Air and Aerodynamics

**Objective: Provide evidence that air takes up space and exerts pressure, and identify examples of these properties in everyday applications.**

Air has many properties. It is invisible, is a gas, takes up space, has mass, and exerts pressure. You know air is everywhere because living things need it to survive. You cannot see air, but sometimes you can hear it. For example, you can hear a hissing sound as air escapes from a tire or a balloon and you can feel the wind (fast-moving air).

**Air Takes up Space**

There is evidence everywhere in our world that air takes up space. Think about basketballs, tires, and balloons. It is the space the air takes up that gives these objects their shape. You have a good idea of how much space the air is occupying by the size of them. When you blow into a balloon, the air entering the balloon causes it to inflate. The air you are putting into the balloon requires space and causes the balloon to expand and change shape. This clearly demonstrates that air takes up space.

**Air Exerts Pressure**

Air also exerts pressure. Because the air pressure on the inside of the balloon is the same as the air pressure on the outside of the balloon, the balloon keeps a constant shape. If the air pressure were greater on the inside than the outside, the balloon would burst. If the air pressure on the outside were greater than the air pressure on the inside of the balloon, it would collapse.

Air pressure is the force exerted on an object by the weight of tiny particles of air. Atmospheric pressure is Earth’s gravitational field pulling on air. Air is made up of invisible gases that you can’t see, taste, or smell. Almost all of the gases that make up air are attracted to Earth by gravity. Therefore, the air that surrounds Earth is being pulled down toward us. Our bodies are designed to handle a certain amount of air pressure. Earth’s atmosphere is pressing against each square inch of you. For each square centimeter of your body, there is one kilogram of air pressing on you. You also have air inside your body. The air pressure is the same inside and outside your body.

**Air Has Mass and Density**

Air also has mass and density. Mass is defined as the amount of matter in an object. All matter is made up of molecules. Density refers to how tightly or how loosely ‘packed’ the molecules of an object are. Some objects are heavier than others, even if they are the same size. An empty bottle and a full bottle of water are the same size, but the full bottle of water is heavier. It has a greater density.

Because air has density and mass, it exerts pressure. At sea level, air is the densest and exerts the most air pressure. Air pressure decreases the higher you go above sea level because the air becomes less dense. When you climb to high altitudes where the air is less dense and the air pressure is reduced, you pant and puff to get enough oxygen into your lungs. As air pressure decreases, oxygen continues to account for about 21 % of the gasses in the air. But, there is less oxygen available because there are less of all the air’s gasses at high altitudes. Airplanes use pressurized cabins to overcome the effects of lower air pressure and density at high altitudes.

**Objective: Provide evidence that air is a fluid and is capable of being compressed, and identify examples of these properties in everyday life.**

**Air is a Fluid**

Every object on Earth or in space can be classified as a solid, a liquid, or a gas. Air is a fluid. A fluid can be a liquid or a gas.

Every object on Earth has mass and density. Molecules are the smallest parts of something. Water has more density than air because molecules of water are closer together than molecules of air. Some matter, like air, can be compressed (squeezed) into a smaller space by forcing the molecules closer together than they would normally be (this can be done with pressure e.g. your lungs blowing against the air in a balloon). Some matter, like water, cannot be compressed.

When pressure or temperature change in a fluid, density changes. Molecules get closer together or farther apart. When air is heated, it expands because the molecules that make up air start to move faster and take up more space. The farther apart the molecules are, the less dense the air becomes. When air gets cold, it contracts. As air cools, its molecules settle closer together and the density increases. Warm air rises because it is less dense than the cool air surrounding it.

Compressed air is air that is squeezed into a smaller space. The molecules that make up gases are far apart therefore they can be compressed by employing pressure. When air is compressed, the molecules that make up air are forced together. It is possible to compress air to higher pressures. When you put air into your car tires, it is forced or squeezed into a confined space. It is compressed. The molecules of the compressed air inside the tire push on the wall, keeping the tire from going flat.

Compressed air is used for many things in our world. Compressed air is used for aerosol spray cans, sports balls, vehicle tires, machines, scuba tanks, and to generate power for pneumatic tools (nail gun, jackhammer)

**Objective: Describe and demonstrate instances in which air movement across a surface results in lift – Bernoulli’s Principle.**

**Objective: Recognize that in order for devices or living things to fly, they must have sufficient lift to overcome the downward force of gravity.**

**Bernoulli’s Principle**

Bernoulli’s Principle states that as the speed of a moving fluid increases, the pressure within the fluid decreases.

Bernoulli’s Principle was a key idea in the development of human flight. Aircraft wings are designed so that air flows over the top of the wing faster than it flows under the wing. This causes the air pressure on top of the wing to be lower. The comparatively higher air pressure underneath the wing pushes the air plane up and lift is created. Lift is an upward force that acts against the force of gravity.

