Chapter 9

Forces and Fluids

Key Terms

- hydraulic systems
- incompressible
- mass
- neutral buoyancy
- pascal
- pneumatic systems
- pressure
- unbalanced forces
- weight
- Archimedes' principle
- average density
- balanced forces
- buoyancy
- buoyant force
- compressibility
- force

Force

- Anything that causes a change in the motion of an object.

- A push or pull.

Figure 9.1 The force applied to the tennis ball by the player and racket will make the ball change direction.

Balanced forces:

1. Equal in strength
2. Opposite in direction
3. No movement

Unbalanced Forces:

- Unequal in strength
- Cause a change in speed or direction

Figure 9.2 The forces being applied to each side of the box are equal so the box does not move.

Figure 9.3 Forces that are unbalanced will start an object moving, speed up or slow down the object, or change the direction of its movement.

Force Simulations:

http://phet.colorado.edu/en/simulation/forces-1d

Mass vs. Weight

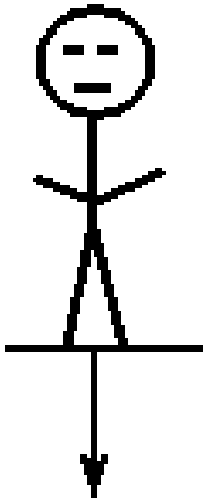
Mass

- Stays the same everywhere
- Amount of matter in a substance
- Kilograms (kg)

Weight

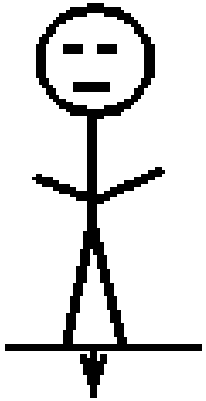
- A measure of the push or pull acting on an object.
- Measure of the force of gravity on an object
- Newton (N)

Earth



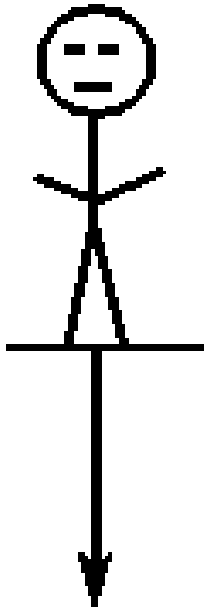
Mass = 63.5 kg
Weight = 623 N
(140 lbs)

Moon



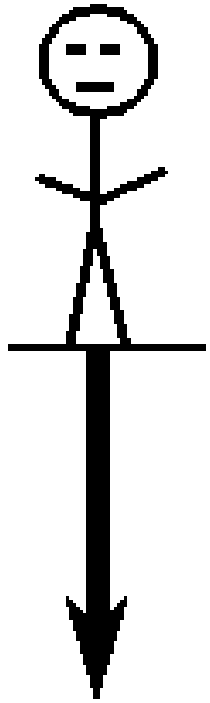
Mass = 63.5 kg
Weight = 103 N
(23 lbs)

Jupiter



Mass = 63.5 kg
Weight = 1582 N
(355 lbs)

Sun



Mass = 63.5 kg
Weight = 17418 N
(3914 lbs)

Buoyancy

The **upward** force on an object submerged in or floating on a fluid.

http://phet.colorado.edu/sims/density-and-buoyancy/buoyancy_en.html

- A floating object has **neutral buoyancy**

- A sinking object does not.

