



PHYSICS

ATAR COURSE YEAR 12

FORMULAE AND DATA BOOKLET

2017

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This document is valid for teaching and examining until 31 December 2017.

Gravity and motion

Average velocity	$v_{av} = \frac{s}{t}$		
Equations of motion	$v = u + at$	$s = ut + \frac{1}{2} at^2$	$v^2 = u^2 + 2as$
Force	$F_{net} = ma$		
Weight force	$F = mg$		
Kinetic energy	$E_k = \frac{1}{2} mv^2$		
Gravitational potential energy	$E_p = m g \Delta h$		
Work done	$W = Fs = \Delta E$		
Equations of circular motion	$v = \frac{2\pi r}{T}$	$a_c = \frac{v^2}{r}$	$F_c = ma_c = \frac{mv^2}{r}$
Newton's law of universal gravitation	$F = G \frac{m_1 m_2}{r^2}$		
Kepler's 3rd law	$T^2 = \frac{4\pi^2}{GM} r^3$		
Gravitational field strength	$g = G \frac{M}{r^2}$		
Moment of a force (force at angle θ to lever arm)	$\tau = r F \sin\theta$		

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

Wave particle duality and the quantum theory

Wave period	$T = \frac{1}{f}$
Wave equation	$c = f\lambda$
Energy of photon	$E = hf$
Energy transitions	$\Delta E = E_2 - E_1 = hf$
Photoelectric effect	$E_k = hf - W$
De Broglie wavelength	$\lambda = \frac{h}{p}$

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 field strength	$B = \frac{\mu_0}{2\pi} \frac{I}{r}$		
Magnetic force on a charged particle	$F = q v B$ where $v \perp B$		
Magnetic force on a current-carrying conductor	$F = I \ell B$ where $\ell \perp B$		
Particle motion in a magnetic field	$r = \frac{m v}{q B}$		
Torque on a coil	$\tau = r F$		
Magnetic flux	$\Phi = B A_{\perp}$		
Electromagnetic induction	induced emf = $\ell v B$ where $v \perp B$		
	induced emf = $-N \frac{(\Phi_2 - \Phi_1)}{t} = -N \frac{\Delta\Phi}{t} = -N \frac{\Delta(B A_{\perp})}{t}$		
	AC generator emf _{max} = $2N\ell v B = 2\pi N B A_{\perp} f$		$emf_{rms} = \frac{emf_{max}}{\sqrt{2}}$
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	$P = VI$

Special relativity

Relativistic effects	$\ell = \ell_0 \sqrt{\left(1 - \frac{v^2}{c^2}\right)}$	$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$
	$u = \frac{v + u'}{1 + \frac{v u'}{c^2}}$	$u' = \frac{u - v}{1 - \frac{v u}{c^2}}$
Relativistic momentum	$p_v = \frac{m v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$	
Mass-energy equivalence	$E = \frac{m c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$	

The Standard Model

Elementary particles

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

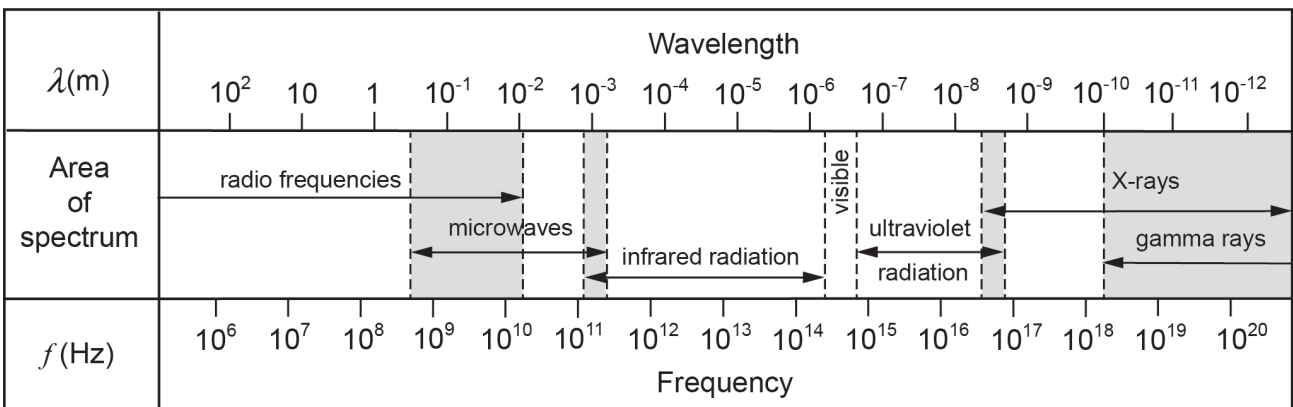
Physical data

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.....	=	$1.50 \times 10^{11} \text{ m}$
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 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	=	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Electron volt..... 1 eV	=	$1.60 \times 10^{-19} \text{ J}$
Electronic constant..... ϵ_0	=	$8.85 \times 10^{-12} \text{ F m}^{-1}$
Magnetic constant..... μ_0	=	$4\pi \times 10^{-7} \text{ N A}^{-2} = 1.26 \times 10^{-6} \text{ N A}^{-2}$

Electromagnetic spectrum



Note: shaded areas represent regions of overlap.

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

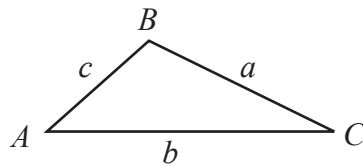
Mathematical expressions

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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ACKNOWLEDGEMENTS

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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