**Forces of Flight**

For aircraft to achieve lift, the forces of flight must be balanced. There are four forces of flight at work when an airplane flies: thrust, drag, lift, and gravity. Thrust gives an airplane forward motion. It is the force that overcomes drag. Drag is the force that acts to slow down an object as it moves through a gas or liquid. The larger the surface area of an object, the more drag the object has. Today, many manufactures design objects with smooth, streamlined shapes to overcome the force of drag. Aircrafts are designed to overcome drag. Lift is an upward force that must overcome the force of gravity. Gravity is the force that pulls objects down toward Earth.

**Objective: Identify adaptations that enable birds and insects to fly**

**Objective: Describe the means of propulsion for flying animals and for aircraft**

**Propulsion**

In order for birds and insects to fly, they must create lift. They must also generate enough thrust to create propulsion. Lift is an upward force that acts against the force of gravity. Thrust is the act of an object moving forward and propulsion is what drives the object the force to move forward. Thrust and propulsion for flying animals are generated by flapping their wings and creating lift. Thrust and propulsion for aircraft are generated by either a propeller or a jet engine. An engine gives propellers the force to move flying aircraft forward. The movement results in a difference in pressure, which results in lift. The jet engine generates thrust through a mixture of hot gases that ignite to create enough force for propulsion.

**Adaptations**

An adaptation is a device or mechanism that changes so as to become suitable to a new situation. A number of adaptations combine to enable birds and insects to fly. Most bird species are expertly designed for flight. Some birds, such as hawks, are able to soar. Other birds, like geese, have adapted so that they can fly long distances. Still other birds, such as Hummingbirds, are able to fly swiftly.

Birds have special adaptations to achieve flight. Some adaptations that birds have for flight are feathers, powerful flight muscles, air sacs, hollow bones, and winds. Feathers give birds a smooth, streamlined shape that reduces drag and maintains their body temperature. Bird muscles are designed to be strong to provide sufficient power for flight. The muscles for both the wings and the legs are designed so they do not tire quickly. A lot of energy is needed to power the flight muscles of birds. To get this energy, birds need a large, constant supply of oxygen. Air sacs in a bird’s thorax and abdomen fill up with air and provide its body with with the oxyen needed during flight. The hollow bones of a bird help reduce its weight and allow it to keep a large supply of air in its lungs. The shape of a bird’s wings allows them to achieve lift. The wings are curved on top and flat on the bottom. As the bird flaps its wings, air travels over the top of the wing and creates a difference in pressure; life and thrust are achieved on the downward stroke.

Insects have many similar adaptations such as wings which are airfoil shaped (curved on the top, flat on the bottom) and specially designed flight muscles. Their wings are made up of a thin membrane supported by blood-filled veins. Insect wings are one of nature’s lightest structures , lacking bone and muscle.

**Objective: Recognize that streamlining reduces drag, and predict the effects of specific design changes on the drag of a model aircraft or aircraft components.**

Drag is the force that acts to slow down an object as it moves through a gas or liquid. The larger the surface area of an object, the more drag the object has. A crumpled piece of paper falls to the floor faster than a flat sheet of paper due to the flat piece having a larger surface area resulting in more drag. Today, many manufacturers design objects to have a smooth, streamlined shape to reduce drag. Aircraft are designed to overcome drag.

**Recognize that air is composed of different gases, and indentify evidence for different gases. Example evidence might include effects on flames, the ‘using up’ of a particular gas by burning or rusting and animal needs for air exchange.**

**Air Composition**

Air is a mixture of gases; 78% nitrogen and 21% oxygen with traces of water vapour, carbon dioxide, argon, and various other components. Normally, air is a colourless, odourless, tasteless, and mostly non-metal gas. It is a constituent of all living tissues. Oxygen is a fuel for combustion and oxidation.

**Oxidation**

Oxidation is the combination of a substance with oxygen. Certain substances have a reaction with oxygen. If a peeled apple is left exposed to the air, it turns brown. The brown colour is the result of the apple reacting to the oxygen in the air surrounding it. Metal and iron also react with air. This is why vehicles rust. Rusting demonstrates the process of oxidation. Oxygen also provides the fuel necessary for burning.

There are ways to prevent or slow oxidation. To protect fruit from rapid oxidation, leave the peel on, refrigerate it, add ascorbic acid like lemon juice, or limit air exposure by covering with plastic wrap. For protecting metal such as iron, paint acts as a thin wall to reduce contact with oxygen, thick layers of grease or oil also provide excellent protection against rusting. Coating Iron with a thin layer of zinc, called Galvanizing, is also an effective rust reducer.

**Combustion**

Combustion is the process of burning. If a candle is lit and left to burn in a closed-in space, it will only burn as long as there is air inside the closed-in space. Once the oxygen in the air is used up, the candle no longer burns.