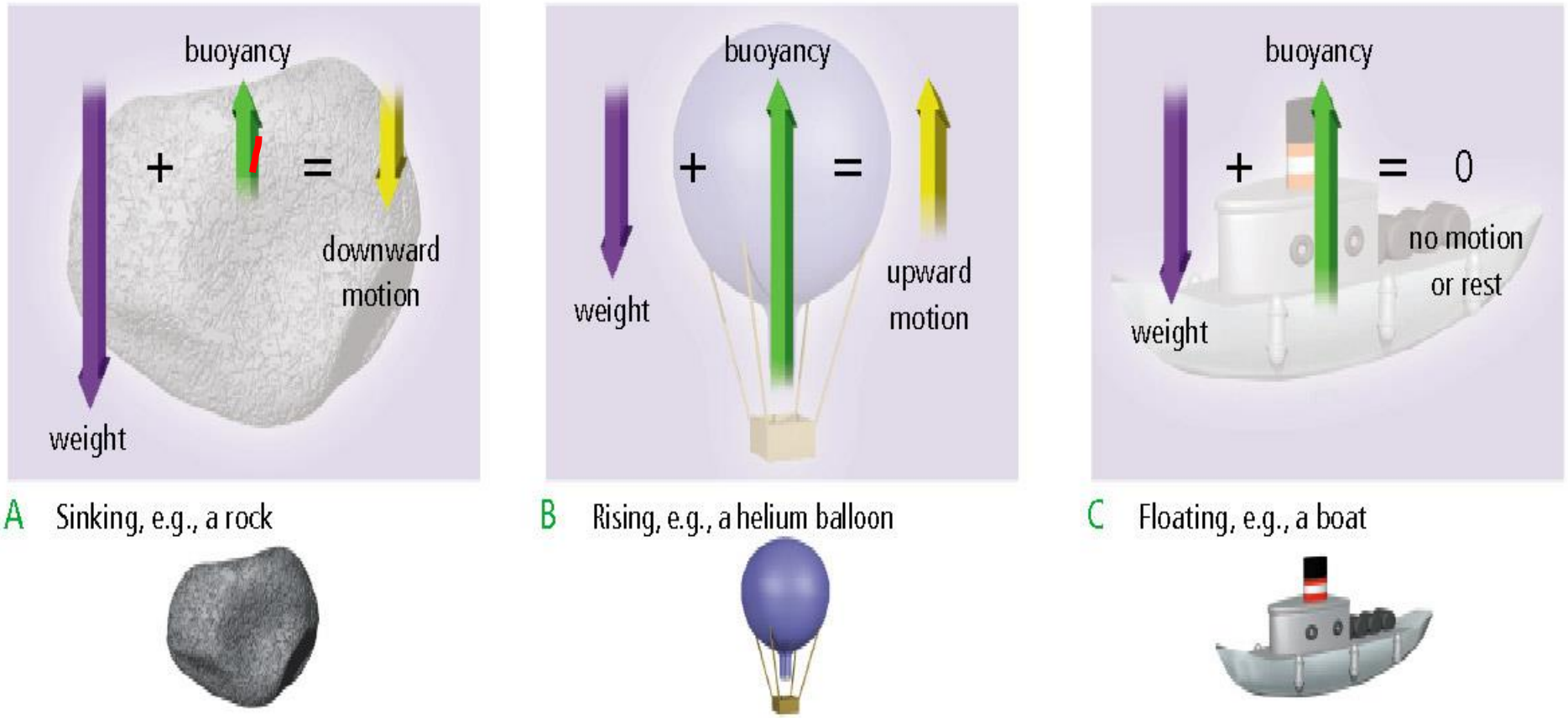


Figure 9.6 The difference between an object's weight and the buoyant force acting on the object will determine whether the object sinks, rises, or floats.

Archimedes Principle

- Buoyant force equals the *weight* (force of gravity) of the fluid displaced by an object.

Examples:

- A rock sinking in a lake
  - Weight of rock > buoyant force (weight of water rock displaces)
    (greater than)
- A chunk of wood floating on the surface of a lake
  - NEUTRAL BUOYANCY
  - weight of the wood = Buoyant force (weight of water wood displaces)
- A helium balloon rising
  - Weight of helium balloon < buoyant force (weight of air balloon displaces)
    (less than)

When swimming why you do sink when you roll yourself into a ball, but you float when you lie flat on your back?

- When in a ball you weigh more than the water you displaced.

- As you lie back a larger of volume of water is displaced

- The weight of the displaced water is now greater than your weight and you float.

Density and Buoyancy

- If the density of the immersed object is greater than the density of the fluid, it will SINK.

- If an object weighs the same or less than the water it is displacing, it will FLOAT.

Which will sink and which will float?

- wooden boat vs. water logged stick?
- metal block vs. metal boat?
- a sealed empty plastic bottle vs. a plastic bottle full of water?

Average Density

- The total mass of all substances that make up an object divided by the total volume.

- If the volume of an object is increased, the average density will decrease.

