2021

CfE Higher Physics Compendium

NAME: _____

CLASS: _____

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Much of this material is taken from the SQA Higher Physics Course Specifications

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	Symbol	Value	Quantity	Symbol	Value
Speed of light in vacuum	c	$3.00 \times 10^8 \text{ m s}^{-1}$	Planck's constant	h	$6.63 \times 10^{-34} \text{ J s}$
Magnitude of the charge on an electron	e	$1.60 \times 10^{-19} \text{ C}$	Mass of electron	m_e	$9.11 \times 10^{-31} \text{ kg}$
Universal Constant of Gravitation	G	$6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$	Mass of neutron	m_n	$1.675 \times 10^{-27} \text{ kg}$
Gravitational acceleration on Earth	g	9.8 m s^{-2}	Mass of proton	m_p	$1.673 \times 10^{-27} \text{ kg}$
Hubble's constant	H_0	$2.3 \times 10^{-18} \text{ s}^{-1}$			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	Refractive index	Substance	Refractive index
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

SPECTRAL LINES

Element	Wavelength/nm	Colour	Element	Wavelength/nm	Colour
Hydrogen	656	Red	Cadmium	644	Red
	486	Blue-green		509	Green
	434	Blue-violet		480	Blue
	410	Violet			
	397	Ultraviolet		Lasers	
	389	Ultraviolet	Element	Wavelength/nm	Colour
			Carbon dioxide	9550 } 10590 }	Infrared
Sodium	589	Yellow	Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

Substance	Density/kg m^{-3}	Melting Point/K	Boiling Point/K
Aluminium	2.70×10^3	933	2623
Copper	8.96×10^3	1357	2853
Ice	9.20×10^2	273	. . . .
Sea Water	1.02×10^3	264	377
Water	1.00×10^3	273	373
Air	1·29	. . . .	. . . .
Hydrogen	9.0×10^{-2}	14	20

The gas densities refer to a temperature of 273 K and a pressure of 1.01×10^5 Pa.

RELATIONSHIPS REQUIRED FOR HIGHER PHYSICS

$$d = \bar{v}t$$

$$s = \bar{v}t$$

$$v = u + at$$

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

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

$$s = \frac{1}{2}(v + u)t$$

$$F = ma$$

$$W = mg$$

$$E_w = Fd, \text{ or } W = Fd$$

$$E_p = mgh$$

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

$$P = \frac{E}{t}$$

$$p = mv$$

$$Ft = mv - mu$$

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

$$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$l' = l\sqrt{1 - \left(\frac{v}{c}\right)^2}$$

$$f_o = f_s\left(\frac{v}{v \pm v_s}\right)$$

$$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$$

$$z = \frac{v}{c}$$

$$v = H_o d$$

$$W = QV$$

$$E = mc^2$$

$$I = \frac{P}{A}$$

$$I = \frac{k}{d^2}$$

$$I_1 d_1^2 = I_2 d_2^2$$

$$E = hf$$

$$E_k = hf - hf_o$$

$$v = f\lambda$$

$$E_2 - E_1 = hf$$

$$d\sin\theta = m\lambda$$

$$n = \frac{\sin\theta_1}{\sin\theta_2}$$

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$$

$$\sin\theta_c = \frac{1}{n}$$

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$$

$$I_{rms} = \frac{I_{peak}}{\sqrt{2}}$$

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

$$V = IR$$

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

$$R_T = R_1 + R_2 + \cdots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

$$V_1 = \left(\frac{R_1}{R_1 + R_2}\right)V_s$$

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$E = V + Ir$$

$$C = \frac{Q}{V}$$

$$Q = It$$

$$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$Path\ difference = m\lambda \text{ or } \left(m + \frac{1}{2}\right)\lambda, where\ m = 0,1,2\ldots$$

$$Random\ Uncertainty = \frac{max\ value - \min value}{number\ of\ values}$$

$$or\ \Delta R = \frac{R_{max} - R_{min}}{n}$$

ANNOTATED RELATIONSHIPS SHEET FOR HIGHER PHYSICS

$$d = \bar{v}t$$

distance (m) = average speed $\left(ms^{-1}\right) \times$ time (s)

$$s = \bar{v}t$$

displacement (m) = average velocity $\left(ms^{-1}\right) \times$ time (s)

$$v = u + at$$

final velocity $\left(ms^{-1}\right)$ = initial velocity $\left(ms^{-1}\right)$ + acceleration $\left(ms^{-2}\right) \times$ time (s)

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

displacement = initial velocity $\times$ time $+ \dfrac{1}{2} \times$ acceleration $\left(ms^{-2}\right) \times time^2 (s^2)$

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

final velocity $^2 \left(ms^{-1}\right)^2$ = initial velocity $^2 \left(ms^{-1}\right)^2 + 2 \times$ acceleration $\left(ms^{-2}\right) \times$ dispacement (m)

$$s = \frac{1}{2}(v + u)t$$

displacement (m) $= \dfrac{1}{2} \times \left(final\ velocity\ (ms^{-1}) + initial\ velocity\ (ms^{-1})\right) \times$ time (s)

$$F = ma$$

force (N) = mass (kg) $\times$ acceleration (ms^{-2})

$$W = mg$$

weight (N) = mass (kg) $\times$ gravitational field strength $(N\ kg^{-1})$

$$E_w = Fd$$

work done (J) = force (N) $\times$ distance (m)

$$E_p = mgh$$

gravitational potential energy (J) = mass (kg) $\times$ gravitational field strength $\left(N\ kg^{-1}\right) \times$ vertical height (m)

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

kinetic energy (J) $= \dfrac{1}{2} \times$ mass (kg) $\times speed^2 (ms^{-1})^2$

$$P = \frac{E}{t}$$

power (W) $= \dfrac{energy\ (J)}{time\ (s)}$

$$p = mv$$

$$momentum \ (kgms^{-1}) = mass(kg) \times velocity \ (ms^{-1})$$

$$Ft = mv - mu$$

$$Impulse \ (Ns) = mass \ (kg) \times final \ velocity \ (ms^{-1}) - mass \ (kg) \times initial \ velocity \ (ms^{-1})$$

$$Impulse \ (Ns) = change \ in \ momentum \ (kg \ ms^{-1})$$

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

$$Force \ (N) = Universal \ gravitational \ Constant \ (m^3 kg^{-1}s^{-2}) \frac{Mass_1(kg) \times Mass_2(kg)}{separation \ distance^2 \ (m^2)}$$

NB The Universal Gravitational Constant $= 6.67 \times 10^{-11} \ m^3 kg^{-1}s^{-2}$

$$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$relativistic \ time \ (s) = \frac{time \ (s)}{\sqrt{1 - \left(\frac{speed \ (ms^{-1})}{speed \ of \ light \ in \ vacuum \ (ms^{-1})}\right)^2}}$$

NB time can be in other units as this is a ratio, but both times must be in the same unit.

c = 3.0 × 10⁸ ms⁻¹

$$l' = l \sqrt{1 - \left(\frac{v}{c}\right)^2}$$

$$relativistic \ length \ (m) = length \ (m) \times \sqrt{1 - \left(\frac{speed \ (ms^{-1})}{speed \ of \ light \ in \ vacuum \ (ms^{-1})}\right)^2}$$

c = 3.0 × 10⁸ ms⁻¹

$$f_o = f_s \left(\frac{v}{v \pm v_s}\right)$$

$$\begin{matrix} frequency \ observed \\ (Hz) \end{matrix} = \begin{matrix} frequency \ of \ source \\ (Hz) \end{matrix} \times \left(\frac{speed \ of \ sound \ (ms^{-1})}{\begin{matrix} speed \ of \ sound \pm velocity \ of \ source \\ (ms^{-1}) \qquad \qquad (ms^{-1}) \end{matrix}} \right)$$

ADD when the object moves **A**WAY from the observer and

TAKE AWAY (subtract) when the object comes **T**OWARDS the observer

$$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$$

$$Redshift \ (no \ unit) = \frac{observed \ wavelength \ (m) - rest \ wavelength \ (m)}{rest \ wavelength \ (m)}$$

$$z = \frac{v}{c}$$

$$Redshift\ (no\ unit) = \frac{recessional\ velocity\ (ms^{-1})}{speed\ of\ light\ in\ vacuum\ (ms^{-1})}$$

$$v = H_o d$$

$$\begin{matrix} recessional\ velocity \\ (ms^{-1}) \end{matrix} = \begin{matrix} Hubble's\ Constant \\ (s^{-1}) \end{matrix} \times \begin{matrix} distance\ from\ galaxy\ to\ observer \\ (m) \end{matrix}$$

NB for this course the Hubble Constant Ho is given as 2·3 x 10⁻¹⁸ s⁻¹

$$W = QV$$

Work done moving a charge across a p.d. (J) = electrical charge (C) × voltage (V)

$$E = mc^2$$

Energy (J) = mass (kg) × speed of light squared (ms⁻¹)²

NB the speed of light squared is equal to $9.0 \times 10^{16}\ m^2s^{-2}$

$$I = \frac{P}{A}$$

$$irradiance\ (Wm^{-2}) = \frac{power\ (W)}{area\ (m^2)}$$

$$I = \frac{k}{d^2}$$

$$irradiance\ (Wm^{-2}) = \frac{constant\ (W)}{distance^2\ (m^2)}$$

This is more easily understood as

$$irradiance\ (Wm^{-2}) \times distance^2\ (m^2) = constant\ value\ (W)$$

$$I_1 d_1^2 = I_2 d_2^2$$

$$irradiance_1\ (Wm^{-2}) \times initial\ distance\ ^2(m^2) = Irradiance_2\ (Wm^{-2}) \times final\ distance\ ^2(m^2)$$

$$E = hf$$

energy (J) = Planck's Constant (Js) × frequency (Hz)

