Conceptual Physics
11th Edition

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Chapter 14:
GASES

- The Atmosphere
- Atmospheric Pressure
- The Barometer
- Boyle's Law
- Buoyancy of Air
- Bernoulli's Principle
- Plasma

The Atmosphere

Atmosphere
- Ocean of air
- Exerts pressure

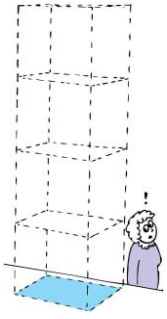
The Magdeburg-hemispheres demonstration shows the large magnitude of atmosphere's pressure.

Atmospheric Pressure

Atmospheric pressure
- Caused by weight of air
- Varies from one locality to another
- Not uniform
- Measurements are used to predict weather conditions

Atmospheric Pressure

- Pressure exerted against bodies immersed in the atmosphere result from the weight of air pressing from above.
- At sea level is 101 kilopascals (101 kPa).
- Weight of air pressing down on 1 m^2 at sea level ~ 100,000 N, so atmospheric pressure is ~ 10^5 N/m^2.



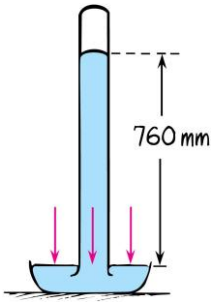
Atmospheric Pressure

- Pressure at the bottom of a column of air reaching to the top of the atmosphere is the same as the pressure at the bottom of a column of water 10.3 m high.
- Consequence: The highest the atmosphere can push water up into a vacuum pump is 10.3 m.

- Mechanical pumps that don't depend on atmospheric pressure don't have the 10.3-m limit.

The Barometer

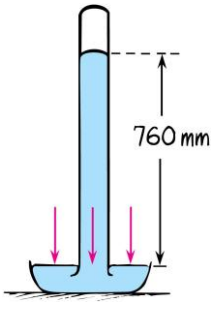
- The barometer is a device to measure atmospheric pressure.
- It consists of a mercury tube upside down in a dish filled with mercury.
- The height of the mercury column tells us the atmospheric pressure.
- Atmospheric pressure decreases with increasing altitude, so it also measures elevation—an *altimeter.*



The Barometer

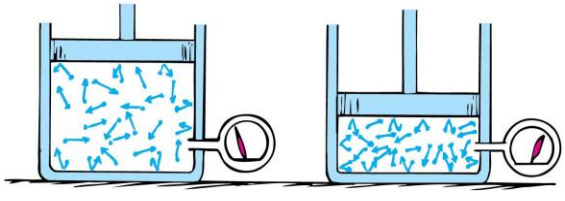
The principle of the barometer:

- Mercury column exerts pressure on the mercury in the dish.
- Atmosphere exerts pressure on the mercury in the dish.
- These two pressures must be equal so that the atmospheric pressure supports the mercury column.



Boyle's Law

- The pressure and volume of a gas enclosed in a space are *inversely proportional*.
- If you increase pressure, the volume will decrease by the same factor.
  - Example: If pressure is doubled, volume will halve.



Boyle's Law

- The product of pressure and volume of a given mass of gas will always remain the same.

$$P_1V_1 = P_2V_2$$

LARGE Pressure; Small Volume; Small Pressure; LARGE Volume

Buoyancy in Air

Archimedes' principle applies to air as well as liquids.

- An object surrounded by air is buoyed up by a force equal to the weight of the air displaced

[image downloaded Jan.24 2013 from http://saigon-hobby.com/products/2739-air-swimmer-nemo.aspx]

Buoyancy in Air

Rules for "lighter-than-air"objects:

- When the weight of air displaced by an object is greater than the weight of the object, it rises.
- When the weight of air displaced by an object equals the weight of the object, it hovers in air.
- When the weight of air displaced by an object is less than the weight of the object, it is not supported by air.

[image downloaded Jan.24 2013 from http://restaurantreservationwallpaper.blogspot.ca/2012/10/helium-balloons.html]

Buoyancy in Air

Gas-filled balloons

- Gas prevents atmosphere from collapsing them
- Best buoyancy with hydrogen, the lightest gas (flammable, so seldom used)
- Next-best buoyancy with helium
- Heated air used in sports balloons

As balloons rise, atmosphere becomes less dense with altitude.

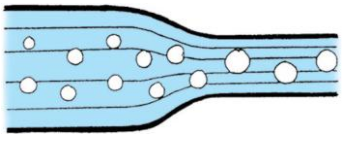
Bernoulli's Principle

- Discovered by Daniel Bernoulli, a 15th century Swiss scientist
- States that where the speed of a fluid increases, internal pressure in the fluid decreases (and vice versa)
- Applies to a smooth, steady flow

Bernoulli's Principle

Streamlines

- Thin lines representing fluid motion
- Closer together, flow speed is greater and pressure within the fluid is less
- Wider, flow speed is less and pressure within the fluid is greater

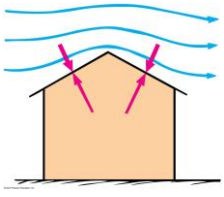


Applications of Bernoulli's principle

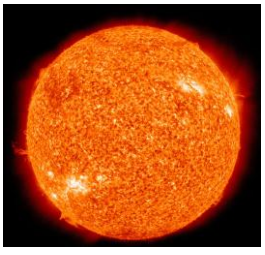
- Blow on the top surface of a paper and the paper rises.

  Reason: Pressure of the moving air is less than the atmospheric pressure beneath it.
- Wind blowing across a peaked roof can lift the roof off the house.

  Reason: Pressure is reduced as wind gains speed as it flows over the roof. The greater pressure inside the house lifts the roof up.



Plasma



- Plasma is the fourth state of matter (after solids, liquids and gases).
- A plasma is an electrified gas. The atoms that make it up are ionized, stripped of one or more electrons, with a corresponding number of free electrons.

Plasma

Fluorescent lamps, neon signs

- When you turn the lamp on, a high voltage between electrodes of the tube causes electrons to flow.
- These electrons ionize some atoms, forming plasma.
- Plasma provides a conducting path that keeps the current flowing.
- The current activates some mercury atoms, causing them to emit ultraviolet radiation.
- This radiation causes the phosphor coating on the tube's inner surface to glow with visible light.

Plasma

Plasma screen TVs

- Flat plasma TV screens are composed of many thousands of pixels.
- Each has three separate cells—red, green and blue—each containing a different gas.
- Pixels are sandwiched between a network of electrodes.
- Electrodes are charged to produce electric currents flowing through cells.
- Gases convert to glowing plasmas, releasing ultraviolet light to stimulate the phosphors.
- The image on the screen is the blend of pixel colors activated by the TV control signal.