Physics formulae and data booklet

Year 11

Heating processes

first law of thermodynamics	$\Delta U = Q - W$
temperature change	$Q = mc\Delta T$
latent heat	$Q = mL$
	$Q = mL_{fusion}$
	$Q = mL_{vapour}$

Applying thermodynamic principles

Wien's law	$\lambda_{max}T = 2.898 \times 10^{-3}$
rate of energy radiation	$P \propto T^4$
Stefan–Boltzmann equation	$P = e\sigma AT^4$
for objects at T in surroundings of T_s	$P = e\sigma A(T^4 - T_s)$

Electrical physics

current	$I = \frac{Q}{t}$
potential difference	$V = \frac{E}{Q}$
power	$P = \frac{E}{t} = VI$
Ohm's law	$I = \frac{V}{R}$ or $V = IR$

Practical electrical circuits

resistors in series	$R_T = R_1 + R_2 + \ldots + R_n$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$

The origins of everything

distance	$d = \frac{1}{p}$
Hubble's law	$v = H_0 d$
Hubble constant	$H_0 = 70$ km s^{-1} Mpc^{-1}

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Particles in the nucleus

half-life; activity	$N = N_0 \left(\frac{1}{2}\right)^n; A = A_0 \left(\frac{1}{2}\right)^n$

Energy from the atom

Einstein's mass–energy equation	$E = mc^2$

Scalars and vectors

force due to gravity (weight)	$F_g = mg$
gravitational field strength near the surface of the Earth	$g = 9.8$ N kg^{-1}

Linear motion

displacement	s = final position – initial position
average speed	$v_{av} = \frac{d}{\Delta t}$
average velocity	$v_{av} = \frac{s}{\Delta t}$
	$v_{av} = \frac{u + v}{2}$
average acceleration	$a_{av} = \frac{\Delta v}{\Delta t}$
equations of motion with constant acceleration	$v = u + at$
	$s = \frac{1}{2}(u + v)t$
	$s = ut + \frac{1}{2}at^2$
	$s = vt - \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
acceleration due to gravity at Earth's surface	$g = 9.8$ m s^{-2}

Momentum and force

Newton's second law	$F_{net} = ma$
	$F_{net} = \frac{m(v - u)}{\Delta t}$
momentum	$p = mv$
law of conservation of momentum	$\Sigma p_{before} = \Sigma p_{after}$
where two objects collide and remain separate	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
where two objects collide and combine together	$m_1u_1 + m_2u_2 = m_3v_3$
where one object breaks apart into two objects in an explosive collision	$m_1u_1 = m_2v_2 + m_3v_3$
impulse	$I = \Delta p = mv - mu = F\Delta t$

Equilibrium of forces

torque	$\tau = r_{\perp}F$
translational equilibrium in one dimension	$F_{net} = 0$
translational equilibrium in two dimensions	$F_{net,x} = 0$ and $F_{net,y} = 0$
static equilibrium	$F_{net} = 0$ and $\tau_{net} = 0$
rotational equilibrium	$\Sigma\tau_{clockwise} = \Sigma\tau_{anticlockwise}$

Energy, work and power

work	$W = Fs$
kinetic energy	$E_k = \frac{1}{2}mv^2$
gravitational potential energy	$E_g = mg\Delta h$
Hooke's law	$F = -k\Delta x$
elastic potential energy	$E_s = \frac{1}{2}k\Delta x^2$
power required to keep an object moving at a constant speed	$P = Fv_{av}$
efficiency of energy transfer (in %)	efficiency $(\eta) = \frac{\text{useful energy transferred}}{\text{total energy supplied}} \times 100\%$ $= \frac{\text{useful energy out}}{\text{total energy in}} \times 100\%$

Stars

speed of electromagnetic waves (light) in a vacuum	$c = 299\,792\,458$ m s^{-1} $\approx 3.0 \times 10^8$ m s^{-1}
speed of light in a particular medium (wave equation for light)	$c = f\lambda$
period	$T = \frac{1}{f}$
Schwarzschild radius	$r_s = \frac{2GM}{c^2}$

Forces in the human body

centre of mass	$x_{cm} = \frac{m_1x_1 + m_2x_2 + \ldots + m_nx_n}{m_1 + m_2 + \ldots + m_n}$
stress	$\sigma = \frac{F}{A}$
strain	$\varepsilon = \frac{\Delta l}{l}$
Young's modulus	$E = \frac{\sigma}{\varepsilon}$

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Nuclear medicine

absorbed radiation dose	$AD = \frac{\text{energy absorbed by the tissue}}{\text{mass of tissue}}$
dose equivalent	DE = absorbed dose × quality factor
effective dose	$\Sigma(\text{dose equivalent} \times W)$

Particle accelerators

speed of accelerated electrons	$E_k = \Delta E$ or $\frac{1}{2}mv^2 = eV$

Sport

coefficient of restitution	$e = \frac{v_2}{v_1} = \sqrt{\frac{h}{H}}$
angular speed	$\omega = \frac{\theta}{t} = 2\pi f$
linear and angular speed	$v = r\omega$
relationship between the force of friction and the normal force	$F_f = \mu F_N$
period of a pendulum	$T = 2\pi\sqrt{\frac{L}{g}}$
straight line equations of motion in the horizontal direction	$s = ut = vt$
equations of motion in the vertical direction	$v = u + 9.8t$
	$v^2 = u^2 + 19.6s$
	$s = \frac{1}{2}(u + v)t$
	$s = ut + 4.9t^2$
drag force	$F_D = \frac{1}{2}C_D\rho v^2 A$
terminal velocity when drag force on an object and weight of an object are equal	$v_t = \sqrt{\frac{2mg}{C_D\rho A}}$

Constants

universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m² kg⁻²
mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
radius of Earth	$R_E = 6.37 \times 10^{6}$ m
mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
charge on the electron	$e = -1.6 \times 10^{-19}$ C
speed of light	$c = 3.0 \times 10^{8}$ m s^{-1}

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Prefixes/Units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^{3}

M = mega = 10^{6}

G = giga = 10^{9}

t = tonne = 10^{3} kg

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