NB Planck's constant = 6.63 x 10⁻³⁴ Js

$$E_k = hf - hf_o$$

$$\begin{matrix} Kinetic\ Energy \\ (J) \end{matrix} = \begin{pmatrix} Planck's\ Constant \\ (Js) \end{pmatrix} \times \begin{pmatrix} incident\ frequency \\ (Hz) \end{pmatrix} - \begin{pmatrix} Planck's\ Constant \\ (Js) \end{pmatrix} \times \begin{pmatrix} threshold\ frequency \\ (Hz) \end{pmatrix}$$

NB Planck's constant = 6.63 x 10⁻³⁴ Js

hf_o is also known as the work function (J), hf is the energy of the incident photon (J)

$$v = f\lambda$$

speed (ms⁻¹) = frequency (Hz) × wavelength (m)

$$E_2 - E_1 = hf$$

most excited energy(J) − least excited energy (J) = Planck's Constant (Js) × frequency (Hz)

$$d \sin \theta = m\lambda$$

Slit separation (m) × sin of angle from centre to the spot
= m a whole number of wavelengths (m)

NB This equation is for constructive interference

$$n = \frac{\sin \theta_1}{\sin \theta_2}$$

Refractive index $= \dfrac{\text{sine of the angle in vacuum/air}}{\text{sine of the angle in the material}}$

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$$

Refractive index $= \dfrac{\text{sin of the angle in vacuum/air}}{\text{sin of the angle in the material}} = \dfrac{\text{wavelength (air)(m)}}{\text{wavelength (material)(m)}}$

$= \dfrac{\text{speed (air) } (ms^{-1})}{\text{speed (material)}(ms^{-1})}$

refractive index = ratio of wavelengths in vacuum/air and material

refractive index = ratio of the speeds in $\dfrac{vacuum}{air}$ *and the material*

This formula really applies to material 1 being a vacuum, but there is not much difference between the refractive indexes of air and a vacuum ∴ we assume for Higher they have the same value.

$$\sin \theta_c = \frac{1}{n}$$

Sine of the critical angle $= \dfrac{1}{\text{refractive index}}$

The critical angle is the angle in the material when the angle in air is 90°

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$$

root mean square A.C. voltage (V) $= \dfrac{\text{peak voltage (V)}}{1.414}$

$$l_{rms} = \frac{I_{peak}}{\sqrt{2}}$$

root mean square A.C. current (A) $= \dfrac{\text{peak current (A)}}{1.414}$

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

Period (s) $= \dfrac{1}{\text{Frequency (Hz)}}$

$$V = IR$$

Voltage(V) = Current (A) × Resistance(Ω)

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

Power (W) = current (A) × voltage(V) = current$^2(A^2)$ × Resistance (Ω) $= \dfrac{\text{Voltage}^2 (V^2)}{\text{Resistance (Ω)}}$

For resistors in series

$$R_T = R_1 + R_2 + \cdots$$

total resistance (Ω) = resistance $_1$(Ω) + resistance $_2$(Ω) + ⋯

For resistors in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

$$\frac{1}{\textit{total resistance }(\Omega)} = \frac{1}{\textit{resistance }_1(\Omega)} + \frac{1}{\textit{resistance }_2(\Omega)} + \cdots$$

$$V_1 = \left(\frac{R_1}{R_1 + R_2}\right) V_s$$

$$\textit{voltage across component 1 in potential divider}(V) = \left(\frac{\textit{resistance}_1\ (\Omega)}{\textit{total resistance}(\Omega)}\right) \times \textit{supply voltage }(V)$$

For resistances in series (potential divider circuits)

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

Ratio of the voltages in series = ratio of the resistance in series

$$\frac{\textit{Voltage across resistor}1\ (V)}{\textit{voltage across resistor 2 }(V)} = \frac{\textit{resistance of resistor}1\ (\Omega)}{\textit{resistance of resistor 2 }(\Omega)}$$

$$E = V + Ir$$

$$\textit{e.m.f }(V) = \textit{terminial potential difference }(V) + \textit{current }(A) \times \textit{internal resistance }(\Omega)$$

This can also be written as

$$E = I(R + r) \quad or \quad E = IR + Ir$$

I is the total current in the circuit, r is in series with the combined circuit resistance

$$C = \frac{Q}{V}$$

$$\textit{Capacitance }(F) = \frac{\textit{Charge }(C)}{\textit{Voltage }(V)}$$

$$Q = It$$

$$\textit{Charge }(C) = \textit{current }(A) \times \textit{time }(s)$$

$$\textit{This is better explained as current is the rate of flow of charge }\left(I = \frac{Q}{t}\right)$$

$$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$\begin{matrix}\textit{Energy stored in capacitor} \\ (J)\end{matrix} = \frac{1}{2} \times \begin{matrix}\textit{charge stored in capacitor} \\ (C)\end{matrix} \times \begin{matrix}\textit{voltage across capacitor} \\ (V)\end{matrix}$$

$$\begin{matrix}\textit{Energy stored in capacitor} \\ (J)\end{matrix} = \frac{1}{2} \times \begin{matrix}\textit{capacitance} \\ (F)\end{matrix} \times \begin{matrix}\textit{voltage across capacitor}^2 \\ (V)^2\end{matrix}$$

$$\begin{matrix}\textit{Energy stored in capacitor} \\ (J)\end{matrix} = \frac{1}{2} \times \frac{(\textit{charge stored in capacitor})^2\ (C^2)}{\textit{voltage across capacitor}(V)}$$

$$\textit{Path difference} = m\lambda \ or\ \left(m + \frac{1}{2}\right)\lambda, \textit{where } m = 0, 1, 2 \ldots$$

$$\begin{matrix}\textit{Path difference} \\ (m)\end{matrix} = \begin{matrix}\textit{whole number of wavelengths} \\ (\textit{constructive interference})\end{matrix}$$

$$\begin{matrix}\textit{path difference} \\ (m)\end{matrix} = \begin{matrix}\textit{whole number of wavelengths} + \frac{1}{2} \textit{ a wavelength} \\ (\textit{destructive interference})\end{matrix}$$

$$Random\ Uncertainty = \frac{Max\ value - \min value}{number\ of\ values}$$

$$or\ \Delta R = \frac{R_{max} - R_{min}}{n}$$

NB for the random uncertainty in a value the units of the random uncertainty are the same as for the quantity you are finding the uncertainty for.

$$Random\ Uncertainty(units\ of\ the\ quantity) = \frac{Max\ value - \min value}{number\ of\ values}$$

QUANTITY SYMBOL UNIT AND UNIT SYMBOL

Physical Quantity	Symbol	Unit	Unit Abb.
acceleration	a	metre per second per second	m s^{-2}
acceleration due to gravity	g	metre per second per second	m s^{-2}
amplitude	A	metre	m
angle	θ	degree	°
area	A	square metre	m^2
average speed	$\bar{v}$	metres per second	m s^{-1}
average velocity	$\bar{v}$	metres per second	m s^{-1}
capacitance	C	farad	F
change of speed	Δv	metre per second	m s^{-1}
change of velocity	Δv	metre per second	m s^{-1}
critical angle	θc	degree	°
current	I	ampere	A
displacement	s	metre	m
distance	D	metre, light year	m , ly
distance, depth, height	$d\ or\ h$	metre	m
electric charge	Q	coulomb	C
electric charge	$Q\ or\ q$	coulomb	C
electric current	I	ampere	A
electric field strength	E	newton per coulomb volts per metre	N C^{-1} Vm^{-1}
electromotive force (e.m.f)	$E\ or\ \varepsilon$	volt	V
energy	E	joule	J
energy level	E_1, E_2	joule	J
final velocity	v	metre per second	m s^{-1}
force	F	newton	N
force, tension, upthrust, thrust	F	newton	N
frequency	f	hertz	Hz
frequency of source	f_s	hertz	Hz
fringe separation	Δx	metre	m

Physical Quantity	Symbol	Unit	Unit Abb.
grating to screen distance	D	metre	m
gravitational field strength	g	newton per kilogram	N kg^{-1}
gravitational potential energy	E_p	joule	J
heat energy	E_h	joule	J
height, depth	h	metre	m
impulse	Ft	newton second kilogram metre per second	Ns kgm s^{-1}
initial speed	u	metre per second	ms^{-1}
initial velocity	u	metre per second	m s^{-1}
internal resistance	r	ohm	Ω
irradiance	I	watt per square metre	W m^{-1}
kinetic energy	Ek	joule	J
length	l	metre	m
mass	m	kilogram	kg
momentum	p	kilogram metre per second	kg m s^{-1}
number of photons per second per cross sectional area	N	-	-
observed wavelength	$\lambda_{observed}$	metre	m
peak current	I_{peak}	ampere	A
peak voltage	V_{peak}	volt	V
period	T	second	s
Planck's constant	h	joule second	Js
potential difference	V	volt	V
potential energy	E_p	joule	J
power	P	watt	W
pressure	$P\ or\ p$	pascal	Pa
radius	r	metre	m
Redshift	Z	-	-
refractive index	n	-	-
relativistic length	l'	metre	m
relativistic time	t'	second	s
resistance	R	ohm	Ω
rest wavelength	λ_{rest}	metre	m
root mean square current	I_{rms}	ampere	A
root mean square voltage	V_{rms}	volt	V
slit separation	d	metre	m
specific heat capacity	c	joule per kilogram per kelvin	Jkg^{-1}K^{-1}
specific latent heat	l	joule per kilogram	Jkg^{-1}
speed of light in a vacuum	c	metre per second	m s^{-1}
speed, final speed	v	metre per second	ms^{-1}
speed, velocity, final velocity	v	metre per second	m s^{-1}