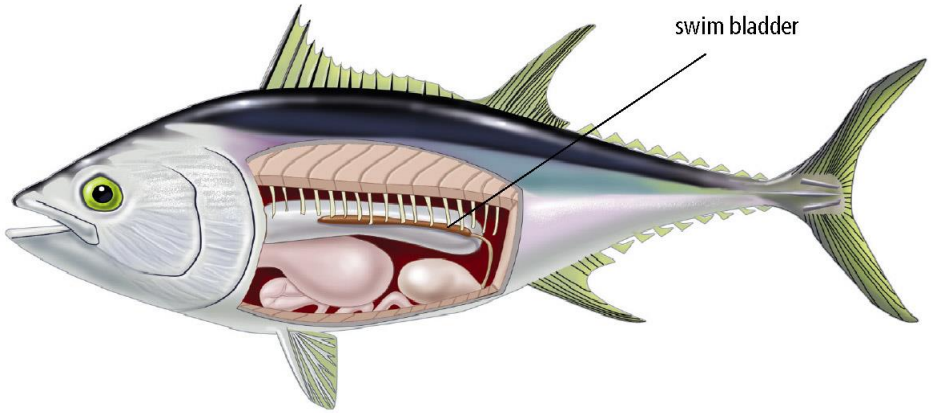


Figure 9.9 Cutaway drawing showing the swim bladder inside a fish. The fish can control its depth in the water by changing the amount of air in the bladder.

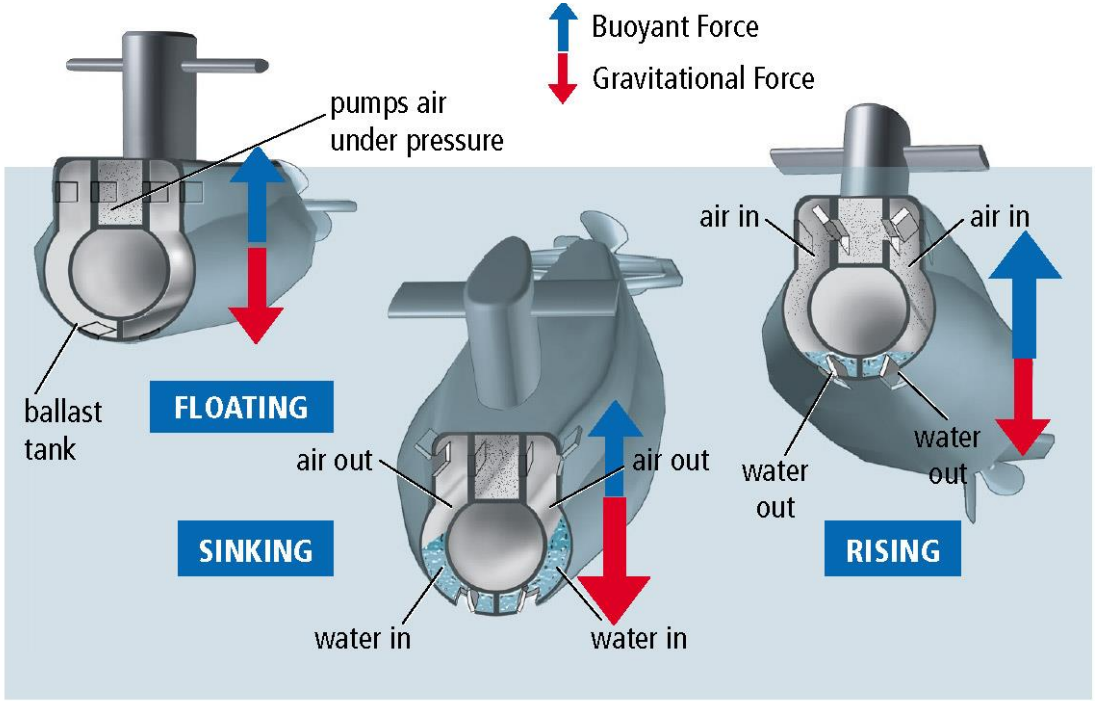


Figure 9.10 Engineers have used the example of a fish's swim bladder to allow crews to control the depth of a submarine. By allowing water to flow in or out, the submarine can rise or sink in the water. The submarine floats when its weight is equal to the buoyant force. The submarine sinks when its weight is greater than the buoyant force.

