Physics Constants & Formulae

This is stuff that every self-respecting physics student will know without having to look it up!

The MKS system:

Length in **meters**, **volume** in **liters**, **mass** in **kilograms**, **time** in **seconds**.

The **kilogram** = 1000g, so 1g = 0.001 kg.

The **liter** is $1dm^3$. Since there are $1000cm^3$ in a dm^3 and 1000ml in a L, 1ml = $1cm^3$.

The **kilogram of mass** is the mass of **1 dm^3** (liter) of water at **4°C.**

The density of water is **1g/cm^3** at **4°C** or 1kg/L

c = the speed of light in vacuum = 300,000 km/s = 3 X 10^8 m/s

h = the quantum constant (Planck's) = 6.6 X 10^{-34} j.s (the basic unit of energy).

E = hυ where E is energy in j & **υ** is the frequency of the light quanta in hz.

E = mc^2 where E is in j, m is in Kg, c (speed of light) is 3 X 10^8 m/s.

The newton, n, of force will accelerate a **1kg mass at 1m/s^2**.

Newton's Laws of Motion:

The First Law is the Law of Inertia.

Every body either remains at rest or continues at constant velocity in a straight line unless acted upon by an external force.

The Second Law is the **Law of Acceleration**, Acceleration is directly proportional to the force and inversely proportional to the mass.
a= f/m. (or **f= ma**). f is force in n, m is mass in kg, a is acceleration in m/s^2. **Acceleration** is a change in velocity/time: **a = v/t**

The Third Law is the Law of **Action & Reaction**. For every action there is an equal and opposite reaction. **Mv = mV**.

The Law of Gravity. Every body attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

$$F = G \frac{Mm}{d^2}$$

eg. F is your weight in n, M is the mass of the earth in kg, m is your mass in kg, d is distance to the center of the earth in m. The radius of the Earth is 6000km = 6×10^6 m.

Weight, **Fwt = mg** Fwt is in n, m is mass in kg, **g = 9.8m/s^2**.

The Inverse Square Law applies to anything that radiates from a point source. eg. gravity, sound, light, magnetism, electric charge.

Escape velocity from Earth = 30km/s.

Terminal Velocity is the velocity at which the weight of a falling object is balanced by the force of friction in the medium. eg. humans in air is about 270 km/hr (75m/s).

Torque is force times distance from the center of rotation. **T = fd.**

Hooke's Law: **Stress = Strain**. **Stress = F/A**, **Strain = ΔL/L**

Equilibrium is the state in which translatory motion and torques are in balance.

The **resultant** is balanced by the **equilibrant** and the clockwise torques are balanced by the counterclockwise torques.

Circular Forces:

Centrifugal effect, a **fictitious force,** center fleeing, Law of Inertia.

Centripetal effect, center seeking, gravity for satellites, string tension for "whip it around" things.

- $$CF = mv^2/r.$$

Coriolis Effect, a **fictitious force,** the apparent deviation of objects moving over the turning earth due to the earth's different velocities at different latitudes. It deflects to the right in the northern hemisphere.

Pressure is force/area. The **pascal** is $1n/m^2$.

Atmospheric pressure = **100 kPa** (kilopascals). **1kg/cm^2** (mass/cm2),**10m** of water, **760**mm of Hg.

"Suction" is the <u>push</u> of atmospheric pressure (or water pressure) into regions of lesser pressure.

Vapor pressure is the force of evaporating molecules.

Boiling Point is the temperature at which the vapor pressure equals the atmospheric pressure. **Two** ways to boil a liquid: Raise VP by heating, lower atmospheric pressure by pump or condensation.

The Gas Laws:

   Boyle's Law states that the volume of a gas varies inversely as the pressure.

   Charles' Law states that the volume of a gas varies directly as the Absolute temperature, **K**.

$$\frac{PV}{T} = \frac{P'V'}{T'}$$

The joule is the work done when a force of 1n acts through a distance of 1m. **W= fd.**

Power is the rate of doing work. **P = W/t** where P is the power in watts, W is the work in joules, and t is in seconds.

Speed is distance per time, Velocity is speed in a direction (a vector). **v = d/t** in m/s.

