Important Physics stuff!

Important Values

Speed of light in a vacuum: 3×10^{8} ms^{-1}
Planck's constant (h): 6.63×10^{-34} Js
Avogadro constant (N_A): 6.02×10^{23} mol^{-1}
Universal molar gas constant (R): 8.31 $JK^{-1}mol^{-1}$
Peak mains value ≈ 340V
RMS mains value: 240V
Mains frequency: 50Hz

Most of these values can be found on the data sheet.

Equations

Mechanics

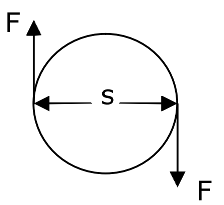
SUVAT equations

v = final velocity (ms^{-1})
u = initial velocity (ms^{-1})
a = acceleration (ms^{-2})
t = time (s)
s = displacement (m) ***not*** *speed*

$v = u + at$
$s = \frac{1}{2}(u + v)t$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

Other mechanics equations

F = ma *(force (N) = mass (kg) × acceleration (ms^{-2}))*
p = mv *(momentum ($kgms^{-1}$) = mass (kg) × velocity (ms^{-1}))*
$E_K = \frac{1}{2}mv^2$ *(kinetic energy (J) = ½ × mass (kg) × velocity^2 (ms^{-1}))*
$E_P = mg\Delta h$ *(gravitational PE (J) = mass (kg) × GFS (ms^{-2}) × change in height (m))*
work (J) = force (N) × distance moved (m)
P = mv *(power (W) = motive force (N) × velocity (ms^{-1}))*
$P = \frac{W}{t}$ *(power (W) = $\frac{\text{energy transferred (work) (J)}}{\text{time (s)}}$)*
$mu = mv_1 + mv_2$ *(conservation of momentum)*
$\frac{1}{2}mu^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2$ *(conservation of kinetic energy E_k)*
$F = \frac{p_2 - p_1}{t}$ *(force (N) = $\frac{\text{change in momentum } (kgms^{-1})}{\text{time (s)}}$)*
weight = mg *(weight (N) = mass (kg) × GFS (ms^{-2}))*
moment (Nm) = force (N) × perpendicular distance from pivot (m)
torque due to a couple = Fs *(torque = force (N) × distance (m))*



A couple – two forces that are equal in magnitude and anti-parallel. They only ever produce a turning effect.

$\Delta Q = mc\Delta\theta$ *(heat energy (J) = mass (kg) × SHC ($Jkg^{-1}C^{-1}$) × change in temperature (K))**

$\Delta Q = ml$ *(heat energy (J) = mass (kg) × specific latent heat (Jkg^{-1}))***

$pV = nRT$ *(pressure (Pa) × volume (m^3) = moles × UMGC ($JK^{-1}mol^{-1}$) × temperature (K))†*

$pV = \frac{1}{3}mN\overline{c}^2$

(pressure (Pa) × volume (m^3) = ⅓ × mass (kg) × no. of molecules × mean velocity² (ms^{-1}))

$\frac{1}{2}m\overline{c}^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$

** SHC is the specific heat capacity of the material – the heat energy needed to raise 1kg of the material by 1K.*

*** Specific latent heat of fusion of a substance is the amount of heat energy needed to cause 1kg of that substance to change state **without** temperature change.*

† UMGC is the universal molar gas constant, 8.31 $JK^{-1}mol^{-1}$

Electricity

$\epsilon = I(r + R)$ *(EMF of a cell = current × (internal resistance + external resistance))*

$I_{RMS} = I_P / \sqrt{2}$ *(RMS current = Peak current / √2)*

$V_{RMS} = V_P / \sqrt{2}$ *(RMS potential difference = Peak potential difference / √2)*

$Q = It$ *(charge (C) = current (A) × time (s))*

$R_T = R_1 + R_2 \ldots$ *(resistors in series)*

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \ldots$ *(resistors in parallel)*