Physical Quantity	Symbol	Unit	Unit Abb.
supply voltage	V_s	volt	V
temperature	T	degree Celsius	°C
temperature	T	kelvin	K
threshold frequency	f_o	hertz	Hz
time	t	second	s
total resistance	R_t	ohm	Ω
velocity of observer	v_o	metre per second	m s^{-1}
velocity of source	v_s	metre per second	m s^{-1}
voltage	V	volt	V
voltage, potential difference	V	volt	V
volume	V	cubic metre	m^3
Wavelength	λ	metre	m
weight	W	newton	N

GREEK ALPHABET

Upper Case A Alpha Lower Case α	Upper Case B Beta Lower Case β	Upper Case Γ Gamma Lower Case γ	Upper Case Δ Delta Lower Case δ
Upper Case E Epsilon Lower Case ε	Upper Case Z Zeta Lower Case ζ	Upper Case H Eta Lower Case η	Upper Case Θ Theta Lower Case θ
Upper Case I Iota Lower Case ι	Upper Case K Kappa Lower Case κ	Upper Case Λ Lambda Lower Case λ	Upper Case M Mu Lower Case μ
Upper Case N Nu Lower Case ν	Upper Case Ξ Xi Lower Case ξ	Upper Case O Omicron Lower Case o	Upper Case Π Pi Lower Case π
Upper Case P Rho Lower Case ρ	Upper Case Σ Sigma Lower Case σ	Upper Case T Tau Lower Case τ	Upper Case Υ Upsilon Lower Case υ
Upper Case Φ Phi Lower Case φ	Upper Case X Chi Lower Case χ	Upper Case Ψ Psi Lower Case ψ	Upper Case Ω Omega Lower Case ω

PERIODIC TABLE

Electron Arrangements of Elements

Key

Atomic number
Symbol
Electron arrangement
Name

Transition Elements

Group 1 (1)	Group 2 (2)
1 H Hydrogen	
3 Li 2,1 Lithium	4 Be 2,2 Beryllium
11 Na 2,8,1 Sodium	12 Mg 2,8,2 Magnesium
19 K 2,8,8,1 Potassium	20 Ca 2,8,8,2 Calcium
37 Rb 2,8,18,8,1 Rubidium	38 Sr 2,8,18,8,2 Strontium
55 Cs 2,8,18,18,8,1 Caesium	56 Ba 2,8,18,18,8,2 Barium
87 Fr 2,8,18,32,18,8,1 Francium	88 Ra 2,8,18,32,18,8,2 Radium

(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
21 Sc 2,8,9,2 Scandium	22 Ti 2,8,10,2 Titanium	23 V 2,8,11,2 Vanadium	24 Cr 2,8,13,1 Chromium	25 Mn 2,8,13,2 Manganese	26 Fe 2,8,14,2 Iron	27 Co 2,8,15,2 Cobalt	28 Ni 2,8,16,2 Nickel	29 Cu 2,8,18,1 Copper	30 Zn 2,8,18,2 Zinc
39 Y 2,8,18,9,2 Yttrium	40 Zr 2,8,18,10,2 Zirconium	41 Nb 2,8,18,12,1 Niobium	42 Mo 2,8,18,13,1 Molybdenum	43 Tc 2,8,18,13,2 Technetium	44 Ru 2,8,18,15,1 Ruthenium	45 Rh 2,8,18,16,1 Rhodium	46 Pd 2,8,18,18,0 Palladium	47 Ag 2,8,18,18,1 Silver	48 Cd 2,8,18,18,2 Cadmium
57 La 2,8,18,18,9,2 Lanthanum	72 Hf 2,8,18,32,10,2 Hafnium	73 Ta 2,8,18,32,11,2 Tantalum	74 W 2,8,18,32,12,2 Tungsten	75 Re 2,8,18,32,13,2 Rhenium	76 Os 2,8,18,32,14,2 Osmium	77 Ir 2,8,18,32,15,2 Iridium	78 Pt 2,8,18,32,17,1 Platinum	79 Au 2,8,18,32,18,1 Gold	80 Hg 2,8,18,32,18,2 Mercury
89 Ac 2,8,18,32,18,9,2 Actinium	104 Rf 2,8,18,32,32,10,2 Rutherfordium	105 Db 2,8,18,32,32,11,2 Dubnium	106 Sg 2,8,18,32,32,12,2 Seaborgium	107 Bh 2,8,18,32,32,13,2 Bohrium	108 Hs 2,8,18,32,32,14,2 Hassium	109 Mt 2,8,18,32,32,15,2 Meitnerium	110 Ds 2,8,18,32,32,17,1 Darmstadtium	111 Rg 2,8,18,32,32,18,1 Roentgenium	112 Cn 2,8,18,32,32,18,2 Copernicium

Group 3 (13)	Group 4 (14)	Group 5 (15)	Group 6 (16)	Group 7 (17)	Group 0 (18)
					2 He 2 Helium
5 B 2,3 Boron	6 C 2,4 Carbon	7 N 2,5 Nitrogen	8 O 2,6 Oxygen	9 F 2,7 Fluorine	10 Ne 2,8 Neon
13 Al 2,8,3 Aluminium	14 Si 2,8,4 Silicon	15 P 2,8,5 Phosphorus	16 S 2,8,6 Sulfur	17 Cl 2,8,7 Chlorine	18 Ar 2,8,8 Argon
31 Ga 2,8,18,3 Gallium	32 Ge 2,8,18,4 Germanium	33 As 2,8,18,5 Arsenic	34 Se 2,8,18,6 Selenium	35 Br 2,8,18,7 Bromine	36 Kr 2,8,18,8 Krypton
49 In 2,8,18,18,3 Indium	50 Sn 2,8,18,18,4 Tin	51 Sb 2,8,18,18,5 Antimony	52 Te 2,8,18,18,6 Tellurium	53 I 2,8,18,18,7 Iodine	54 Xe 2,8,18,18,8 Xenon
81 Tl 2,8,18,32,18,3 Thallium	82 Pb 2,8,18,32,18,4 Lead	83 Bi 2,8,18,32,18,5 Bismuth	84 Po 2,8,18,32,18,6 Polonium	85 At 2,8,18,32,18,7 Astatine	86 Rn 2,8,18,32,18,8 Radon

Lanthanides

57 La 2,8,18,18,9,2 Lanthanum	58 Ce 2,8,18,20,8,2 Cerium	59 Pr 2,8,18,21,8,2 Praseodymium	60 Nd 2,8,18,22,8,2 Neodymium	61 Pm 2,8,18,23,8,2 Promethium	62 Sm 2,8,18,24,8,2 Samarium	63 Eu 2,8,18,25,8,2 Europium	64 Gd 2,8,18,25,9,2 Gadolinium	65 Tb 2,8,18,27,8,2 Terbium	66 Dy 2,8,18,28,8,2 Dysprosium	67 Ho 2,8,18,29,8,2 Holmium	68 Er 2,8,18,30,8,2 Erbium	69 Tm 2,8,18,31,8,2 Thulium	70 Yb 2,8,18,32,8,2 Ytterbium	71 Lu 2,8,18,32,9,2 Lutetium

Actinides

89 Ac 2,8,18,32,18,9,2 Actinium	90 Th 2,8,18,32,18,10,2 Thorium	91 Pa 2,8,18,32,20,9,2 Protactinium	92 U 2,8,18,32,21,9,2 Uranium	93 Np 2,8,18,32,22,9,2 Neptunium	94 Pu 2,8,18,32,24,8,2 Plutonium	95 Am 2,8,18,32,25,8,2 Americium	96 Cm 2,8,18,32,25,9,2 Curium	97 Bk 2,8,18,32,27,8,2 Berkelium	98 Cf 2,8,18,32,28,8,2 Californium	99 Es 2,8,18,32,29,8,2 Einsteinium	100 Fm 2,8,18,32,30,8,2 Fermium	101 Md 2,8,18,32,31,8,2 Mendelevium	102 No 2,8,18,32,32,8,2 Nobelium	103 Lr 2,8,18,32,32,9,2 Lawrencium

SI UNITS

There is an international standard for units called the Systeme International D'Unites, SI units for short.

These consist of seven basic units, two of which we do not use in this course (the unit of luminous intensity, the candela, and the amount of substance containing a certain number of elementary particles, the mole).

The 5 basic units we use are units of mass, length, time, temperature and current. Every other unit can be expressed using a combination of these seven basic units.

