Government of **Western Australia**
School Curriculum and Standards Authority

PHYSICS
ATAR COURSE YEAR 12

FORMULAE AND DATA BOOKLET

2023

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	$v = \frac{2\pi r}{T}$	$a_c = \frac{v^2}{r}$	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	$\lambda = \frac{h}{p}$	

See next page

Electromagnetism

Coulomb's law $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

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 $F = I\ell B\sin\theta$ 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 : $\varepsilon = \ell v B\sin\theta$

where θ = angle between the field B and the conductor length ℓ

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

$\varepsilon_{max} = 2N\ell vB = 2\pi NBAf$ $\varepsilon_{rms} = \frac{\varepsilon_{max}}{\sqrt{2}}$

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

See next page

Special relativity

Relativistic effects

$$\ell = \ell_0\sqrt{(1-\frac{v^2}{c^2})} \qquad t = \frac{t_0}{\sqrt{(1-\frac{v^2}{c^2})}}$$

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

Relativistic momentum

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

Hubble's law $v = H_0 d$

Rest energy $E_{rest} = mc^2$

Mass-energy equivalence

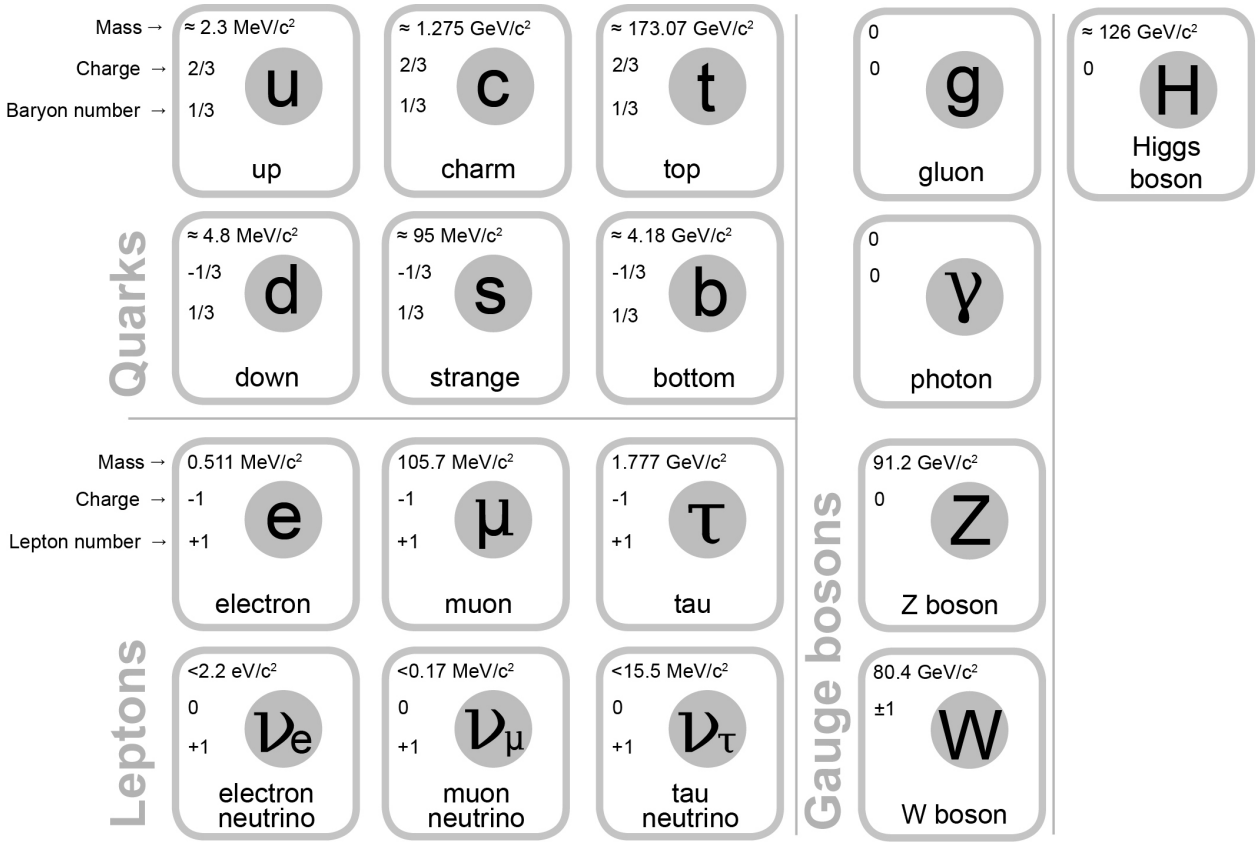
$$E_t = \frac{mc^2}{\sqrt{(1-\frac{v^2}{c^2})}}$$

