Liquids

Topics

- Pressure
- Pressure in a Liquid
- Buoyancy
- Archimedes' Principle
- Flotation
- Pascal;s Principle
- Surface Tension
- Capillarity

Pressure

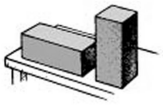
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Units:

N/m^2 -- named the Pascal (Pa)

very small unit; kPa

lb/in^2

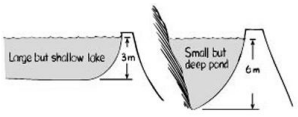


Concept Test

- Which has the greatest pressure?
  - A. A point 1 cm below the surface of Lake Michigan
  - B. A point 1 cm below the surface of a bucket of water
  - C. A point 1 cm below the surface of a 2-cm deep puddle
  - D. All are the same pressure.

Pressure in a Liquid

Liquid Pressure = weight density × depth

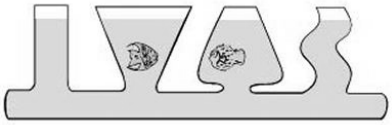


- average water pressure acting against dam depends on average depth of water
- **not** on volume of water held back
- large shallow lake exerts only one half the average pressure that the small deep pond exerts.

Calculation Practice

- How much greater than the pressure at the surface is the pressure 5 m below the surface of a lake?

Pressure in a Liquid



- Liquid pressure is same for any given depth below surface
  - Independent of shape of the container
  - Liquid rises to same height in each

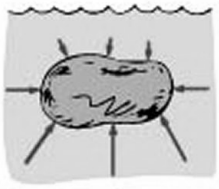
Pressure in a Liquid

- forces of a liquid pressing against a surface add up to a net force that is perpendicular to the surface

Pressure in a Liquid

- Water pressure acts perpendicular to the sides of a container, and increases with increasing depth

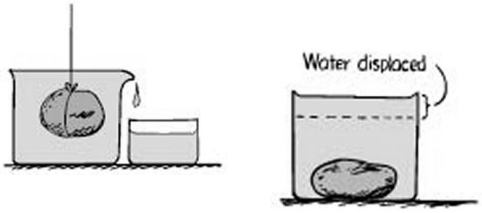
Buoyancy



buoyant force is a consequence of pressure increasing with depth

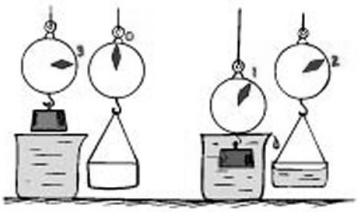
- greater pressure against the bottom of a submerged object produces an upward **buoyant force**

Water Displacement



- A submerged object displaces a volume of water equal to volume of object

Archimedes' Principle



- An immersed body is buoyed up by a force equal to the weight of the fluid it displaces

Check Yourself

- Does Archimedes' principle tell us that if an immersed object displaces liquid weighing 10 N, the buoyant force on the object is 10 N?

Check Yourself

- Does Archimedes' principle tell us that if an immersed object displaces liquid weighing 10 N, the buoyant force on the object is 10 N?
- Yes. Looking at it another way, the immersed object pushes 10 N of fluid aside. The displaced fluid reacts by pushing back on the immersed object with 10 N.

Concept Test

- A 1-liter container completely filled with lead has a mass of 11.3 kg and is submerged in water. What is the buoyant force acting on it?
  - A. less than 113 N
  - B. 113 N
  - C. more than 113 N

Sinking and Floating

- If an object is denser than the fluid in which it is immersed, it will sink.
- If an object is less dense than the fluid in which it is immersed, it will float.
- If an object has a density equal to the density of the fluid in which it is immersed, it will neither sink nor float.

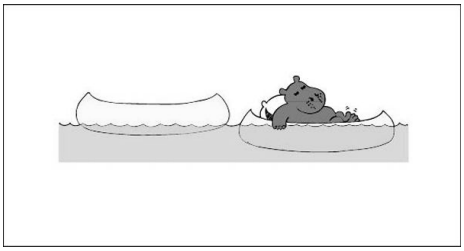
Density

$$Density = \frac{mass}{volume}$$

- Units:
  - kg/m^3
  - kg/L
  - g/cm^3
- Water:
  - 1000 kg/m^3
  - 1 kg/L
  - 1 g/cm^3

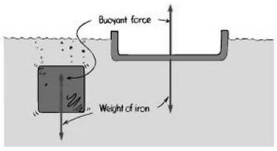
Material	Density (g/cm^3)
Osmium	22.6
Platinum	21.5
Gold	19.3
Mercury	13.6
Lead	11.3
Silver	10.5
Tin	7.3
Aluminum	2.7
Water @ 4°C	1.00
Ice	0.92
Ethanol	0.79

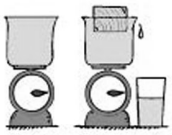
Flotation



- The weight of a floating object equals the weight of the water displaced by the submerged part.

