



PHYSICS
ATAR COURSE YEAR 12
FORMULAE AND DATA BOOKLET
2025

Note: the variable t refers to the 'time taken', sometimes referred to as the 'change in time' or Δt .

Gravity and motion

Average velocity

$$v_{av} = \frac{s}{t}$$

Equations of motion

$$v = u + at$$

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

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

$$p = mv$$

Force

$$F_{net} = ma$$

Weight force

$$F_{weight} = mg$$

Kinetic energy

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

Gravitational potential energy

$$E_p = mg\Delta h$$

Work done

$$W = Fs$$

$$W = \Delta E$$

Equations of circular motion

$$v = \frac{2\pi r}{T}$$

$$a_c = \frac{v^2}{r}$$

$$\text{resultant } F_c = ma_c = \frac{mv^2}{r}$$

Newton's law of universal gravitation

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

Kepler's 3rd law

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

Gravitational field strength

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

Moment of a force

$$\tau = rF \sin \theta$$

where θ = angle between the force F and the lever arm

Wave particle duality and the quantum theory

Wave period

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

Wave equation

$$c = f\lambda$$

Energy of photon

$$E = hf$$

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

Energy transitions

$$\Delta E = hf$$

$$\Delta E = E_2 - E_1$$

Photoelectric effect

$$E_k = hf - W$$

de Broglie wavelength

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

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Electromagnetism

Coulomb's law	$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$	
Electric field strength	$E = \frac{F}{q} = \frac{V}{d}$	
Magnetic flux density	$B = \frac{\mu_0}{2\pi} \frac{I}{r}$	
Magnetic force on a charged particle	$F = qvB\sin\theta$	where θ = angle between the field B and the velocity v
Magnetic force on a current-carrying conductor	$F = IlB\sin\theta$	where θ = angle between the field B and the conductor length ℓ
Particle motion in a magnetic field	$r = \frac{mv}{qB}$	
Torque on a coil	$\tau = rF\sin\theta$	where θ = angle between the force F and the lever arm
Magnetic flux	$\Phi = BA_{\perp}$	where A = area perpendicular to the field B
Electromagnetic induction	induced emf : $\varepsilon = \ell v B \sin\theta$	
	induced emf : $\varepsilon = -N \frac{(\Phi_2 - \Phi_1)}{t} = -N \frac{\Delta\Phi}{t} = -N \frac{\Delta(BA_{\perp})}{t}$	
	where A = area perpendicular to the field B	
	$\varepsilon_{\max} = 2N\ell v B = 2\pi N B A f$	$\varepsilon_{\text{rms}} = \frac{\varepsilon_{\max}}{\sqrt{2}}$
Ohm's law	$V = IR$	
Electric current	$I = \frac{q}{t}$	Work and energy $W = Vq$
Ideal transformer turns ratio	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	Power $P = VI = I^2R = \frac{V^2}{R}$

Special relativity

Relativistic effects

$$\ell = \ell_0 \sqrt{1 - \frac{v^2}{c^2}}$$

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

$$u = \frac{v + u'}{1 + \frac{vu'}{c^2}}$$

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}}$$

Relativistic momentum

$$p_v = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Hubble's law

$$v = H_0 d$$

Rest energy

$$E_{\text{rest}} = mc^2$$

Mass-energy equivalence

$$E_t = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Total energy

$$E_t = E_k + E_{\text{rest}}$$

The Standard Model

Elementary particles

Mass →	$\approx 2.3 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 173.07 \text{ GeV}/c^2$	0	$\approx 126 \text{ GeV}/c^2$
Charge →	$2/3$	$2/3$	$2/3$	0	0
Baryon number →	$1/3$	$1/3$	$1/3$		
	u	c	t	g	H
	up	charm	top	gluon	Higgs boson
Quarks	$\approx 4.8 \text{ MeV}/c^2$	$\approx 95 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
	$-1/3$	$-1/3$	$-1/3$	0	
	$1/3$	$1/3$	$1/3$		
	d	s	b	γ	
	down	strange	bottom	photon	
Mass →	$0.511 \text{ MeV}/c^2$	$105.7 \text{ MeV}/c^2$	$1.777 \text{ GeV}/c^2$	$91.2 \text{ GeV}/c^2$	
Charge →	-1	-1	-1	0	
Lepton number →	+1	+1	+1		
	e	μ	τ	Z	
	electron	muon	tau	Z boson	
Leptons	$<2.2 \text{ eV}/c^2$	$<0.17 \text{ MeV}/c^2$	$<15.5 \text{ MeV}/c^2$	$80.4 \text{ GeV}/c^2$	
	0	0	0	± 1	
	+1	+1	+1		
	ν_e	ν_μ	ν_τ	W	
	electron neutrino	muon neutrino	tau neutrino	W boson	

