Fluids, Floating & Flying

(Chapter 5)

Student Learning Outcomes: Distinguish between force and pressure and recall how pressure applies to all fluids, recall factors that allow floating, distinguish between cohesion and adhesion, and analyze systems involving Archimedes principle, Pascal's principle, and Bernoulli's principle.

1. *How is pressure different from force?*
2. *What determines the amount of pressure in a fluid?*
3. *What factors allow floating?*
4. *What factors affect pressure in a gas?*
5. *What is Pascal's Principle and its applications?*
6. *What is Bernoulli's Principle and its applications?*

How is pressure different from force?

Questions:

1. Which would result in the greater pressure on your bare foot?

   a. A 150 pound person steps on your foot with her bare foot.
   b. A 150 pound person steps on your foot with a spike heal. (Ouch!)

2. Why do large trucks have so many tires?

- ❖ Pressure is determined from how the force is distributed.
- ❖ Pressure is directly related to the magnitude of the force and inversely related to the area where the force acts.

$$\mathbf{P = \frac{F}{A}}$$

- ❖ The standard unit of pressure is the Pascal (Pa).

$$Pa = \frac{N}{m^2}$$

What determines the amount of pressure in a fluid?

- In a fluid, pressure is exerted in all directions.
  - In a swimming pool, water pressure exerts a force perpendicular to all surfaces in contact with the water.
  - Water pressure increases as you swim to the bottom of a pool.
- **Fluid pressure depends on density and depth.**

$$\mathbf{P = Dgh}$$

Go To: http://hyperphysics.phy-astr.gsu.edu/hbase/pflu.html

- Air pressure is usually measured in atmospheres or psi.

Questions: What is psi? Where do we typically measure pressure in psi?

$$\mathbf{1\ atm = 14.7\ lbs/in^2 = 1.013 \times 10^5\ Pa}$$

- The normal atmospheric pressure at sea level is 1 atmosphere.
- The pressure in water (pure or sea) increases by *about* 1 atm for every 10 m of depth.

Questions:

1. Where would the air pressure be greater, Denver, CO (elevation 5000 ft) or at the beach in California (elevation 0 ft)? Why?

2. How much pressure would a scuba diver experience 5 meters down in water?

What factors allow floating?

- **Relative density allows objects or substances to float.**
- Density is the amount of mass contained in a standard volume.

$$\mathbf{D = \frac{m}{V}}$$

- Density measures how compact the material is.

Some Examples

Air	D = 0.00129 g/cm^3
Water	D = 1 g/cm^3
Sea Water	D = 1.025 g/cm^3
Steal	D = 7.85 g/cm^3
Lead	D = 11.389 g/cm^3
Gold	D = 19.3 g/cm^3

Question: A single gold bar from Fort Knox measures 17.78 cm, 9.21 cm, and 4.45 cm. How many of these gold bars do you think you could carry?

Question: How is a steal ship able to float?

- **Archimedes Principle states that the buoyancy force is equal to the weight of the fluid displaced by the object.**

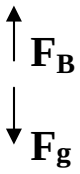
$$F_B = W_{fluid}$$

Go To: http://physics.weber.edu/carroll/archimedes/principle.htm
http://resources.yesican-science.ca/lpdd/g08/lp/unit1_archimedes.html

Weight of floating object = Weight of fluid displaced

- Any fluid applies a buoyant force to an object that is in contact with the fluid (partially or completely immersed).

- For an object to float, the buoyant force must balance the force due to gravity (weight).



$$F_B = F_g$$

- The buoyancy force is a result of the net upward pressure from the fluid.

$$F_B = PA = W_{fluid}$$

Go To: http://hyperphysics.phy-astr.gsu.edu/hbase/pbuoy.html (2nd image)

Questions:

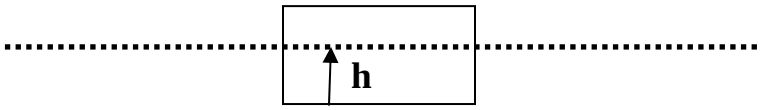
1. A toy boat weighs 20 lbs (89 N) and floats in fresh water (D = 1000 kg/m^3).

   a) What is the buoyant force on the boat?

   b) What does the water weigh that is displaced by the boat?

   c) How many kilograms of water are displaced by the boat?

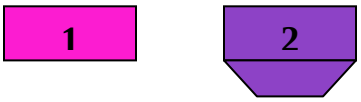
2. If an 89 N boat has a flat bottom that measures 50 cm by 20 cm, and the boat is floating in water, what is the height of the water line on the boat?



3. How is the Good Year Air Ship able to float?

4. My body displaces the same volume of air as water; however I do not float in air. Why?

5. Two ships of equal mass are made of the same material, but have different shapes. Both ships are floating in water.



a) Is the buoyancy force greater on ship 1 or ship 2?

b) Which ship's square cargo area sits higher on the water?

c) Which ship can carry more people?

Question: How does a water skipper walk on water?

Go To: http://cals.arizona.edu/arizonawet/teachersupport/supportmats/water-strider

- **Surface tension is caused by the electrical attractions between molecules in a liquid.**

Go To: http://hyperphysics.phy-astr.gsu.edu/hbase/surten.html

- **Cohesion** is the attraction between molecules in a fluid.
- **Adhesion** is the attraction between unlike molecules, like water and glass.

- **Cohesive forces are strongest at the surface which causes surface tension.**
- Cohesive and adhesive forces often produce a **meniscus** at the surface.

Go To: http://www.sciencephoto.com/media/92139/enlarge

- Water has a relatively strong electrical attractions resulting in a great amount of surface tension.
- Surface tension may allow an object with a greater density than the fluid to sit on top of the fluid.

What factors affect pressure in a gas?

- The pressure in any fluid depends on the **density** and **depth** of the fluid.
- In a gas, the density and pressure are determined by factors such as temperature, volume, and number of particles.

$$\boxed{PV = nkT}$$

- Regions of air have different barometric pressures because of differences in temperature.

Questions:

1. If volume is maintained as temperature increases, what happens to the pressure of a gas?

2. If the temperature is maintained as the volume increases, what happens to the pressure of a gas?

3. What does barometric pressure measure?

What is Pascal's Principle and its applications?

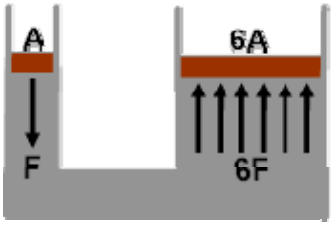
- **A change in pressure at any point in an enclosed fluid is exerted on all other parts of the fluid.**

- A force on the enclosed fluid is distributed throughout the fluid.

Example: Hydraulic lift & Piston

Go To: http://hyperphysics.phy-astr.gsu.edu/hbase/pasc.html (bottom of page)

- The pressure is equal on both sides of a piston; however, the Force and Area are different.



What is Bernoulli's Principle and its applications?

- There is a change in pressure when a fluid flows, or an object moves through the fluid.

- **As the velocity of the fluid increases, the pressure within the fluid decreases.**

Speed ↑ = Pressure ↓

- The pressure from a high velocity fluid on a barrier is great. If the barrier is placed within the flow instead of stopping it, the pressure is decreased.

Examples: Airplanes, Passing, & Trains