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Science: Lesson 5 – Gases and Properties of Gases

Pressure: force applied perpendicular to the surface of an object per unit area.

- **Pressure of Solids:** $Pressure = \frac{Force}{Area}$

- **Pressure of Liquids:** $Pressure = \rho gh$
  - where ρ is the density of the fluid
  - g is acceleration due to gravity
  - h is the height of the fluid above the object.

- **Atmospheric Pressure** is the pressure exerted by the atmosphere and is denoted by P_{atm}.
- **Gauge Pressure:** the pressure of a system above atmospheric pressure. The readings from gauge pressure includes the weight of the atmosphere.
- **Pneumatic Pressure:** the pressure exerted by a pressurized gas. Pneumatic systems work by compressing the gas and increasing pressure.
- **Hydraulic Pressure:** the pressure that is generated by a hydraulic fluid in a confined space when it is subjected to an external force.
- **Hydrostatic Pressure:** the pressure exerted by a liquid at rest due to the force of gravity acting on it.

$$P_H = \rho gh$$

- Absolute pressure, Gauge pressure, Atmospheric pressure Explained. Absolute pressure Gauge. English
- Pressure: Atmospheric & Hydrostatic Pressure and Fluids – Physics | Lecturio

Ideal Gas: a gas which obeys the ideal gas laws at all pressures and temperatures.

- **Ideal Gas Law:** states that the pressure of a gas is inversely proportional to volume and directly proportional to temperature. It is a relation between the pressure P, volume V, and temperature T of a gas in the limit of low pressures and high temperatures.

$$\mathbf{PV = nRT}$$

  - P is the pressure
  - V is the volume
  - n is the number of moles of gas
  - R is the ideal gas constant
  - T is the temperature in Kelvin.

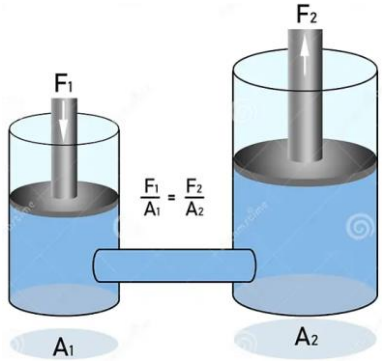
Ideal Gas Law

Pascal's Principle: When a change in pressure is applied to an enclosed fluid, it is transmitted undiminished to all portions of the fluid and to the walls of its container.

$$P = \frac{F_1}{A_1}, \qquad P = \frac{F_2}{A_2}$$

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

This figure[1] provides a visualization of Pascal's principle.



Pascal's law - Animated and explained with 3d program (youtube.com).

Pressure and Altitude (or Height):

- The higher the altitude of an object, the lower the pressure exerted on that object.
- The lower the altitude of that object, the higher the pressure exerted on the object.
- The pressure on a mountain top is lower than the pressure at sea level. Pressure is **inversely proportional** to altitude.

$$P \; \alpha \; \frac{1}{h}$$

This is why the boiling point of water is lower at the top of the mountain (due to lower pressure) and higher at sea level.

Atmospheric Pressure and Boiling - YouTube.

[1]The figure was snipped from Pascals Law for (principle of Transmission of Fluid Pressure Stock Illustration - Illustration of water, automotive: 281662369 (dreamstime.com) website.

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Science: Lesson 6 – Intro to Mechanical Science

Energy is defined as the ability to do work.

- **Joules** is the SI unit of energy.
- The six different forms of energy are:
    - chemical, electrical, mechanical, radiant, thermal, and nuclear energy.

All energy can be classified into two broad types of energy:

1. **Kinetic Energy** is the energy of motion.

$$K.E. = \frac{1}{2}mv^2$$

2. **Potential Energy** is the internal energy a body possesses (or stored energy in a body).

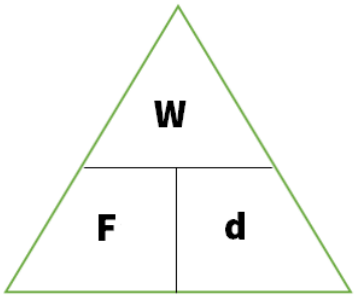
$$P.E. = mgh$$

It is essential to remember that the weight of an object is the force exerted on the object by gravity, $W = mg$.

Law of Conservation of Energy: energy can neither be created nor destroyed but can be changed from one form to another or can be transformed from one system to another.