Vectors:

      Vectors are quantities that have both magnitude and direction. eg. A velocity of 10m/s NE. A force of 20n acting west.

      The resultant vector is the diagonal of a parallelogram with two vectors as sides.

      The Equilibrant vector is equal and opposite to the resultant.

Potential Energy (stored):

PE = mgh (weight X height), PE is in joules.

Kinetic Energy (in motion):

$$KE = \frac{1}{2}mv^2$$ KE is in joules, m is kg, v is m

Acceleration:

$$d = \frac{1}{2}at^2$$ d= distance in m, a = accelera in m/s, t is time in seconds.

For free fall:

$$d = \frac{1}{2}gt^2$$ d= distance in m, g = accelera of gravity in m/s, t is time in

The Speed of Sound is about **350m/s**. Depends upon temperature and pressure of the air.

Intensity of Sound is the decibel. A unit based on human hearing. 0 db is about the softest sound audible.

The Period of the Pendulum

$$T = 2\pi \sqrt{\frac{l}{g}}$$ Where T is the period in seconds
l is the length in meters
g is the acceleration of gravity (9.8 m/s/s)

Electrical Units:

Charge is the coulomb = 10^{18} electrons.

Electromotive force is the volt = j/c.

Current flow is the ampere = c/s.

Resistance is the ohm. Found by **Ohm's Law**, **I= V/R**.

Capacitance in farads.

Impedance (Z) the net opposition to electric current in AC circuits. It is the vector sum of resistance, inductive reactance, and capacitive reactance. Ohm's law for AC, **I= V/Z**.

Sub-atomic particles:

Proton has a mass of 1 amu and a charge of +1

**Electron** has a mass of 1/2000 amu and a charge of -1

Neutron has a mass of 1 amu and a charge of 0.

Anti-particles have the same masses but opposite charges. Upon meeting, they annihilate each other to become energy according to $E=mc^2$.

Isotopes are **nuclei** of the same element having **different mass** due to a different number of neutrons. *Unstable* isotopes are those that are radioactive and decay into new isotopes. **Half-life** is the time for 1/2 of a radioactive isotope to decay into another isotope.

Ions are charged particles such as atomic nuclei that have lost some or all of their electrons.

Atomic fission is the splitting up of atomic nuclei into smaller ones.

$_{92}U^{235} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\ _{0}n^{1} +$ Big Energy! (A-bomb & reactors).
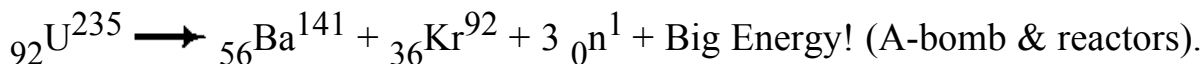
Atomic fusion is the putting together of atomic nuclei to form heavier ones.

$_{1}H^{2} + {}_{1}H^{3} \longrightarrow {}_{2}He^{4} + {}_{0}n^{1} +$ Bigger Energy. (H-bomb & stars).

Cosmic rays are **ions** or atoms coming in from far, far away. They originate in the stars.

Nuclear accelerators accelerate charged particles for nuclear experiments.

Linear accelerator uses electric charges and electromagnet waves. eg. Stanford's 3600 meter "SLAC".

Circular accelerators use electric charges and huge magnetic fields to energize particles in a circle. eg the cyclotron, bevatron, synchrotron.

Common Temperatures:

Absolute zero = 0 K = -273 C.

Freezing of water = 0 C.

Room = 20 C.

Human body = 37 C

Boiling water at 1 atm. = 100 C.

Light:

Intensity = cd.

Illumination = lumen (lux). $e = lm/m^2$.

Heat energy in calories. 1 cal warms 1g of water 1Co. $Q = mc\Delta T$.

The Laws of Thermodynamics:

First is the **Law of Conservation of Mass & Energy**.

Second is the Law of Entropy. Tendency to achieve minimum energy and maximum randomness.

Maxwell's Demon is an hypothetical character who, without using energy, can reverse entropy.

Boltzman's Statistics are a calculation of the probability that all of the molecules in a room will move in the same direction. WOW!