$\rho = \frac{RA}{\ell}$ *(resistivity (Ωm) = $\frac{\text{resistance (Ω) × cross-sectional area (m}^2\text{)}}{\text{length (m)}}$)*

$P = I^2R$ *(power (W) = current² (A) × resistance (Ω))*

Stretching of materials

Tensile strain (no units) = $\frac{\text{extension (m)}}{\text{original length (m)}}$

Tensile stress (Pa) = $\frac{\text{force (N)}}{\text{cross-sectional area (m}^2\text{)}}$

Young modulus (Pa) = $\frac{Fl}{eA}$ *(using above units)*

strain energy stored in a stretched cord = ½Fe *(½× tensile stress × tensile strain)*

N.B. A lot of these equations can be found on the data sheet in one form or another. The ones that are *not* on the data sheet are highlighted.

System International (SI) - Standard Units

Base quantities	Base units
Length	**metres (m)**
Mass	**kilograms (kg)**
Time	**seconds (s)**
Temperature	**Kelvin (K)**
Current	**Ampères (A)**
Quantity of substance	**mole**

Derived quantities

Quantity	Definition	Name of unit	Base units
Force	Mass × acceleration	Newton (N)	kg m s^{-2}
Work	Force × distance moved	Joules (J)	kg m^2 s^{-2}
Voltage	Work done/charge moved	Volts (V)	kg m^2 s^{-3} A^{-1}
Momentum	Mass × velocity	-	kg m s^{-1}
Acceleration	Change in velocity/time	-	m s^{-2}

Laws

Hooke's Law

For an elastic material, strain is directly proportional to stress. The extension of a material is proportional to the force applied: F = ke (where k is a constant and represents the stiffness of the material in Nm^{-1}). This law is obeyed up until the **limit of proportionality**, not to be confused with the **elastic limit**, which is where the material stops behaving elastically, i.e. after any subsequent extensions it will not return to its original length and shape.

Newton's Laws of Motion

1. All objects have inertia; that is, an object will remain at rest or in uniform motion unless acted upon by some outside force.

(Inertia is basically how easy or difficult it is to make something move. It depends only on the mass of the object.)

2. An object's acceleration is in the same direction as the force exerted on it. The force exerted on that object is equal to the product of its mass and acceleration.

F = ma

3. For every action there **must** be an equal and opposite reaction.

Boyle's Law

The pressure (p) of a fixed mass of gas at constant temperature is inversely proportional to its volume (V): pV = k (where k is a constant). As volume decreases, pressure increases, and vice versa.

Charles' Law

The volume (V) of a fixed mass of gas at constant pressure is directly proportional to its absolute temperature (T): $\frac{V}{T}$ = k (where k is a constant). As temperature increases, volume increases, and vice versa.

Pressure Law

The pressure (p) of a fixed mass of gas at constant volume is directly proportional to its absolute temperature (T): $\frac{p}{T}$ = k (where k is a constant). As temperature increases, pressure increases, and vice versa.

Scales in Physics

Multiplication factor		Prefix	Symbol	Scale (order of magnitude)
1 000 000 000 000	10^{12}	tera	T	5.9Tm = radius of Pluto's orbit
1 000 000 000	10^{9}	giga	G	0.4Gm = mean Earth-Moon distance
1 000 000	10^{6}	mega	M	6.37Mm = mean radius of Earth
1 000	10^{3}	kilo	k	320km from Manchester to London
0.001	10^{-3}	milli	m	Microwave wavelength
0.000 001	10^{-6}	micro	μ	Wavelength of visible light: 0.4 to 0.7 μm
0.000 000 001	10^{-9}	nano	n	Approximate atomic diameter
0.000 000 000 001	10^{-12}	pico	p	Wavelength of a gamma ray
	10^{-15}	femto	f	Approximate diameter of an atomic nucleus
	10^{-18}	atto	a	Range of weak nuclear force