Technologies Developed

- Personal floatation devices

The **average density** of the person and the jacket is less than the density of water (floats).

The density of the person alone is more than water (sinks).

- Submarines

The sub lets water flow in to sink (density increases) and flow out to float (density decreases).

- Hot air balloons

Air inside is forced out when heated (density decreases). The air inside is then less dense than the air outside and the balloon floats.

Pressure

- The force acting on a certain area of surface.
- *The larger the force, the greater the pressure.*
- *The smaller the area, the greater the pressure.*

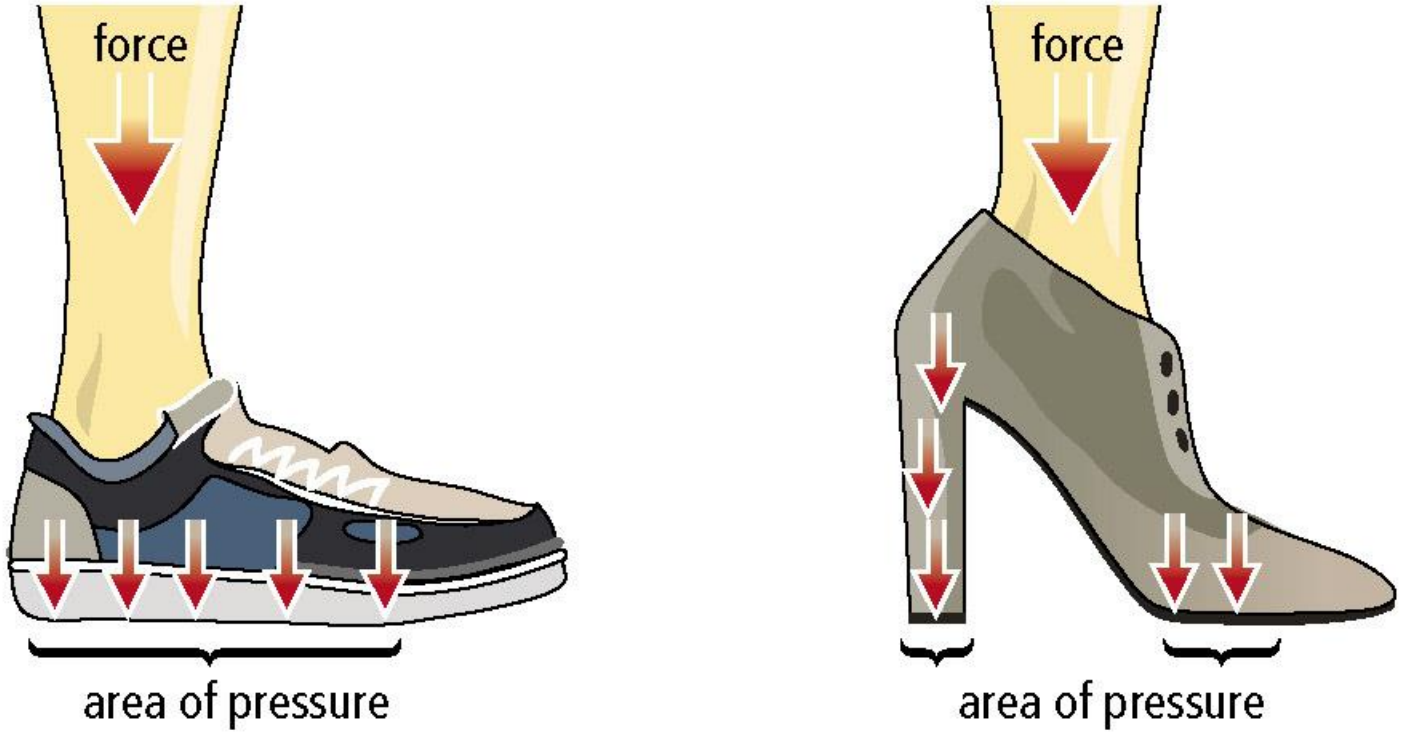


Figure 9.14A and 9.14B High heels exert more pressure on the ground because the pressure is concentrated into a smaller area than a flat shoe.