Boats & Floating





- A floating object displaces a weight of fluid equal to its own weight.
- When an iron boat displaces a weight of water equal to its own weight, it floats. This is sometimes called the principle of flotation:

Concept Test

- A boat loaded with iron is floating on a lake. If the iron cargo is removed from the floating boat and dropped into the lake. What happens to the water level of the lake?
  - A. the water level drops
  - B. the water level remains constant
  - C. the water level increases

Check Yourself

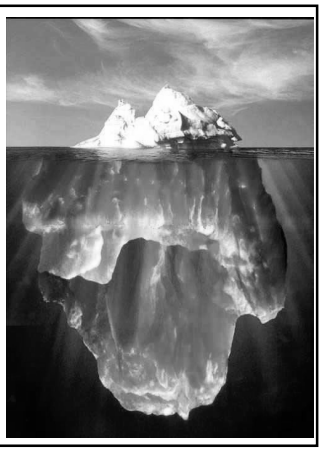
- Why is it easier for you to float in salt water than in fresh water?

Floating Icebergs

- The tip of a floating iceberg above the ocean surface is approximately 10 percent of the whole iceberg.
- That's because ice is 0.9 times the density of water, so 90 percent of it submerges in the water.

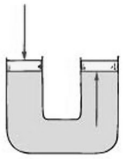
Floating Iceberg

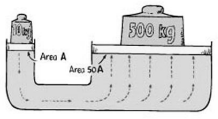
- Newfoundland.
- divert path away from rig by towing them with ships!
- They estimated the weight at 300,000,000 tons.



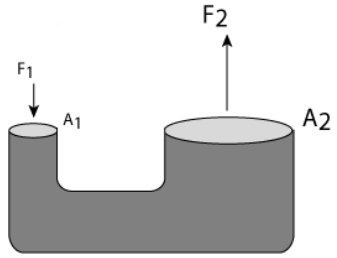
Pascal's Principle

- A change in pressure at any point in an enclosed fluid at rest is transmitted undiminished to all points in the fluid.



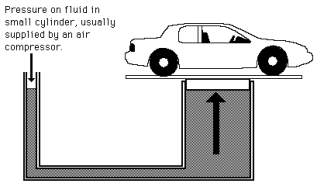


Pascal's Principle



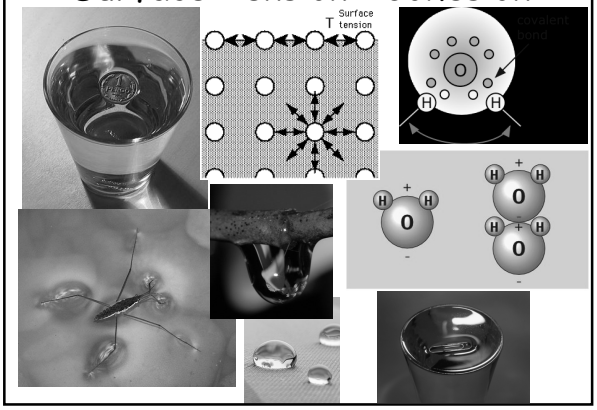
$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Pascal's Principle

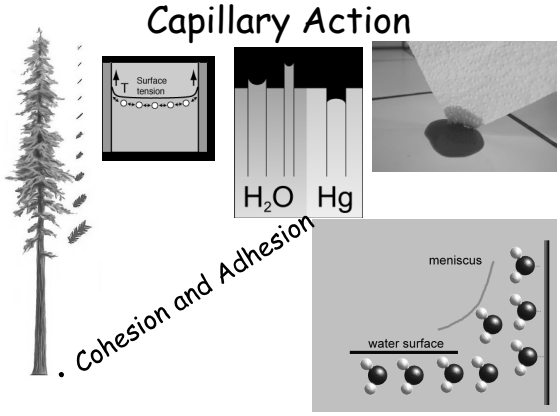


- increased air pressure produced by an air compressor transmitted to the surface of oil in underground reservoir
- oil in turn transmits the pressure to a piston, which lifts the automobile.

Surface Tension - Cohesion



Capillary Action



- Cohesion and Adhesion