Lesson 61 -- FLUID CONCEPTS

- Matter is made up of atoms. Every atom of an element is chemically alike.
- We can model atoms as tiny, hard “billiard balls.”
- In a substance, atoms are combined to form molecules.
- When atoms or molecules collide, they collide elastically (no loss of kinetic energy).
- There are three forms of matter; solids, liquids, and gases. In all cases, the atoms or molecules are in constant motion in a material.
- In a solid, the average position of the atoms or molecules remains constant. That is why solids tend to maintain their shape.
- In a liquid, the atoms or molecules are free to move around, but the distance between atoms or molecules remains relatively small. For this reason, a liquid takes the shape of its container, but does not expand to fill it.
- The molecules of a liquid feel a mutual attraction. This creates surface tension, which acts something like a “skin” on the surface of the liquid.
- In a gas, the molecules are widely separated and feel little mutual attraction. This is why a gas tends to expand to take the shape of its container.
- We will treat liquids as incompressible. It is true that the compressibility for most liquids, in the situations we consider, is negligible.
- Pressure is force per unit of area. The SI unit of pressure is the Pascal (Pa) or N/m^2.
- Since a fluid is not rigid, it can only exert a force perpendicular to a surface. Picture the particles as little balls colliding with the surface, as when you bounce a ball off a wall. Can you see that the direction of the velocity change is always perpendicular to the wall? (Try drawing it).
- A fluid has weight. This is the reason why it exerts a pressure.
- The pressure of a fluid is proportional to the density of the fluid, the gravitation constant (for earth, average g=9.81 N/kg), and the depth of the fluid. Thus the pressure exerted by a fluid only varies with the depth, not with the volume, the shape of the container, or any other factors.
- The atmosphere exerts considerable pressure on objects at the surface of the earth. Gases are fluids, too.

- Many simple devices depend on atmospheric pressure: drinking straws, suction cups, mercury barometers. Be sure you can explain how these and others work using the concepts in this section.

- Gauges measure atmospheric pressure as 0 Pa. Atmospheric pressure must be added to gauge pressure to give the actual pressure (called "absolute pressure").

- Since a liquid is incompressible, a pressure exerted on it is transmitted throughout the liquid (Pascal's Principle).

- An object floats in or on a liquid because it displaces a volume of water whose weight equals the object's weight (Archimedes' Principle). The sum of the vertical forces is zero. Alternate version: an object floats because its average density is less than that of the surrounding fluid. Second alternate version: an object floats because the pressure at the bottom of the object is higher than the pressure at the top. The resulting difference in those two forces must be equal to the weight of the object. Therefore, the sum of all three forces, added as vectors, must be zero.

- We will treat only fluids that flow in thin sheets, i.e. laminar flow. The thin sheets can be modeled from the side, in two dimensions, as streamlines.

- Fluids flow from high pressure to low pressure.

- Because a fluid is incompressible, the volume flow rate is constant, even if the diameter of the pipe changes (Continuity Principle). The product of Area and velocity of a fluid is a constant for a particular pipe. This means the fluid speeds up in a constriction and slows down in the wider parts of the pipe.

- Bernoulli made a conservation of energy statement for a fluid in laminar flow: the energy per volume is constant in a pipe (Bernoulli's Principle). This is true even if the diameter of the pipe and therefore the velocity change.

- Fast-moving fluids are at lower pressure than slow-moving fluids (Venturi Effect). This is a consequence of Bernoulli's Principle (i.e., conservation of energy).

- Airplanes fly b/c of Bernoulli's Principle and the momentum change of the air (due to the "attack angle" of the wing). Can you explain this?