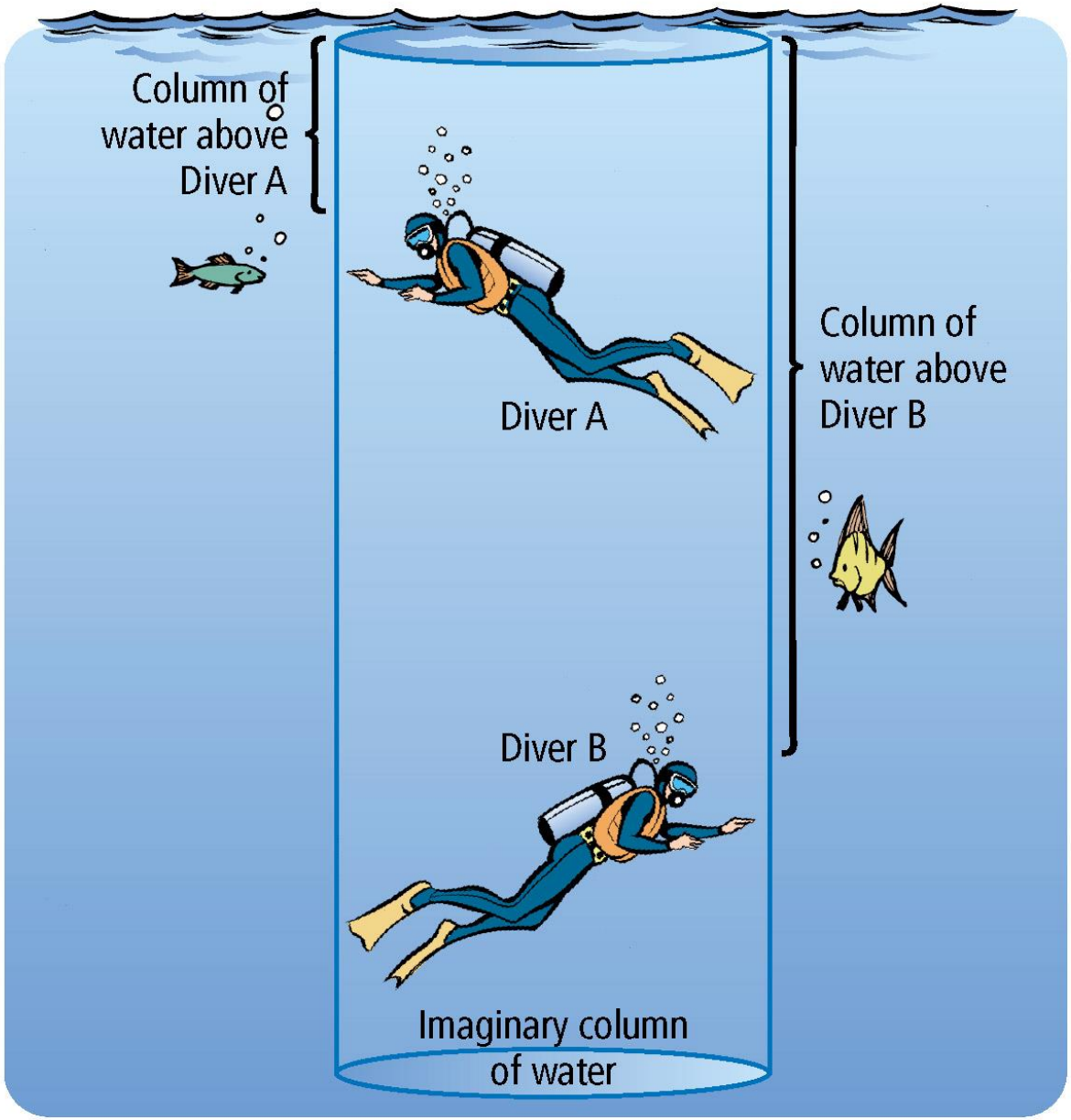
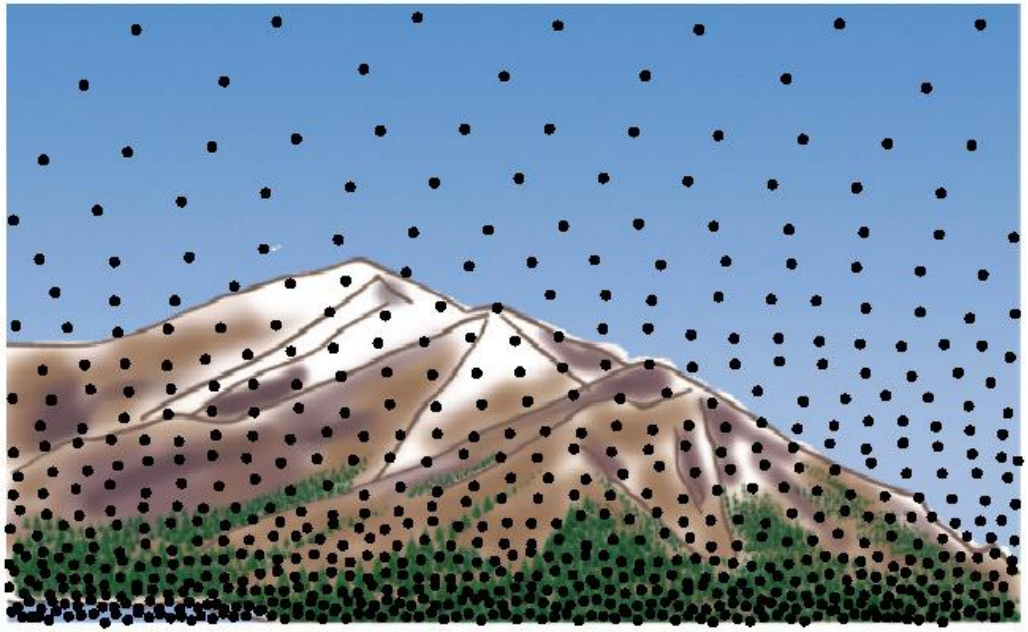