Electromagnetic spectrum

$\lambda(\text{m})$	Wavelength												
	10^2	10	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}
Area of spectrum	radio frequencies			microwaves		infrared radiation			ultraviolet radiation		X-rays		
$f(\text{Hz})$	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}	10^{13}	10^{14}	10^{15}	10^{16}	10^{17}	10^{18}
	Frequency												

Note: shaded areas represent regions of overlap.

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Physical data

Mean acceleration due to gravity on the Earth.. g	=	9.80 m s^{-2}
Mean acceleration due to gravity on the Moon.. g_M	=	1.62 m s^{-2}
Mean radius of the Earth R_E	=	$6.37 \times 10^6 \text{ m}$
Mass of the Earth M_E	=	$5.97 \times 10^{24} \text{ kg}$
Mean radius of the Sun R_S	=	$6.96 \times 10^8 \text{ m}$
Mass of the Sun..... M_S	=	$1.99 \times 10^{30} \text{ kg}$
Mean radius of the Moon..... R_M	=	$1.74 \times 10^6 \text{ m}$
Mass of the Moon M_M	=	$7.35 \times 10^{22} \text{ kg}$
Mean Earth-Moon distance	=	$3.84 \times 10^8 \text{ m}$
Mean Earth-Sun distance	=	$1.50 \times 10^{11} \text{ m}$
.....	=	1.00 astronomical unit (AU)
Mass of electron m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Mass of proton..... m_p	=	$1.67 \times 10^{-27} \text{ kg}$
Tonne.....1.00 t	=	10^3 kg

Physical constants

Speed of light in vacuum or air..... c	=	$3.00 \times 10^8 \text{ m s}^{-1}$
Electron charge e	=	$-1.60 \times 10^{-19} \text{ C}$
Planck constant h	=	$6.63 \times 10^{-34} \text{ J s}$
Newtonian constant of gravitation G	=	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Electric constant ϵ_0	=	$8.85 \times 10^{-12} \text{ F m}^{-1}$
Magnetic constant μ_0	=	$4\pi \times 10^{-7} \text{ N A}^{-2} = 1.26 \times 10^{-6} \text{ N A}^{-2}$

Conversions

Electron volt.....1.00 eV	=	$1.60 \times 10^{-19} \text{ J}$
Light year.....1.00 ly	=	$9.46 \times 10^{12} \text{ km}$
Megaparsec.....1.00 Mpc	=	$3.09 \times 10^{19} \text{ km} = 3.26 \times 10^6 \text{ ly}$

Prefixes of the metric system

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-3}	milli	m
10^9	giga	G	10^{-6}	micro	μ
10^6	mega	M	10^{-9}	nano	n
10^3	kilo	k	10^{-12}	pico	p

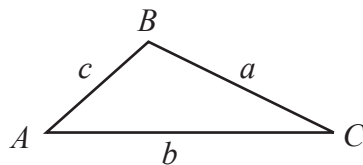
Mathematical expressions

Quadratic equations

Given $ax^2 + bx + c = 0$, $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Triangles

The following expressions apply to the triangle ABC as shown:



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a = \sqrt{b^2 + c^2 - 2bc \cos A}$$

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Elementary particles

Adapted from Standard Model image: MissMJ. (2006). *File:Standard Model of Elementary Particles.svg*. Retrieved June, 2016, from https://commons.wikimedia.org/wiki/File:Standard_Model_of_Elementary_Particles.svg
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