Physics — HSC Reference Sheet

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Constants & Data

Speed of light in vacuum
$c = 3.00 \times 10^{8}$ m s⁻¹

Charge on an electron
$e = 1.602 \times 10^{-19}$ C

Mass of an electron
$m_e = 9.109 \times 10^{-31}$ kg

Mass of a proton
$m_p = 1.673 \times 10^{-27}$ kg

Mass of a neutron
$m_n = 1.675 \times 10^{-27}$ kg

Planck's constant
$h = 6.626 \times 10^{-34}$ J s

Universal gravitational constant
$G = 6.67 \times 10^{-11}$ N m² kg⁻²

Acceleration due to gravity at Earth's surface
$g = 9.8$ m s⁻²

Permeability of free space
$\mu_0 = 4\pi \times 10^{-7}$ H m⁻¹ (N A⁻²)

Permittivity of free space
$\varepsilon_0 = 8.854 \times 10^{-12}$ F m⁻¹ (C² N⁻¹ m⁻²)

Mass of Earth
$M_E = 6.0 \times 10^{24}$ kg

Radius of Earth
$R_E = 6.371 \times 10^{6}$ m

Speed of sound in air
$v_{\text{sound}} = 340$ m s⁻¹

Wien's displacement constant
$b = 2.898 \times 10^{-3}$ m K

Kinematics

First kinematic equation (velocity–time)

$$v = u + at$$

Second kinematic equation (displacement–time)

$$s = ut + \tfrac{1}{2}at^2$$

Third kinematic equation (velocity–displacement)

$$v^2 = u^2 + 2as$$

Displacement (average velocity form)

$$s = \frac{(u+v)}{2}\,t$$

Dynamics & Forces

Newton's second law

$$F_{\text{net}} = ma$$

Linear momentum

$$p = mv$$

Impulse–momentum theorem

$$J = F\Delta t = \Delta p$$

Work done by a constant force

$$W = Fs\cos\theta$$

Power

$$P = \frac{W}{t} = Fv$$

Kinetic energy

$$E_k = \tfrac{1}{2}mv^2$$

Gravitational potential energy

$$E_p = mgh$$

Circular & Projectile Motion

Centripetal acceleration

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

Centripetal force

$$F_c = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2}$$

Projectile horizontal component

$$x = v_x t = v_0\cos\theta \cdot t$$

Projectile vertical component

$$y = v_0\sin\theta \cdot t - \tfrac{1}{2}gt^2$$

Gravitation & Orbits

Newton's law of universal gravitation

$$F_g = \frac{Gm_1m_2}{r^2}$$

Gravitational potential energy (general)

$$U = -\frac{Gm_1m_2}{r}$$

Orbital velocity

$$v = \sqrt{\frac{GM}{r}}$$

Kepler's third law

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

Waves & Sound

Wave speed

$$v = f\lambda$$

Doppler effect

$$f' = f\frac{v_w + v_o}{v_w - v_s}$$

Period–frequency relationship

$$T = \frac{1}{f}$$

Electricity & Magnetism

Charge and current

$$q = It$$

Work on a charge

$$W = qV$$

Coulomb's law

$$F_e = \frac{kq_1q_2}{r^2} = \frac{q_1q_2}{4\pi\varepsilon_0 r^2}$$

Electric field strength

$$E = \frac{F}{q} = \frac{kQ}{r^2}$$

Voltage and resistance (Ohm's law)

$$V = IR$$

Electrical power

$$P = VI = I^2R = \frac{V^2}{R}$$

Force on a current-carrying conductor

$$F = BIl\sin\theta$$

Force on a moving charge in a magnetic field

$$F = qvB\sin\theta$$

Electromagnetism & Induction

Magnetic flux

$$\Phi = BA\cos\theta$$

Faraday's law (induced EMF)

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$$

Transformer equation

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Light & Quantum Physics

Photon energy

$$E = hf = \frac{hc}{\lambda}$$

Photoelectric effect (Einstein's equation)

$$E_k^{\max} = hf - W = hf - hf_0$$

de Broglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Wien's displacement law

$$\lambda_{\max} = \frac{b}{T}$$

Special relativity — time dilation

$$t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma t_0$$

Special relativity — length contraction

$$L = \frac{L_0}{\gamma} = L_0\sqrt{1 - \frac{v^2}{c^2}}$$

Nuclear Physics & the Standard Model

Mass–energy equivalence

$$E = mc^2$$

Radioactive decay / half-life

$$N(t) = N_0\left(\tfrac{1}{2}\right)^{t/t_{1/2}}$$

Photon momentum

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

Relativistic energy–momentum relation

$$E^2 = (pc)^2 + (m_0c^2)^2$$

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