Figure 9.15 As you swim deeper in water, more pressure is exerted on you from the water above.

Figure 9.16 Have you felt pain in your ears when you swam underwater?

Atmospheric Pressure

- The pressure exerted by the layers of air surrounding the Earth that are held by the Earth's gravity. (~ 160 km above the Earth)



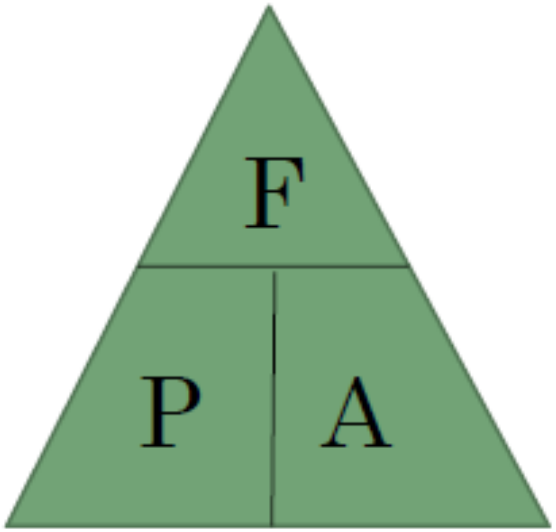
Calculating Pressure

- The unit for pressure is the Pascal (Pa)
- 1 Pa = 1 N/m^2

- You can determine pressure if you know the force and the area.

Formula:

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}}$$



SAMPLE PROBLEMS

1. An aquarium is filled with water that weighs 10 000N. If the base of the aquarium has an area of 1.6 m^2, what pressure does the water exert on its base?

$$P = \frac{F}{A} \qquad P = \frac{10\,000N}{1.6m^2}$$

$$P = 6250\ Pa$$

2. If the atmospheric pressure is 101 200 Pa and you are holding your hand, the atmosphere is exerting a force on your hand. If the area of your palm is 0.006m², calculate the force on your hand.

$$F = P \times A$$

$$F = 101\ 200\ \text{Pa} \times 0.006\ \text{m}^2$$

$$F = 607\ \text{N}$$

3. The weight of water in a glass is 4.9 N. If the water is exerting a pressure of 1700 Pa on the bottom of the glass, what is the area of the bottom of the glass?

Why can….

A person wearing snowshoes walk across a section of deep, soft snow without sinking?

The nozzle on a garden hose be used to create a faster or slower flow of water.