Quantity	Symbol	Units
Mass	m	kilogram, kg
Length	l	metre, m
Time	t	second, s
Temperature	T	degrees Celsius, Kelvin, K
Current	I	ampere, A

e.g. Velocity is measured in metres per second, ms^{-1}

TRIGANOMETRY
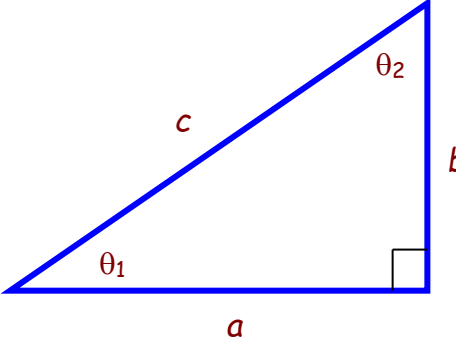
PYTHAGORAS

$$c^2 = a^2 + b^2$$

$$\sin \theta_1 = \frac{b}{c} \qquad \cos \theta_1 = \frac{a}{c}$$

$$\sin \theta_2 = \frac{a}{c} \qquad \cos \theta_2 = \frac{b}{c}$$

$$\therefore \sin \theta_1 \equiv \cos \theta_2$$

$$\tan \theta_1 = \frac{b}{a} \qquad \tan \theta_2 = \frac{a}{b}$$

COSINE RULE

The cosine rule for a triangle states that:

$$a^2 = b^2 + c^2 - 2bc \cos A$$
$$OR \quad b^2 = c^2 + a^2 - 2ca \cos B$$
$$OR \quad c^2 = a^2 + b^2 - 2ab \cos C$$
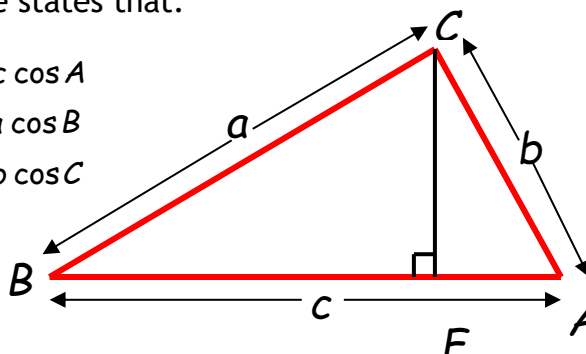
To prove these formula consider the following triangle, ABC:

Drop a line from C to form a perpendicular with AB at F.

$$CF = b \sin A \quad and A \qquad F = b \cos A$$
$$soB \quad F = AB - AF = c - b \cos A$$

Using Pythagoras' theorem in the triangle BFC:

$$B \qquad C^2 \quad = BF^2 + CF^2$$
$$or \quad a^2 \quad = (c - b \cos A)^2 + b^2 \sin^2 A$$
$$= c^2 - 2bc \cos A + b^2(\sin^2 A + \cos^2 A)$$
$$= b^2 + c^2 - 2bc \cos A$$

SINE RULE

The sine rule for a triangle states that:

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

To prove these formula consider

the following triangle, ABC:

Drop a line from C to form a

perpendicular with BC at D.
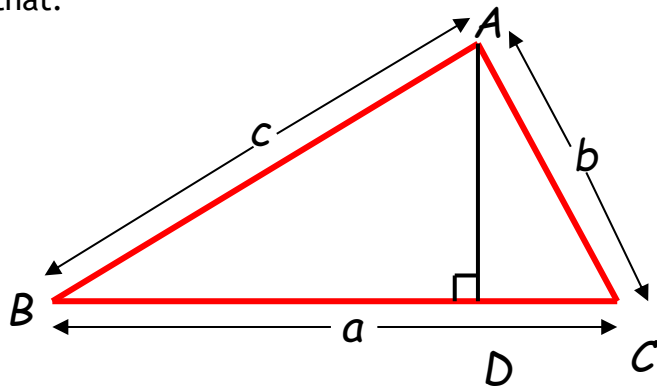
$$AD = c \sin B = b \sin C$$

$$\therefore \frac{b}{\sin B} = \frac{c}{\sin C}$$

PREFIXES

Prefix	Symbol	Multiple	Multiple in full
Tera	T	$\times10^{12}$	x1 000 000 000 000
Giga	G	$\times10^{9}$	x1 000 000 000
Mega	M	$\times10^{6}$	x1 000 000
Kilo	k	$\times10^{3}$	x1 000
		x1	1
Milli	m	$\times10^{-3}$	÷1 000
Micro	μ	$\times10^{-6}$	÷1 000 000
Nano	n	$\times10^{-9}$	÷1 000 000 000
Pico	p	$\times10^{-12}$	÷1 000 000 000 000

Above is a table of prefixes, which you will commonly find in Higher Physics.

NB THE STANDARD UNIT FOR MASS IS THE KILOGRAM. Do not try changing it to grams!

Watch out for ms which is milli seconds not metres per second!

THE PHYSICS COURSE

The following material is taken from the Higher Course Specifications version 1.0 April 2018 produced by the SQA. https://www.sqa.org.uk/sqa/47916.html

There are three units to this course and an Assignment

OUR DYNAMIC UNIVERSE

The topics covered are:

- 🏆 motion — equations and graphs
- 🏆 forces, energy and power
- 🏆 collisions, explosions, and impulse
- 🏆 gravitation
- 🏆 special relativity
- 🏆 the expanding Universe

PARTICLES AND WAVES

The topics covered are:

- 🏆 forces on charged particles
- 🏆 the Standard Model
- 🏆 nuclear reactions
- 🏆 inverse square law
- 🏆 wave-particle duality

- 🏆 interference
- 🏆 spectra
- 🏆 refraction of light

ELECTRICITY

The topics covered are:

- 🏆 monitoring and measuring AC
- 🏆 current, potential difference, power, and resistance
- 🏆 electrical sources and internal resistance
- 🏆 capacitors
- 🏆 semiconductors and p-n junctions

There is also an assignment which must be completed.

The length of time for students to complete the course is 160 hours.
There are three parts to the exam.

Component	Marks	Scaled mark	Duration & Notes
Question paper 1: multiple choice	25	25	45 minutes
Question paper 2	130	95	2 hours and 15 minutes
Assignment	20	30	8 hours including a max of 2 hours for the writing stage

COURSE ASSESSMENT STRUCTURE: QUESTION PAPERS

QUESTION PAPER 1: MULTIPLE CHOICE	25 MARKS
QUESTION PAPER 2:	130 MARKS

The question papers total 155 marks, and makes up 80% of the overall marks

Question paper 1 contains multiple-choice questions and has 25 marks. This is not scaled.

Question paper 2 contains restricted-response and extended-response questions and has 130 marks. This is scaled to 95 marks.

A data sheet and a relationships sheet are provided. The majority of the marks are awarded for applying knowledge and understanding. The other marks are awarded for applying scientific inquiry, scientific analytical thinking and problemsolving skills.

COURSE ASSESSMENT STRUCTURE: ASSIGNMENT

ASSIGNMENT 20 MARKS

The assignment has a total mark allocation of 20 marks. This is scaled to 30 marks by SQA. This contributes 20% to the overall marks for the course assessment.

The assignment assesses the application of skills of scientific inquiry and related physics knowledge and understanding.

It allows assessment of skills that cannot be assessed through the question paper, for example the handling and processing of data gathered from experimental work by the candidate.

The assignment is:

- an individually produced piece of work from each candidate
- started at an appropriate point in the course
- conducted under controlled conditions

MARK SCHEME TO THE ASSIGNMENT

Section	Expected response	Marks
Aim.	An aim that describes clearly the purpose of the investigation	1
Underlying physics	An account of the physics relevant to the aim of the investigation.	3
Data collection and handling	A brief summary of an approach used to collect experimental data.	1
	Sufficient raw data from the candidate's experiment.	1
	Data, including any mean and/or derived values, presented in correctly produced table.	1
	Data relevant to the experiment obtained from an internet/literature source or data relevant to the aim of the investigation obtained from a second experiment.	1
	A citation and reference for a source of internet/literature data or information.	1
Graphical presentation	Axes of the graph have suitable scales.	1
	Axes of the graph have suitable labels and units.	1
	Accurately plotted data points and, where appropriate, a line of best fit.	1
Uncertainties	Scale reading uncertainties and random uncertainties.	2
Analysis	Analysis of experimental data.	1
Conclusion	A valid conclusion that relates to the aim and is supported by all the data in the report.	1
Evaluation	Evaluation of the investigation.	3
Structure	A clear and concise report with an informative title.	1
TOTAL		20

COURSE OUTCOMES / SUCCESS CRITERIA

UNCERTAINTIES

No	CONTENT	✓ ×	Traffic Light		
1.	**Uncertainties**				
eq	random uncertainty $= \dfrac{\text{max. value - min. value}}{\text{number of values}}$ or $$\Delta R = \frac{R_{max} - R_{min}}{n}$$		☺	😐	☹
a)	I can identify that all measurements of physical quantities are liable to uncertainty which I can express in absolute or percentage form.		☺	😐	☹
b)	I can quantify and recognise scale reading, random and systematic uncertainties in a measured quantity.		☺	😐	☹
c)	I can express uncertainties in absolute or percentage form		☺	😐	☹
d)	I know that random uncertainties arise when an experiment is repeated and slight variations occur.		☺	😐	☹
e)	I can explain that scale reading uncertainty is a measure of how well an instrument scale can be read.		☺	😐	☹
f)	I know that scale reading uncertainty is an indication of how precisely a scale can be read.		☺	😐	☹
g)	I can state that random uncertainties can be reduced by taking repeated measurements.		☺	😐	☹
h)	I can explain that systematic uncertainties occur when readings taken are either all too small or all too large.		☺	😐	☹
i)	I can recognise that systematic uncertainties can arise due to measurement techniques or experimental design.		☺	😐	☹
j)	I know the mean of a set of repeated measurements is the best estimate of the 'true' value of the quantity being measured.		☺	😐	☹
k)	I know that when systematic uncertainties are present they offset the mean value		☺	😐	☹
l)	I know when mean values are used, the approximate random uncertainty should be calculated.		☺	😐	☹
m)	I can correctly calculate, use and identify uncertainties during data analysis.		☺	😐	☹
n)	I know that when an experiment is being undertaken and more than one physical quantity is measured, the quantity with the largest percentage uncertainty should be identified and this may often be used as a good estimate of the percentage uncertainty in the final numerical result of an experiment.		☺	😐	☹
o)	I can express the numerical result of an experiment in the form final value ±uncertainty.		☺	😐	☹

UNITS PREFIXES AND SCIENTIFIC NOTATION

No	CONTENT	✓ x	Traffic Light		
2.	**Units, prefixes and scientific notation**				
a)	I know the units for all of the physical quantities used in this unit.		☺	😐	☹
b)	I can use the prefixes: pico (p), nano (n), micro (μ), milli (m), kilo (k), mega (M), giga (G) and tera (T).		☺	😐	☹
c)	I can give an appropriate number of significant figures when carrying out calculations. (This means that the final answer can have no more significant figures than the value with least number of significant figures used in the calculation).		☺	😐	☹
d)	I can use scientific notation when large and small numbers are used in calculations.		☺	😐	☹

