

H2 Physics Data and Formulae List

A-Level H2 (9478) · H2 Physics



The Singapore Syllabus

PRINTED IN THE PAPER

Formulas the H2 Physics paper gives you

In the order SEAB prints them. You do not need to memorise these, but you do need to know when to use each one.

DATA

speed of light in free space

$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$

permeability of free space

$$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$$

permittivity of free space

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$$

$$\left(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1} \right)$$

elementary charge

$$e = 1.60 \times 10^{-19} \text{ C}$$

Planck constant

$$h = 6.63 \times 10^{-34} \text{ J s}$$

unified atomic mass constant

$$u = 1.66 \times 10^{-27} \text{ kg}$$

rest mass of electron

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

rest mass of proton

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

molar gas constant

$$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

Avogadro constant

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$$

Boltzmann constant

$$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

gravitational constant

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

acceleration of free fall

$$g = 9.81 \text{ m s}^{-2}$$

FORMULAE

uniformly accelerated motion

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

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

work done on / by a gas

$$W = p \Delta V$$

pressure

$$p = \frac{F}{A}$$

gravitational potential

$$\phi = -\frac{GM}{r}$$

temperature

$$T/\text{K} = T/^{\circ}\text{C} + 273.15$$

pressure of an ideal gas

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

mean translational kinetic energy of an ideal gas particle

$$E = \frac{3}{2}kT$$

displacement of particle in s.h.m.

$$x = x_0 \sin \omega t$$

velocity of particle in s.h.m.

$$v = v_0 \cos \omega t = \pm \omega \sqrt{(x_0^2 - x^2)}$$

electric current

$$I = nAvq$$

resistors in series

$$R = R_1 + R_2 + \dots$$

resistors in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

capacitors in series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

capacitors in parallel

$$C = C_1 + C_2 + \dots$$

energy in a capacitor

$$U = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$$

charging a capacitor

$$Q = Q_0 \left[1 - e^{-\frac{t}{\tau}} \right]$$

discharging a capacitor

$$Q = Q_0 e^{-\frac{t}{\tau}}$$

RC time constant

$$\tau = RC$$

electric potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

alternating current / voltage

$$x = x_0 \sin \omega t$$

magnetic flux density due to a long straight wire

$$B = \frac{\mu_0 I}{2\pi d}$$

magnetic flux density due to a flat circular coil

$$B = \frac{\mu_0 NI}{2r}$$

magnetic flux density due to a long solenoid

$$B = \mu_0 nI$$

energy states for quantum particle in a box

$$E_n = \frac{h^2}{8mL^2} n^2$$

radioactive decay

$$x = x_0 e^{-\lambda t}$$

radioactive decay constant

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

Formulas the H2 Physics paper does not give you

The syllabus expects you to use these, but the paper does not print them.

FOUNDATIONS OF PHYSICS

Hooke's law

k is the force constant. (Learning outcome 2(c))

$$F = kx$$

Torque of a couple

One of the two equal forces times the perpendicular distance between their lines of action. (Learning outcome 2(d))

$$\text{torque} = Fd$$

Newton's second law in terms of momentum

The resultant force equals the rate of change of momentum. (Learning outcome 3(h))

$$F = \frac{\Delta p}{\Delta t}$$

Work done by a force

s is the displacement in the direction of the force. (Learning outcome 4(c))

$$W = Fs$$

Elastic potential energy

The area under the force-extension graph, up to the limit of proportionality. (Learning outcome 4(k))

$$E_p = \frac{1}{2}Fx = \frac{1}{2}kx^2$$

Mechanical power

v is the velocity in the direction of the force. (Learning outcome 4(m))

$$P = Fv$$

Efficiency (Learning outcome 4(n))

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

Moment of a force

d is the perpendicular distance from the pivot to the line of action of the force. (Learning outcome 2(d))

$$\text{moment} = Fd$$

Linear momentum (Learning outcome 3(g))

$$p = mv$$

Newton's second law

For a body of constant mass. (Learning outcome 3(i))

$$F = ma$$

Kinetic energy (Learning outcome 4(e))

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

Power

Power is the rate of energy transfer. (Learning outcome 4(l))

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

MECHANICS

Change in gravitational potential energy in a uniform field

(Learning outcome 5(d))

$$\Delta E_p = mg\Delta h$$

Impulse

The area under the force-time graph. (Learning outcome 6(a))

$$\text{impulse} = \int F dt = \Delta p$$

Linear speed in circular motion

(Learning outcome 7(c))

$$v = r\omega$$

Centripetal acceleration (Learning outcome 7(e))

$$a = r\omega^2 = \frac{v^2}{r}$$

Centripetal force (Learning outcome 7(f))

$$F = mr\omega^2 = \frac{mv^2}{r}$$

Newton's law of gravitation

(Learning outcome 8(a))

$$F = G \frac{m_1 m_2}{r^2}$$

Gravitational field strength due to a point mass

(Learning outcome 8(c))