Work: is the product of the force applied on an object and the distance the object is moved, i.e.,

$$W = Force \times displacement$$



- Work is the transfer of energy (in or out of a system).
- **Joules** is also the SI unit of work

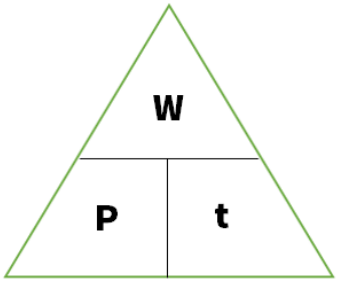
Relationship Between Work and Energy

- Work is the transfer of energy from one object to another.
    - Work is performed when a force is applied in moving an object over a certain distance. This results in the change in energy of the object.
- Energy is the capacity to do the work in moving that object over the distance.

Power: the rate at which work is done or the rate at which energy is transferred or converted.

- **Watts** is the SI unit of power. It is also measured in J/s or kW or $ft\ lb\ \sec^{-1}$.

$$P = \frac{Work}{time} = \frac{Force\ \times distance}{time}$$



Horsepower is another unit of measuring power. An important conversion to take note of is:

$$1\ Hp = 746\ Watts$$

Efficiency: The efficiency of a machine is the measure of how much input power is available as actual output power.

$$Efficiency = \frac{Power\ output}{Power\ input} \times 100\%$$

- Efficiency tells us how efficient the machine is.
  - If the efficiency is 100%, then the machine is perfectly efficient. This means **all** the power is used with NO energy loss.
  - If the efficiency is 0%, then all the input power is lost and the machine cannot put out any energy.

- Example: If a machine has an efficiency of 80%, it means that 80% of the power input is converted into useful work, while the remaining 20% is lost as waste heat, friction, or other inefficiencies.

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Science: Lesson 4 – Fluids

Fluid: A substance that can flow and it doesn't maintain a fixed shape.

- Gases and liquids are usually considered as fluids.
- Characteristics of fluids: compressibility, pressure, buoyancy, viscosity, and surface tension.

Cohesive Forces bind molecules of the same substance together (particles within a fluid being strongly attracted to each other). Cohesion:

- Is strong in solids but weak in gases.
- Is strong enough in liquids to keep the particles together but weak enough to allow the molecules to slide past each other. This lets liquids take the shape of their container.

Adhesive forces bind molecules of different substances together. Particles of different substances are strongly attracted to each other.

Video: Adhesion, Cohesion and Surface Tension Part 10 (youtube.com)

Surface Tension: a contractive tendency of the surface of a liquid that allows it to resist an external force. Examples are the ability of some insects to run on water's surface, needle and plant leaf resting on water.

Video: What is Surface Tension? | Richard Hammond's Invisible Worlds | Earth Science (youtube.com)

Viscosity: the measure of a fluid's resistance to flow.

- It is the internal friction of liquids.
- It can also be how strongly a fluid's cohesive forces will affect the movement of its molecules.
- The stronger the cohesive force, the stronger the viscosity and the slower the fluid will flow.

Video: What is Viscosity | Understanding Resistance to Flow (youtube.com)

Buoyancy: the net upward force on any object in any fluid due to the pressure difference at different depths.

- Any object which is partially or totally submerged in a liquid has a buoyant force acting on it which pushes the object up.

Video: What is Buoyancy? | Physics | Don't Memorise

Archimedes Principle: Any body completely or partially submerged in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the body.

$$F_B = W_{fluid}$$

- F_B is the magnitude of the buoyant force,
- W_{fluid} is the weight of the fluid.

$$F_B = \rho g V$$

- where ρ is the density of the fluid
- g is acceleration due to gravity
- V is the volume of the object.

The following video explains Archimedes principle: Archimedes principle & buoyancy | fluids | Physics | Khan Academy (youtube.com)

An object immersed into a liquid will either float, be partially submerged or totally submerged (and sink).

- The object will rise to the surface and float if the buoyant force is greater than the object's weight.
- The object will sink if the buoyant force is less than the object's weight.
- The object will remain submerged (or suspended) in the liquid if the buoyant force equals the object's weight.

- An object floats if it is less dense than the fluid it is immersed in.
- An object sinks if it is denser than the fluid.

Video: helps with visual explanation: Density & Floating: Why Some Objects Float While Others Sink (youtube.com)

Apparent Weight and Specific Gravity

Apparent weight is the weight that an object appears to have.

- This is not the actual weight of the object.
- Apparent weight differs from the actual weight when the force of gravity acting on the object is not balanced by an equal but opposite force.
- Apparent weight also differs from weight when an object is "partially or completely immersed in a fluid".

$$Apparent\ weight = weight\ of\ object\ - Bouyant\ force$$

Specific Gravity is the measure of the density of a substance in comparison to the density of water.

$$Specific\ gravity\ = \frac{Density\ of\ substance}{Density\ of\ water}$$