OUR DYNAMIC UNIVERSE   (START:_____END: _____)

No	CONTENT	✓ x	Traffic Light		
3.	**Equations of Motion**				
Eq	$d = \bar{v}t$, $s = \bar{v}t$; $s = \frac{1}{2}(u + v)t$; $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$		☺	😐	☹
a)	I can use the equations of motion to find distance, displacement, speed, velocity, and acceleration for objects with constant acceleration in a straight line.		☺	😐	☹
b)	I can interpret and draw motion-time graphs for motion with constant acceleration in a straight line, including graphs for bouncing objects and objects thrown vertically upwards.		☺	😐	☹
c)	I know the interrelationship of displacement-time, velocity-time and acceleration- time graphs.		☺	😐	☹
d)	I can calculate distance, displacement, speed, velocity, and acceleration from appropriate graphs (graphs restricted to constant acceleration in one dimension, inclusive of change of direction).		☺	😐	☹
e)	*I can give a description of an experiment to measure the acceleration of an object down a slope*		☺	😐	☹

4.	Forces, energy and power				
Eq	$W = mg$ $F = ma$ E_w or $W = Fd$ $E_p = mgh$ $E_k = \frac{1}{2}mv^2$ $E = Pt$		☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
a)	I can use vector addition and appropriate relationships to solve problems involving balanced and unbalanced forces, mass, acceleration and gravitational field strength.		☺	😐	☹
b)	I know the effects of friction on a moving object (static and dynamic friction are not required)		☺	😐	☹
c)	I can identify and explain the effects of friction on moving objects. I do not need to use reference to static and dynamic friction.		☺	😐	☹
d)	I can identify and explain, in terms of forces an object moving with terminal velocity		☺	😐	☹
e)	I can interpret and produce velocity-time graphs for a falling object when air resistance is taken into account.		☺	😐	☹
f)	I can analyse motion using Newton's first and second laws.		☺	😐	☹
g)	I can use free body diagrams and appropriate relationships to solve problems involving friction and tension.		☺	😐	☹
h)	I can resolve a vector into two perpendicular components.		☺	😐	☹
i)	I can resolve the weight of an object on a slope into a component acting parallel (down the slope) and a component acting normal to the slope.		☺	😐	☹
j)	I can use the principle of conservation of energy and appropriate relationships to solve problems involving work done, potential energy, kinetic energy and power.		☺	😐	☹

5.	Collisions and explosions				
eq	$p = mv$ $\qquad Ft = mv - mu \qquad E_k = \frac{1}{2}mv^2$		☺	😐	☹
a)	I can use the principle of conservation of momentum and an appropriate relationship to solve problems involving the momentum, mass and velocity of objects interacting in one dimension.		☺	😐	☹
b)	I can explain the role in kinetic energy in determining whether a collision is described as elastic and inelastic collisions or in explosions.		☺	😐	☹
c)	I can use appropriate relationships to solve problems involving the total kinetic energy of systems of interacting objects.		☺	😐	☹
d)	I can use Newton's third law to explain the motion of objects involved in interactions.		☺	😐	☹
e)	I can draw and interpret force-time graphs involving interacting objects.		☺	😐	☹
f)	I know that the impulse of a force is equal to the area under a force-time graph and is equal to the change in momentum of an object involved in the interaction.		☺	😐	☹
g)	I can use data from a force-time graph to solve problems involving the impulse of a force, the average force and its duration.		☺	😐	☹
h)	I can use appropriate relationships to solve problems involving mass, change in velocity, average force and duration of the force for an object involved in an interaction.	x	☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
6.	**Gravitation**				
Eq	$d = \bar{v}t,\ s = \bar{v}t$; $\quad s = \frac{1}{2}(u + v)t$; $v = u + at \qquad s = ut + \frac{1}{2}at^2 \qquad v^2 = u^2 + 2as \qquad F = \frac{Gm_1m_2}{r^2}$		☺	😐	☹
a)	I can use the equation $F = \frac{Gm_1m_2}{r^2}$		☺	😐	☹
b)	*I can give a description of an experiment* to measure the acceleration of a falling object.		☺	😐	☹
c)	I know that the horizontal motion and the vertical motion of a projectile are independent of each other.		☺	😐	☹
d)	I know that satellites are in free fall around a planet/star.		☺	😐	☹
e)	I can resolve the initial velocity of a projectile into horizontal and vertical components and their use in calculations.		☺	😐	☹
f)	I can use resolution of vectors, vector addition, and appropriate relationships to solve problems involving projectiles.		☺	😐	☹
g)	I can use Newton's Law of Universal Gravitation to solve problems involving force, masses and their separation.		☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
7.	**Special relativity**				
Eq	$t' = \dfrac{t}{\sqrt{1 - \dfrac{v^2}{c^2}}} \qquad\qquad l' = l\sqrt{1 - \dfrac{v^2}{c^2}}$		☺	😐	☹
a)	I know that the speed of light in a vacuum is the same for all observers.		☺	😐	☹
b)	I know that measurements of space, time and distance for a moving observer are changed relative to those for a stationary observer, giving rise to time dilation and length contraction.		☺	😐	☹
c)	I can use appropriate relationships to solve problems involving time dilation, length contraction and speed.		☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
8.	**The expanding Universe**				
Eq	$f_o = f_s\left(\dfrac{v}{v \pm v_s}\right) \qquad f_{observed} = f_{source}\dfrac{v}{[v + v_{source}]} \qquad v = H_o d \qquad z = \dfrac{v}{c}$ $z = \dfrac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$		☺	😐	☹
a)	I know that the Doppler effect causes shifts in wavelengths of sound and light.		☺	😐	☹
b)	I can use appropriate relationship to solve problems involving the observed frequency, source frequency, source speed and wave speed.		☺	😐	☹
c)	I know that the light from objects moving away from us is shifted to longer wavelengths (redshift).	x	☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
d)	I know that the redshift of a galaxy is the change in wavelength divided by the emitted wavelength. For slowly moving galaxies, redshift is the ratio of the recessional velocity of the galaxy to the velocity of light.		☺	😐	☹
e)	I can use appropriate relationships to solve problems involving redshift, observed wavelength, emitted wavelength, and recessional velocity		☺	😐	☹
f)	I can use appropriate relationship to solve problems involving the Hubble constant, the recessional velocity of a galaxy and its distance from us.		☺	😐	☹
g)	I know that Hubble's law allows us to estimate the age of the Universe.		☺	😐	☹
h)	I know that measurements of the velocities of galaxies and their distance from us lead to the theory of the expanding Universe.		☺	😐	☹
i)	I know that the mass of a galaxy can be estimated by the orbital speed of stars within it.		☺	😐	☹
j)	I know that evidence supporting the existence of dark matter comes from estimations of the mass of galaxies.		☺	😐	☹
k)	I know that evidence supporting the existence of dark energy comes from the accelerating rate of expansion of the Universe.		☺	😐	☹
l)	I know that the temperature of stellar objects is related to the distribution of emitted radiation over a wide range of wavelengths.		☺	😐	☹
m)	I know that the peak wavelength of this distribution is shorter for hotter objects than for cooler objects.		☺	😐	☹
n)	I know that hotter objects emit more radiation per unit surface area per unit time than cooler objects.		☺	😐	☹
o)	I know of evidence supporting the big bang theory and subsequent expansion of the Universe: cosmic microwave background radiation, the abundance of the elements hydrogen and helium, the darkness of the sky (Olbers' paradox) and the large number of galaxies showing redshift rather than blueshift.		☺	😐	☹

PARTICLES AND WAVES (START:_____END: _____)

No	CONTENT	✓ x	Traffic Light		
9.	**Forces on charged particles**				
eq	$W = QV \qquad E_k = \frac{1}{2}mv^2$		☺	😐	☹
a)	I know that charged particles experience a force in an electric field.		☺	😐	☹
b)	I know that electric fields exist around charged particles and between charged parallel plates.		☺	😐	☹
c)	I can sketch electric field patterns for single-point charges, systems of two-point charges and between two charged parallel plates (ignore end effects).		☺	😐	☹

No	CONTENT	✓✗	Traffic Light		
d)	I can determine the direction of movement of charged particles in an electric field.		☺	😐	☹
e)	I can define voltage (potential difference) as the work done moving unit charge between two points		☺	😐	☹
f)	I can solve problems involving the charge, mass, speed, and energy of a charged particle in an electric field and the potential difference through which it moves.		☺	😐	☹
g)	I know that a moving charge produces a magnetic field.		☺	😐	☹
h)	I can determine the direction of the force on a charged particle moving in a magnetic field for negative and positive charges using the slap rule or other method.		☺	😐	☹
i)	I know the basic operation of particle accelerators in terms of acceleration by electric fields, deflection by magnetic fields and high-energy collisions of charged particles to produce other particles.		☺	😐	☹