Total energy $E_t = E_k + E_{rest}$

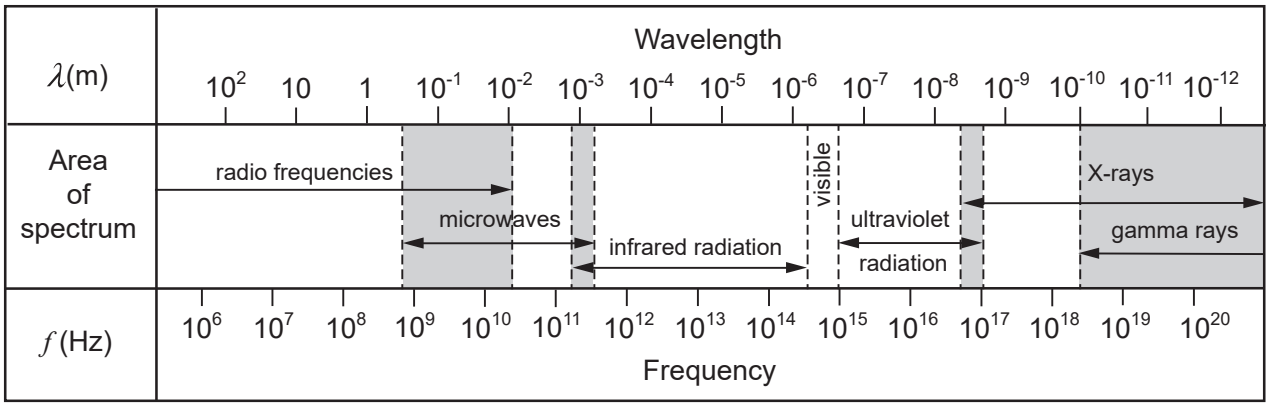
See next page

The Standard Model

Elementary particles



Electromagnetic spectrum



Note: shaded areas represent regions of overlap.

See next page

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 × 10^6 m
Mass of the Earth	M_E	=	5.97 × 10^{24} kg
Mean radius of the Sun	R_S	=	6.96 × 10^8 m
Mass of the Sun	M_S	=	1.99 × 10^{30} kg
Mean radius of the Moon	R_M	=	1.74 × 10^6 m
Mass of the Moon	M_M	=	7.35 × 10^{22} kg
Mean Earth-Moon distance		=	3.84 × 10^8 m
Mean Earth-Sun distance		=	1.50 × 10^{11} m
		=	1.00 astronomical unit (AU)
Mass (at rest) of electron	m_e	=	9.11 × 10^{-31} kg
Mass (at rest) of proton	m_p	=	1.67 × 10^{-27} kg
Tonne	1.00 t	=	10^3 kg

Physical constants

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

Conversions

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

See next page

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

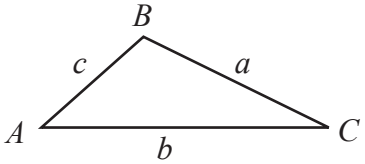
Mathematical expressions

Quadratic equations

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

Triangles

The following expressions apply to the triangle ABC as shown:



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

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

End of booklet

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
Used under Creative Commons Attribution 3.0 Unported licence.

This document is valid for teaching and examining until 31 December 2023.

Published by the School Curriculum and Standards Authority of Western Australia
303 Sevenoaks Street
CANNINGTON WA 6107