PASCAL'S LAW

- Pressure applied to a enclosed fluid is transmitted with equal force throughout the entire container

- Basis for hydraulic and pneumatic devices.

Examples:

- car lift or hoist
- hydraulic jack
- automobile braking system
- air compressors
- automobile/bicycle tires

HYDRAULICS

- The study of pressure in liquids.

- Hydraulic systems: devices that transmit applied force through a liquid to move something else.

- Hydraulic systems use liquids because they are incompressible (they cannot be squeezed into a smaller volume).

- The liquid must be enclosed in a tube or pipe.

- The pressure produced will exert in all directions equally.

- This pressure will cause motion at the other end of the hydraulic system.

PNEUMATIC SYSTEMS

- The study of pressure in gases.
- Compressors are necessary as gases can be compressed.
- They build up air pressure.

Summary:

Property	Hydraulic System	Pneumatic System
State	Liquid	Gas
Volume	Definite	Indefinite
Pressure	Not Compressible	Compressible

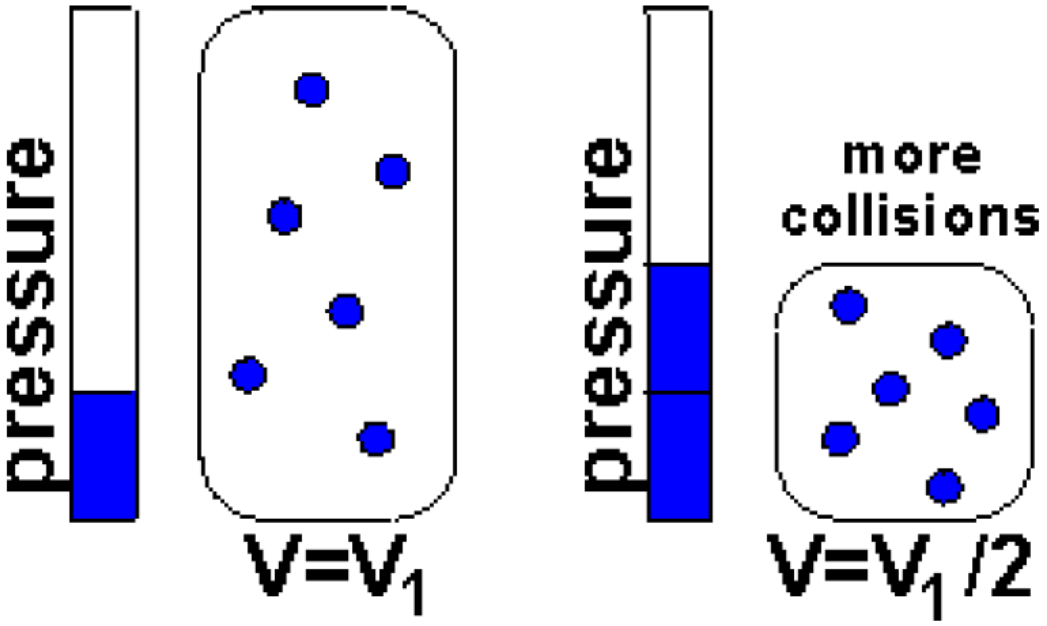
http://www.youtube.com/watch?v=YlmRa-9zDF8

http://www.youtube.com/watch?v=UuK3ESGgbqk&feature=related

Bill nye pressure video

PRESSURE & VOLUME

- Increasing pressure of a fluid will decrease volume by the same amount.
- *known as* ***Boyle's Law***



Example: Propane Cylinders (Page 366)

- **Increase in pressure with a decrease in volume at constant temperature.**

TEMPERATURE & VOLUME

- Increasing temperature will increase the volume of a fluid.

TEMPERATURE & PRESSURE

- Increasing temperature of a fluid will increase the pressure.

In other words…

If the temperature of a fluid is constant (not changing)…

↑P = ↓V

If the pressure of a fluid is constant…

↑T = ↑V

If the volume of a fluid is constant…

↑T = ↑P

Why does this symbol appear on aerosol cans?

http://www.youtube.com/watch?v=wIfKCBt5jVQ

- http://phet.colorado.edu/en/simulation/gas-properties

Questions in Textbook pages 380-383

- Answer all questions

Except for:

16, 38, 39, 40, & 41