apply to land, air, sea and space vehicles.