

## Constants & Data

### Speed of light in vacuum

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

### Charge on an electron

$$e = 1.602 \times 10^{-19} \text{ C}$$

### Mass of an electron

$$m_e = 9.109 \times 10^{-31} \text{ kg}$$

### Mass of a proton

$$m_p = 1.673 \times 10^{-27} \text{ kg}$$

### Mass of a neutron

$$m_n = 1.675 \times 10^{-27} \text{ kg}$$

### Planck's constant

$$h = 6.626 \times 10^{-34} \text{ J s}$$

### Universal gravitational constant

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

### Acceleration due to gravity at Earth's surface

$$g = 9.8 \text{ m s}^{-2}$$

### Permeability of free space

$$\mu_0 = 4\pi \times 10^{-7} \text{ H m A}^{-2}$$

### Permittivity of free space

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ F m}^{-1} (\text{C}^2 \text{ N}^{-1} \text{ m}^{-2})$$

### Mass of Earth

$$M_E = 6.0 \times 10^{24} \text{ kg}$$

### Radius of Earth

$$R_E = 6.371 \times 10^6 \text{ m}$$

### Speed of sound in air

$$v_{\text{sound}} = 340 \text{ m s}^{-1}$$

### Wien's displacement constant

$$b = 2.898 \times 10^{-3} \text{ m K}$$

## Kinematics

### First kinematic equation (velocity–time)

$$v = u + at$$

### Second kinematic equation (displacement–time)

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

### 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

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

### 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

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

## 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

$$F_e = \frac{kq_1q_2}{r^2} = \frac{q_1q_2}{4\pi\epsilon_0r^2}$$

### 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

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

### Photon momentum

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

### Relativistic energy–momentum relation

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