$$g = G \frac{M}{r^2}$$

Gravitational potential energy of two point masses

Zero when the masses are infinitely far apart, so it is negative closer in. (Learning outcome 8(g))

$$U_G = -\frac{GMm}{r}$$

Field strength and potential gradient

The field strength is the negative of the slope of the potential-distance graph. (Learning outcome 8(h))

$$g = -\frac{d\phi}{dr}$$

Angular frequency and period

(Learning outcome 9(c))

$$\omega = 2\pi f = \frac{2\pi}{T}$$

Defining equation of simple harmonic motion

(Learning outcome 9(d))

$$a = -\omega^2 x$$

WAVES**Wave equation** (Learning outcome 10(d))

$$v = f\lambda$$

Intensity For a progressive wave. (Learning outcome 10(g))

$$\text{intensity} = \frac{\text{power}}{\text{area}}, \quad \text{intensity} \propto (\text{amplitude})^2$$

Malus' law

For a plane-polarised wave passing through a polarising filter. (Learning outcome 10(j))

$$I = I_0 \cos^2 \theta$$

Double-slit interference

a is the slit separation and x is the fringe separation. (Learning outcome 11(h))

$$\frac{ax}{D} = \lambda$$

Diffraction grating, principal maxima

a is the slit separation. (Learning outcome 11(i))

$$a \sin \theta = n\lambda$$

Single slit, first minima

b is the slit width. (Learning outcome 11(l))

$$b \sin \theta = \lambda$$

Rayleigh criterion

b is the width of the aperture. (Learning outcome 11(m))

$$\theta \approx \frac{\lambda}{b}$$

THERMAL PHYSICS

Equation of state for an ideal gas

N is the number of particles. (Learning outcome 12(c))

$$pV = NkT$$

First law of thermodynamics

W is the work done on the system. (Learning outcome 13(f))

$$\Delta U = Q + W$$

Specific latent heat (Learning outcome 13(g))

$$Q = mL$$

Moles and particles

n is the number of moles. (Learning outcome 12(d))

$$Nk = nR, \quad N = nN_A, \quad pV = nRT$$

Specific heat capacity (Learning outcome 13(g))

$$Q = mc\Delta\theta$$

ELECTRICITY AND MAGNETISM

Coulomb's law (Learning outcome 14(a))

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$$

Electric field strength due to a point charge

(Learning outcome 14(b))

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

Electric potential energy of two point charges

Positive for like charges, negative for unlike charges. (Learning outcome 14(e))

$$U_E = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r}$$

Electric field strength and potential gradient

The field strength is the negative of the slope of the potential-distance graph. (Learning outcome 14(f))

$$E = -\frac{dV}{dr}$$

Uniform field between parallel plates

d is the plate separation. (Learning outcome 14(g))

$$E = \frac{V}{d}$$

Force on a charge in a uniform electric field

(Learning outcome 14(h))

$$F = QE$$

Capacitance (Learning outcome 14(j))

$$C = \frac{Q}{V}$$

Current and charge (Learning outcome 15(a))

$$Q = It$$

Potential difference (Learning outcome 15(c))

$$V = \frac{W}{Q}$$

Electrical power (Learning outcome 15(d))

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

Mean power in a resistor with sinusoidal a.c.

The mean power is half the peak power. (Learning outcome 15(h))

$$\langle P \rangle = \frac{1}{2} P_0 = \frac{1}{2} I_0 V_0 = I_{\text{rms}} V_{\text{rms}}$$

r.m.s. values for sinusoidal a.c. (Learning outcome 15(i))

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}, \quad V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

Resistance (Learning outcome 16(c))

$$V = IR$$

Resistivity (Learning outcome 16(d))

$$R = \frac{\rho l}{A}$$

Force on a current-carrying conductor

(Learning outcome 17(f))

$$F = BIl \sin \theta$$

Force on a moving charge in a magnetic field

(Learning outcome 17(k))

$$F = BQv \sin \theta$$

Magnetic flux and flux linkage

N is the number of turns. (Learning outcome 18(c))

$$\Phi = BA, \quad N\Phi = NBA$$

Faraday's law and Lenz's law

The minus sign shows the induced e.m.f. opposes the change. (Learning outcome 18(e))

$$E = - \frac{d(N\Phi)}{dt}$$

Ideal transformer (Learning outcome 18(g))

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

MODERN PHYSICS**Energy of a photon** (Learning outcome 19(b))

$$E = hf$$

Momentum of a photon (Learning outcome 19(c))

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

de Broglie wavelength (Learning outcome 19(e))

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

Heisenberg uncertainty principle

(Learning outcome 19(h))

$$\Delta x \Delta p \gtrsim h$$

Photon from an energy level transition

The photon energy equals the difference between the two energy levels, for emission or absorption. (Learning outcome 19(m))

$$hf = E_1 - E_2$$

Activity λ is the decay constant. (Learning outcome 20(h))

$$A = \lambda N$$

Mass-energy equivalence

(Learning outcome 20(q))

$$E = mc^2$$