No	Standard Model	✓✗	Traffic Light		
10.	**Standard Model**				
a)	I know that the Standard Model is a model of fundamental particles and interactions.		☺	😐	☹
b)	I can describe the Standard Model in terms of types of particles and groups		☺	😐	☹
c)	I can use orders of magnitude and am aware of the range of orders of magnitude of length from the very small (sub-nuclear) to the very large (distance to furthest known celestial objects).		☺	😐	☹
d)	I know that evidence for the existence of quarks comes from high-energy collisions between electrons and nucleons, carried out in particle accelerators.		☺	😐	☹
e)	I know that in the Standard Model, every particle has an antiparticle.		☺	😐	☹
f)	I know that the production of energy in the annihilation of particles is evidence for the existence of antimatter		☺	😐	☹
g)	I know that beta decay was the first evidence for the neutrino.		☺	😐	☹
h)	I know the equation for β- decay above (ß+ decay not required) $^{1}_{0}n \rightarrow ^{1}_{1}p + ^{0}_{-1}e + \overline{v_e}$		☺	😐	☹
i)	I know that fermions, the matter particles, consist of quarks (six types: up, down, strange, charm, top, bottom) and leptons (electron, muon and tau, together with their neutrinos).		☺	😐	☹
j)	I know that hadrons are composite particles made of quarks.		☺	😐	☹
k)	I know that baryons are made of three quarks.		☺	😐	☹
l)	I know that mesons are made of quark-antiquark pairs.		☺	😐	☹
m)	I know that the force-mediating particles are bosons: photons (electromagnetic force), W- and Z-bosons (weak force), and gluons (strong force).		☺	😐	☹

No	CONTENT	✓✗	Traffic Light		
11.	**Nuclear reactions**				
eq	$E = mc^2$		☺	😐	☹
a)	I can use nuclear equations to describe radioactive decay, fission (spontaneous and induced), with reference to mass and energy equivalence.		☺	😐	☹
b)	I can use nuclear equations to describe fusion reactions, with reference to mass and energy equivalence.		☺	😐	☹
c)	Use of an appropriate relationship to solve problems involving the mass loss and the energy released by a nuclear reaction. $E = mc^2$		☺	😐	☹
d)	I know that nuclear fusion reactors require charged particles at a very high temperature (plasma) which have to be contained by magnetic fields.		☺	😐	☹

No	CONTENT	✓✗	Traffic Light		
12.	**Inverse square law**				
eq	$I = \dfrac{P}{A}$ $I = \dfrac{k}{d^2}$ $I_1 d_1^2 = I_2 d_2^2$		☺	😐	☹
a)	I know that irradiance is the power per unit area incident on a surface.		☺	😐	☹
b)	I can use the equation $I = \dfrac{P}{A}$ to solve problems involving irradiance, the power of radiation incident on a surface and the area of the surface.		☺	😐	☹
c)	I know that irradiance is inversely proportional to the square of the distance from a point source.		☺	😐	☹
d)	*I can describe an experiment to verify the inverse square law for a point source of light*		☺	😐	☹
e)	I can use $I = \dfrac{k}{d^2}$ and $I_1 d_1^2 = I_2 d_2^2$ to solve problems involving irradiance and distance from a point source of light.		☺	😐	☹

No	CONTENT	✓✗	Traffic Light		
13.	**Wave Particle Duality**				
eq	$E = hf$ $E = \dfrac{hc}{\lambda}$ $E_k = hf - hf_0$ $E_k = \frac{1}{2}mv^2$ and $v = f\lambda$		☺	😐	☹
a)	I know that the photoelectric effect is evidence for the particle model of light.		☺	😐	☹
b)	I know that photons of sufficient energy can eject electrons from the surface of materials (photoemission).		☺	😐	☹
c)	I can use $E = hf$ and $E = \dfrac{hc}{\lambda}$ to solve problems involving the frequency and energy of a photon.		☺	😐	☹
d)	I know that the threshold frequency, f_0 is the minimum frequency of a photon required for photoemission.		☺	😐	☹
e)	I know that the work function, W or hf_0 of a material is the minimum energy of a photon required to cause photoemission.		☺	😐	☹

No	CONTENT	✓ ×	Traffic Light		
f)	I can use $E_k = hf - hf_0$ $E_k = \frac{1}{2}mv^2$ and $v = f\lambda$ to solve problems involving the mass, maximum kinetic energy and speed of photoelectrons, the threshold frequency of the material, and the frequency and wavelength of the photons.		☺	😐	☹

14.	Interference				
Eq	$path\ difference = m\lambda\ or\ \left(m + \frac{1}{2}\right)\lambda$ where m =0,1,2. $d\ sin\theta = m\lambda$		☺	😐	☹
a)	I know that interference is evidence for the wave model of light.		☺	😐	☹
b)	I know that coherent waves have a constant phase relationship.		☺	😐	☹
c)	I can describe of the conditions for constructive and destructive interference in terms of the phase difference between two waves.		☺	😐	☹
d)	I know that maxima are produced when the path difference between waves is a whole number of wavelengths		☺	😐	☹
e)	I know that minima are produced when the path difference between waves is an odd number of half-wavelengths respectively.		☺	😐	☹
f)	I can use $path\ difference = m\lambda\ or\ \left(m + \frac{1}{2}\right)\lambda$ where m =0,1,2... to solve problems involving the path difference between waves, wavelength and order number.		☺	😐	☹
g)	I can use $d\ sin\theta = m\lambda$ to solve problems involving grating spacing, wavelength, order number and angle to the maximum.		☺	😐	☹

15.	Spectra				
Eq	$E_2 - E_1 = hf$ and $E = hf$		☺	😐	☹
a)	I have knowledge of the Bohr model of the atom.		☺	😐	☹
b)	I can explain the Bohr model of the atom using the terms *ground state, energy levels, ionisation and zero potential energy*.		☺	😐	☹
c)	I know the mechanism of production of line emission spectra, continuous emission spectra and absorption spectra in terms of electron energy level transitions.		☺	😐	☹
d)	I can use $E_2 - E_1 = hf$ and $E = hf$ to solve problems involving energy levels and the frequency of the radiation emitted/absorbed.		☺	😐	☹
e)	I know that the absorption lines (Fraunhofer lines) in the spectrum of sunlight provide evidence for the composition of the Sun's outer atmosphere.		☺	😐	☹

16.	Refraction				
Eq	$n = \dfrac{\sin\theta_1}{\sin\theta_2} = \dfrac{\lambda_1}{\lambda_2} = \dfrac{v_1}{v_2}$ and $v = f\lambda$ and $\sin\theta_c = \dfrac{1}{n}$		☺	😐	☹

No	CONTENT	✓✗	Traffic Light		
a)	I can define absolute refractive index of a medium as the ratio of the speed of light in a vacuum to the speed of light in the medium.		☺	😐	☹
b)	I can use $n = \dfrac{\sin \theta_1}{\sin \theta_2}$ to solve problems involving absolute refractive index, the angle of incidence and the angle of refraction.		☺	😐	☹
c)	*I can describe an experiment to determine the refractive index of a medium.*		☺	😐	☹
d)	I can use $\dfrac{\sin \theta_1}{\sin \theta_2} = \dfrac{\lambda_1}{\lambda_2} = \dfrac{v_1}{v_2}$ and $v = f\lambda$ to solve problems involving the angles of incidence and refraction, the wavelength of light in each medium, the speed of light in each medium, and the frequency, including situations where light is travelling from a more dense to a less dense medium.		☺	😐	☹
e)	I know that the refractive index of a medium increases as the frequency of incident radiation increases.		☺	😐	☹
f)	I can define critical angle as the angle of incidence which produces an angle of refraction of 90°.		☺	😐	☹
g)	I know that total internal reflection occurs when the angle of incidence is greater than the critical angle.		☺	😐	☹
h)	I can use $\sin \theta_c = \dfrac{1}{n}$ to solve problems involving critical angle and absolute refractive index.		☺	😐	☹

ELECTRICITY (START:_____END: _____

| No	CONTENT	✓✗	Traffic Light		
17.	**Monitoring and Measuring A.C.**				
eq	$T = \dfrac{1}{f}$ $V_{rms} = \dfrac{V_{peak}}{\sqrt{2}}$ $I_{rms} = \dfrac{I_{peak}}{\sqrt{2}}$		☺	😐	☹
a)	I know that an A.C. is a current which changes direction and instantaneous value with time.		☺	😐	☹
b)	I can use $V_{rms} = \dfrac{V_{peak}}{\sqrt{2}}$ $I_{rms} = \dfrac{I_{peak}}{\sqrt{2}}$ to solve problems involving peak and r.m.s. values.		☺	😐	☹
c)	I can determine the frequency, peak voltage and r.m.s. values from graphical data.		☺	😐	☹
d)	I can use $T = \dfrac{1}{f}$ to determine the frequency.		☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
18.	**Current, potential difference, power and resistance**				
eq	$V = IR$ $\quad P = IV = I^2R = \dfrac{V^2}{R} \quad R_T = R_1 + R_2 + ...$		☺	😐	☹
Eq	$\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + ... \quad V_2 = \left(\dfrac{R_2}{R_1 + R_2}\right)V_s \quad \dfrac{V_1}{V_2} = \dfrac{R_1}{R_2}$		☺	😐	☹
a)	I can use relationships involving potential difference, current, resistance and power to analyse circuits even those that may involve several steps in the calculations.		☺	😐	☹
b)	I can correctly use calculations involving potential dividers circuits.		☺	😐	☹
19.	**Electrical sources and internal resistance**				
eq	$E = V + Ir \qquad V = IR$		☺	😐	☹
a)	I can correctly use and explain the terms electromotive force (E.M.F), internal resistance, lost volts, terminal potential difference (t.p.d) ideal supplies, short circuits and open circuits.		☺	😐	☹
b)	I can use $E = V + Ir$ and $V = IR$ to solve problems involving EMF, lost volts, t.p.d., current, external resistance, and internal resistance.		☺	😐	☹
c)	*I can describe of an experiment to measure the EMF and internal resistance of a cell*.		☺	😐	☹
d)	I can determine electromotive force, internal resistance and short circuit current using graphical analysis.		☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
20.	**Capacitors**				
eq	$C = \dfrac{Q}{V} \qquad Q = It \qquad E = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \tfrac{1}{2}\dfrac{Q^2}{C}$		☺	😐	☹
a)	I know that a capacitor of 1 farad will store 1 coulomb of charge when the potential difference across it is 1 volt.		☺	😐	☹
b)	I can use the equation C=Q/V to solve problems involving capacitance, charge and potential difference.		☺	😐	☹
c)	I can use the equation $Q = It$ to determine the charge stored on a capacitor for a constant charging current.		☺	😐	☹
d)	I know the total energy stored in a charged capacitor is equal to the area under a charge-potential difference graph.		☺	😐	☹
e)	I can use $E = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \tfrac{1}{2}\dfrac{Q^2}{C}$ to solve problems involving energy, charge, capacitance, and potential difference.		☺	😐	☹
f)	I know the variation of **current** with time for both charging and discharging cycles of a capacitor in an RC circuit (charging and discharging curves).		☺	😐	☹

