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

PHYSICS
ATAR COURSE YEAR 12

FORMULAE AND DATA BOOKLET

2022

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 (force at angle θ to lever arm)	$\tau = rF\sin\theta$			

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	$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$
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	$F = qvB$ 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	$r = \frac{mv}{qB}$
Torque on a coil	$\tau = r_\perp F$
Magnetic flux	$\Phi = BA_\perp$
Electromagnetic induction	induced emf : $\varepsilon = \ell v B$ where $v \perp B$
	induced emf : $\varepsilon = -N\frac{(\Phi_2 - \Phi_1)}{t} = -N\frac{\Delta\Phi}{t} = -N\frac{\Delta(BA_\perp)}{t}$
	AC generator $\text{emf}_{\max}$: $\varepsilon_{\max} = 2N\ell v B = 2\pi N B A_\perp f$ $\quad \varepsilon_{\text{rms}} = \frac{\varepsilon_{\max}}{\sqrt{2}}$
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	$P = VI$

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

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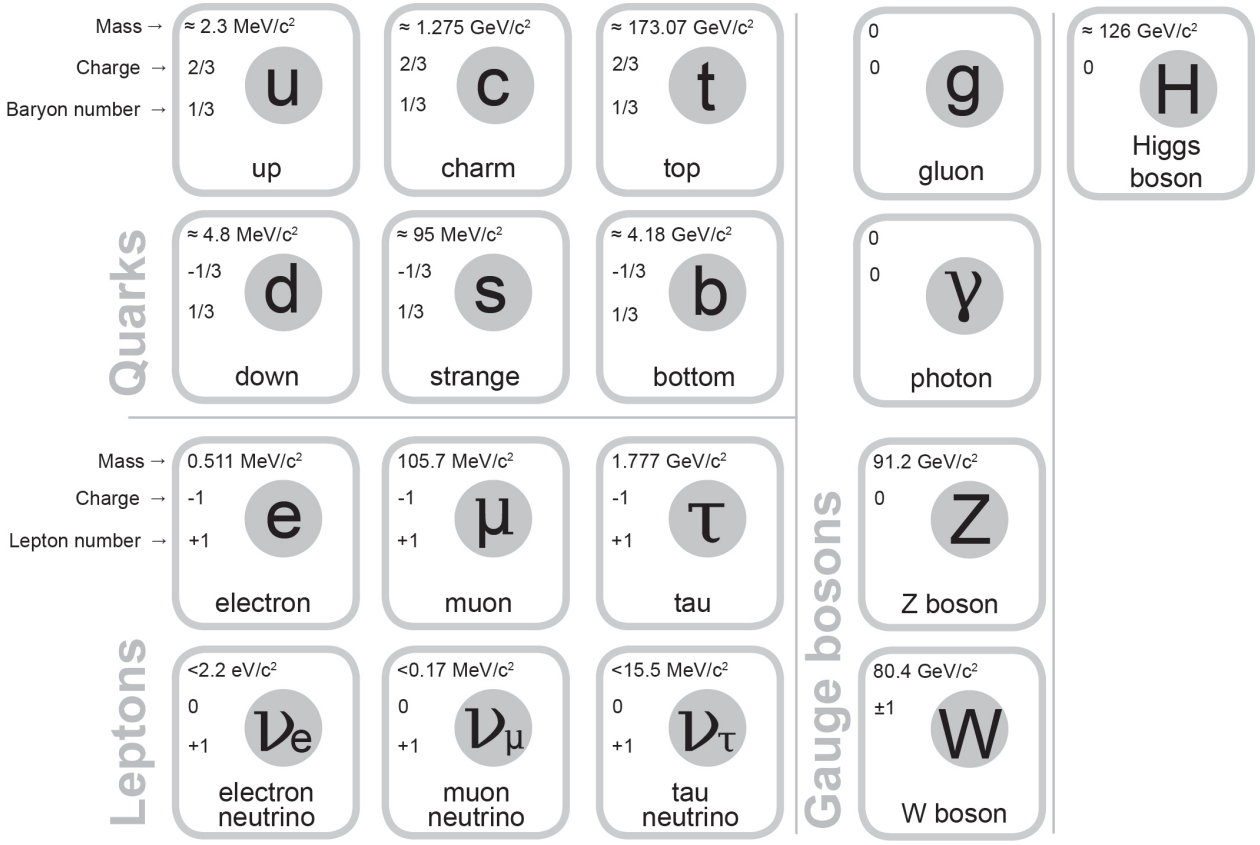
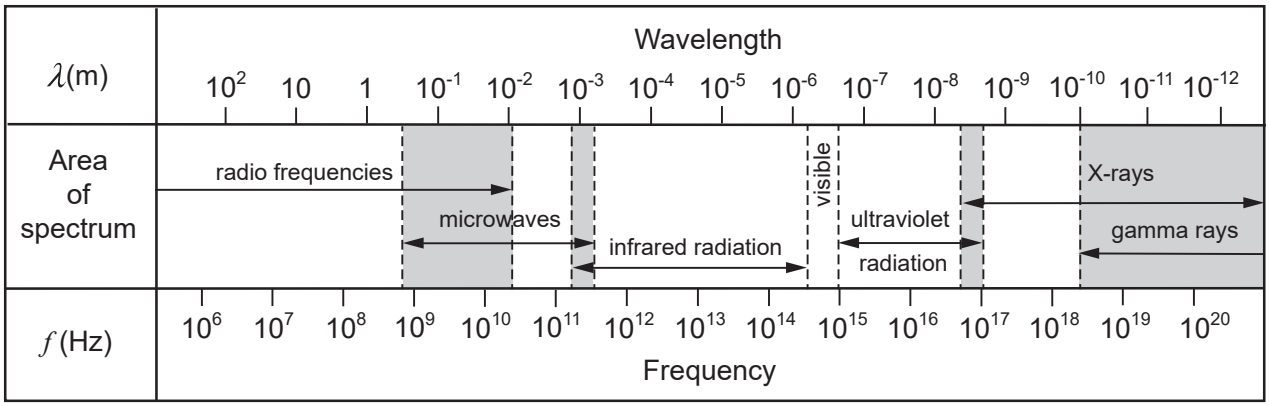
The Standard Model

Elementary particles



Electromagnetic spectrum



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	=	6.37×10^6 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
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 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	=	$4\pi \times 10^{-7}$ N A^{-2} = 1.26×10^{-6} N A^{-2}

Conversions

Electron volt	1 eV	=	1.60×10^{-19} J
Light year	ly	=	9.46×10^{12} km
Megaparsec	Mpc	=	3.09×10^{19} km = 3.26×10^6 ly

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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

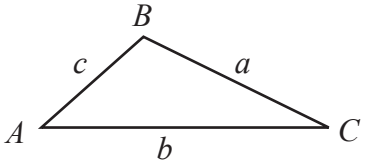
Mathematical expressions

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

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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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