No	CONTENT	✓ x	Traffic Light		
g)	I know the variation of **potential difference** with time for both charging and discharging cycles of a capacitor in an RC circuit (charging and discharging curves).		☺	😐	☹
h)	I know the effect of resistance and capacitance on charging and discharging curves in an RC circuit.		☺	😐	☹
i)	*I can describe experiments to investigate the variation of current in a capacitor and voltage across a capacitor with time, for the charging and discharging of capacitors*		☺	😐	☹
21.	**Semiconductors and p-n junctions**				
a)	I know and can explain the terms conduction band and valence band.		☺	😐	☹
b)	I know that solids can be categorised into conductors, semiconductors or insulators by their band structure and their ability to conduct electricity. Every solid has its own characteristic energy band structure. For a solid to be conductive, both free electrons and accessible empty states must be available.		☺	😐	☹
c)	I can explain qualitatively the electrical properties of conductors, insulators and semiconductors using the electron population of the conduction and valence bands and the energy difference between the conduction and valence bands. (Reference to Fermi levels is not required.)		☺	😐	☹
d)	I know that the electrons in atoms are contained in energy levels. When the atoms come together to form solids, the electrons then become contained in energy bands separated by gaps.		☺	😐	☹
e)	I know that for metals we have the situation where one or more bands are partially filled.		☺	😐	☹
f)	I know that some metals have free electrons and partially filled valence bands, therefore they are highly conductive.		☺	😐	☹
g)	I know that some metals have overlapping valence and conduction bands. Each band is partially filled and therefore they are conductive.		☺	😐	☹
h)	I know that in an insulator, the highest occupied band (called the valence band) is full. The first unfilled band above the valence band is the conduction band. For an insulator, the gap between the valence band and the conduction band is large and at room temperature there is not enough energy available to move electrons from the valence band into the conduction band where they would be able to contribute to conduction. There is no electrical conduction in an insulator.		☺	😐	☹

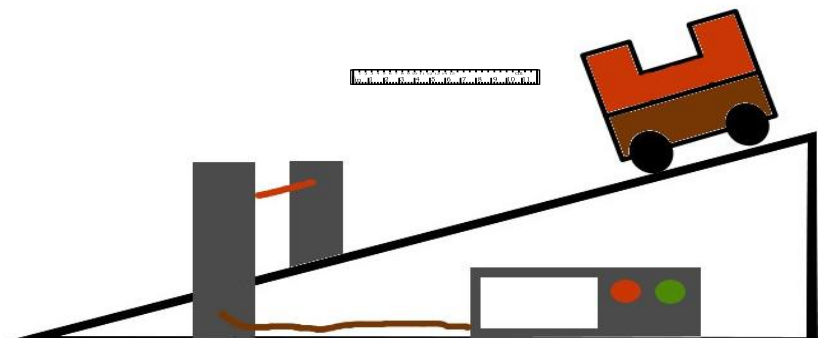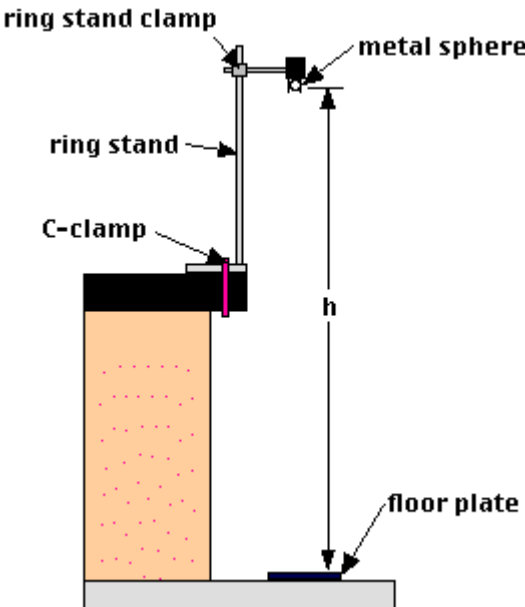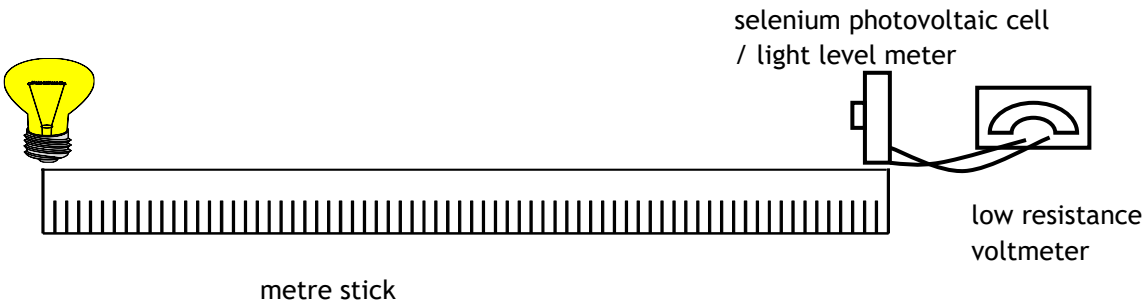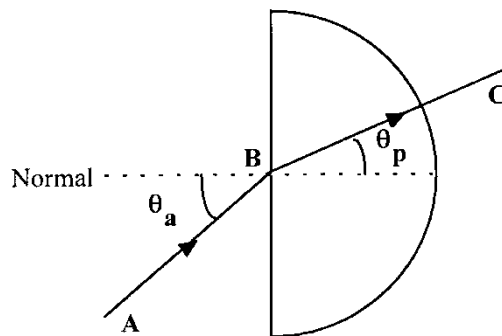| No	CONTENT	✓ x	Traffic Light		
i)	I know that in a semiconductor, the gap between the valence band and conduction band is smaller and at room temperature there is sufficient energy available to move some electrons from the valence band into the conduction band allowing some conduction to take place. An increase in temperature increases the conductivity of a semiconductor.		☺	😐	☹
j)	I know that, during manufacture, semiconductors may be doped with specific impurities to increase their conductivity, resulting in two types of semiconductor: p-type and n-type.		☺	😐	☹
k)	I know that, when a semiconductor contains the two types of doping (p-type and n- type) in adjacent layers, a p-n junction is formed. There is an electric field in the p-n junction. The electrical properties of this p-n junction are used in a number of devices.		☺	😐	☹
l)	I know and can explain the terms forward bias and reverse bias. Forward bias reduces the electric field; reverse bias increases the electric field in the p-n junction.		☺	😐	☹
m)	I know that LEDs are forward biased p-n junction diodes that emit photons. The forward bias potential difference across the junction causes electrons to move from the conduction band of the n-type semiconductor towards the conduction band of the p- type semiconductor. Photons are emitted when electrons 'fall' from the conduction band into the valence band either side of the junction		☺	😐	☹
n)	I know that solar cells are p-n junctions designed so that a potential difference is produced when photons are absorbed. (This is known as the photovoltaic effect.) The absorption of photons provides energy to 'raise' electrons from the valence band of the semiconductor to the conduction band. The p-n junction causes the electrons in the conduction band to move towards the n-type semiconductor and a potential difference is produced across the solar cell.		☺	😐	☹

PROGRESSING THROUGH THE COURSE
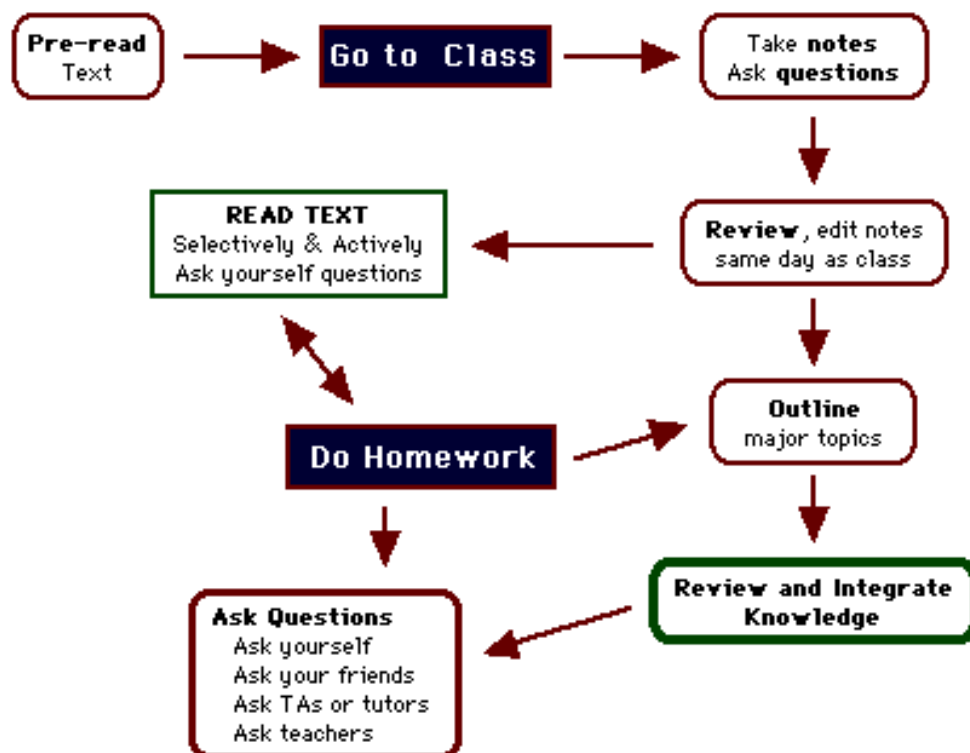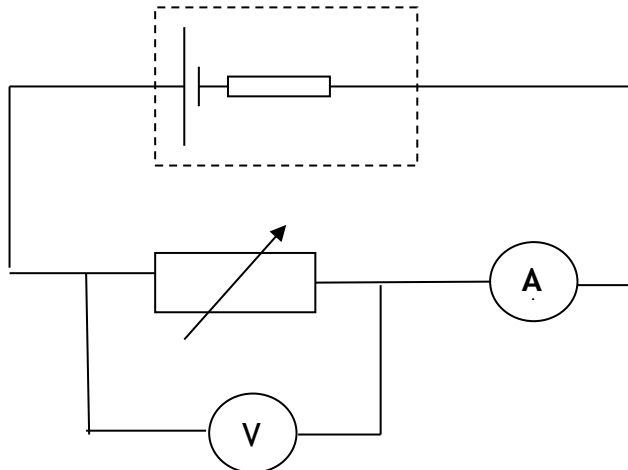

NOTES

PRESCRIBED PRACTICAL EXPERIMENTS

One example of a method has been exemplified for each practical. Many more alternatives are available and just as good.

1e	An experiment to measure the acceleration of an object down a slope

4b	An experiment to measure the acceleration of a falling object.

11e	*I can describe an experiment to verify the inverse square law for a point source of light*

15c	*I can describe an experiment to determine the refractive index of a medium.*
19c	*I can describe of an experiment to measure the EMF and internal resistance of a cell.*
20i	*I can describe experiments to investigate the variation of current in a capacitor and voltage across a capacitor with time, for the charging and discharging of capacitors*
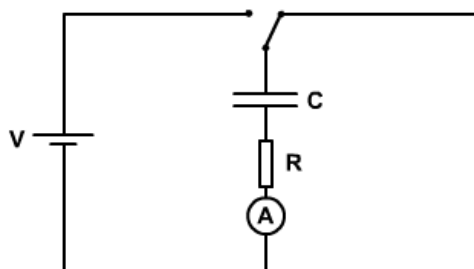
1. Find the mean

$$\text{mean value} = \frac{\Sigma \text{results}}{\text{no. of observation}}$$
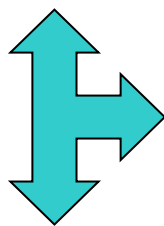
This is the best estimate of the "true" value but not necessary the "true" value

2. Find the approximate random uncertainty in the mean (absolute uncertainty)

$$\text{random uncertainty} = \frac{\text{max. value - min. value}}{\text{number of values}}$$

This can be written as $= \dfrac{\text{range}}{\text{no. of observation}}$ and it is sometimes referred to as *average deviation or absolute uncertainty*.
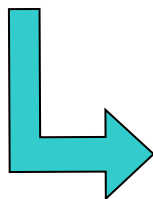
stop here and quote the result with an approx. random uncertainty

MEAN ± approx. random uncertainty (UNITS)

3. Find the percentage uncertainty.

$$\text{percentage uncertainty} = \frac{approximately\ randon\ uncertainty}{mean\ value} \times 100\% =$$

$$\text{percentage uncertainty} = \frac{\dfrac{range}{n}}{mean\ value} \times 100\%$$

stop here and quote the result with a percentage uncertainty

MEAN (UNITS)± percentage uncertainty (%)

Or (uncertainty in reading/reading)$\times$ 100%

SCALE READING UNCERTAINTY

Analogue device = ±½ scale division

Digital device = ±1 in the last digit

OVERALL UNCERTAINTY IN AN EXPERIMENT

In an experiment, where more than one physical quantity has been measured, spot the quantity with the largest percentage uncertainty. This percentage uncertainty is often a good estimate of the percentage uncertainty in the final numerical result of the experiment.

eg if one measurement has an uncertainty of 3% and another has an uncertainty of 5%, then the overall percentage uncertainty in this experiment should be taken as 5%

When completing an experimental EVALUATION, always refer to the magnitude of the uncertainty to give an indication of how reliable your results are.

ACCURACY & PRECISION

Accuracy is **how close your answer is to the true value. Precision is how repeatable a measurement is.** Use the diagram below to remind you which is which.

http://preview.tinyurl.com/lwanwoh
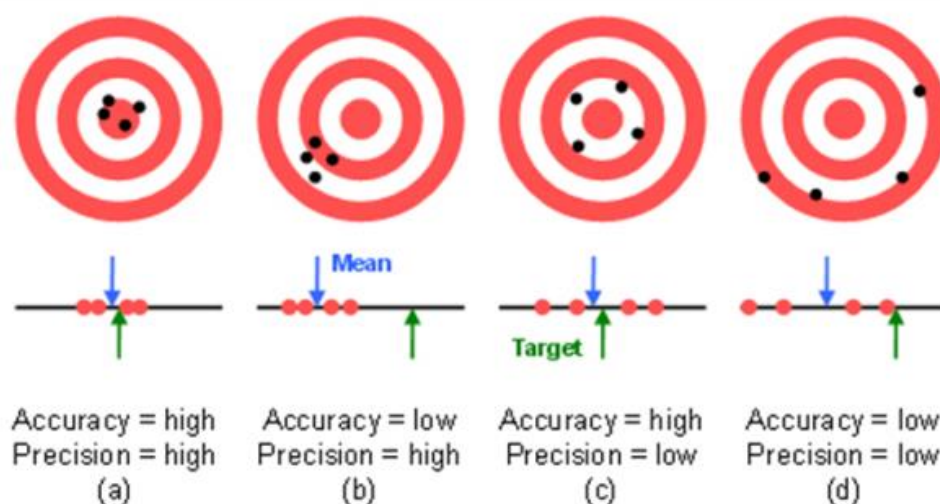
In Physics you will often calculate an answer to a question that has a large number of significant figures or decimal places. Because it is highly unlikely that we need to know the answer that precisely. It is important to round off any answers that you find.

HOW MANY SIGNIFICANT FIGURES?

The simple rule is this: Your answer should have no more than the number of significant figures given in the question.

If different numbers in the question are given to a different number of significant figure you should use the number of significant figures in the value given to the smallest number of significant figures.

Question: A rocket motor produces 4,570N of thrust to a rocket with a mass of 7.0kg.What is the acceleration of the rocket?

The calculated answer to this question would be 652.8571429 ms^{-2} . However the least accurate value we are given in the question is the value of the mass. This is only given to two significant figures. Therefore our answer should also be to two significant figures: 650 ms^{-2} .

FROM THE GENERAL MARKING PRINCIPLES

Question: Calculate the kinetic energy of a 0·950 kg ball travelling at 2·35 m s^{-1}.

Response

$$E_k = \frac{1}{2}mv^2$$
$$E_k = 0.5 \times 0.950 \times 2.35^2$$
$$E_k = 2.6231875$$
$$E_k = 2.62 \, J$$

Award 3 marks

In rounding to an expected number of significant figures, the mark can be awarded for answers which have **up to two figures more** or **one figure less** than the number in the data with the fewest significant figures.
1 mark for selected relationship.
1 mark for correct substitution.
1 mark for the correct final answer, including unit.

(2·6 J, 2·623 J and 2·6232 J are also acceptable)

If the final answer in the Response is
3 J, 2·62319 J, 2·623188 J or 2·6231875 J

Mark for final answer is not awarded.

Award a maximum of 2 marks

Question

An unbalanced force of 4·0 N is applied to a 6·0 kg mass. Calculate the cceleration of the mass.

Response

$$F = ma$$
$$4.0 = 6.0 \times a$$
$$a = 0.6\dot{6}ms^{-2}$$

Award 2 marks

1 mark for selected relationship.

1 mark for correct substitution.

Mark for final answer is not awarded.

(Use of the recurrence dot implies an infinite number of significant figures.)

Question

In a ripple tank, a wave generator produces 9 waves in 27 seconds. The wavelength of the waves is 4·5 cm. Determine the speed of the waves.

Response

$$f = \frac{N}{t}$$

$$f = \frac{9}{27}$$

$$f = 0 \cdot 3$$

In numerical calculations involving intermediate stages, candidates should not round intermediate values. If intermediate rounding leads to a final answer which is incorrect then treat as an arithmetic error.

1 mark for selected relationship.
1 mark for correct substitution.

$$v = f\lambda$$

$$v = 0 \cdot 3 \times 4 \cdot 5$$

$$v = 1 \, \mathrm{cm\,s^{-1}}$$

Award 4 marks

1 mark for selected relationship.
1 mark for correct substitution.
Mark for final answer not awarded (rounding of f at an intermediate stage has resulted in an incorrect final answer). (Final answer should be 2 cm s^{-1} rounded from 1·5 cm s^{-1}.)

MARKING PRINCIPLES

You need to refer to the document General Marking Principles for guidance on how questions are marked.

http://www.sqa.org.uk/files_ccc/Physicsgeneralmarkingprinciples.pdf

Before you get in to the Higher Physics Course make sure you've looked over this material (there are laminated sheets in the Physics Dept).

PERSONAL NOTES

EXAM DATE: