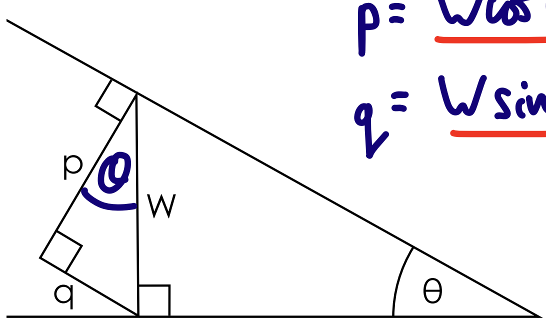
1st December

1 2 3

1. State the **principle of moments**.

For a system in equilibrium, the sum of the clockwise moments is equal to the sum of the anti-clockwise moments.

2. Form **expressions** for p and q in terms of θ and W.



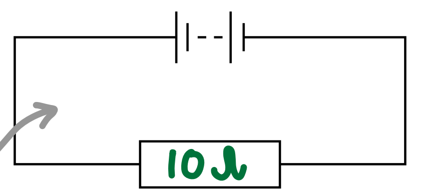
$p = W\cos\theta$

$q = W\sin\theta$

3. A 10 Ω resistor is connected to a 6.0 V battery.

Calculate the **change in current** drawn from the battery when a 10 Ω resistor is added:

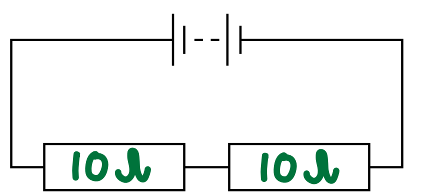
$I = \frac{V}{R} = \frac{6.0}{10} = 0.60\ A$



a. In **series**

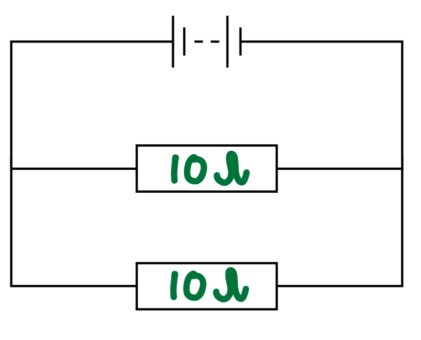
$R_T = 20\ \Omega$

$I = \frac{V}{R_T} = \frac{6.0}{20} = 0.30\ A$



$\Delta I = 0.60 - 0.30$
$= 0.30\ A$

b. In **parallel**



$R_T = 5.0\ \Omega$

$I = \frac{V}{R_T} = \frac{6.0}{5.0} = 1.2\ A$

$\Delta I = 1.2 - 0.60$
$= 0.60\ A$

2nd December

1 2 3

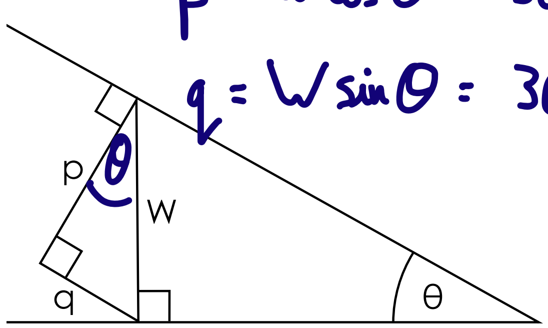
1. Define **resistance**.

Resistance is defined as the ratio of the potential difference across a component to the current through it.

2. Calculate the **lengths** of p and q when θ = 24˚ and W = 30.

$p = W\cos\theta = 30\cos 24 = 27.4 = \underline{27}$

$q = W\sin\theta = 30\sin 24 = 12.2 = \underline{12}$



3. The following data was recorded:

Quantity	Value	Uncertainty	% Uncertainty
Mass	0.250 kg	± 0.001 kg	0.40
Velocity	0.337 m s^{-1}	± 0.010 m s^{-1}	3.0

Calculate the **percentage uncertainty** in the calculated value of:

a. Momentum

$p = mv$ $\quad \%p = \%m + \%v = 0.40 + 3.0 = \underline{3.4\%}$

b. Kinetic energy

$E_K = \frac{1}{2}mv^2$ $\quad \%E_K = \%m + (2 \times \%v) = 0.40 + (2 \times 3.0) = \underline{6.4\%}$

3rd December

1 2 3

1. Three measurements of the gravitational field strength are made: 9.58 N kg^{-1}, 9.92 N kg^{-1} and 10.14 N kg^{-1}.

   Calculate the **mean** gravitational field strength and its **absolute uncertainty**.

   $g = \underline{9.88}\ \mathrm{N\,kg^{-1}}$

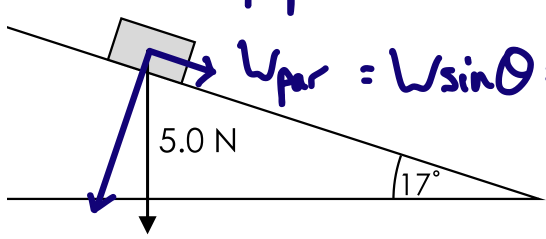
   $\dfrac{10.14 - 9.58}{2} = \underline{0.28}\ \mathrm{N\,kg^{-1}}$

2. A wooden block of weight 5.0 N is at rest on a slope in a Physics classroom at an angle of 17˚ from the desk.

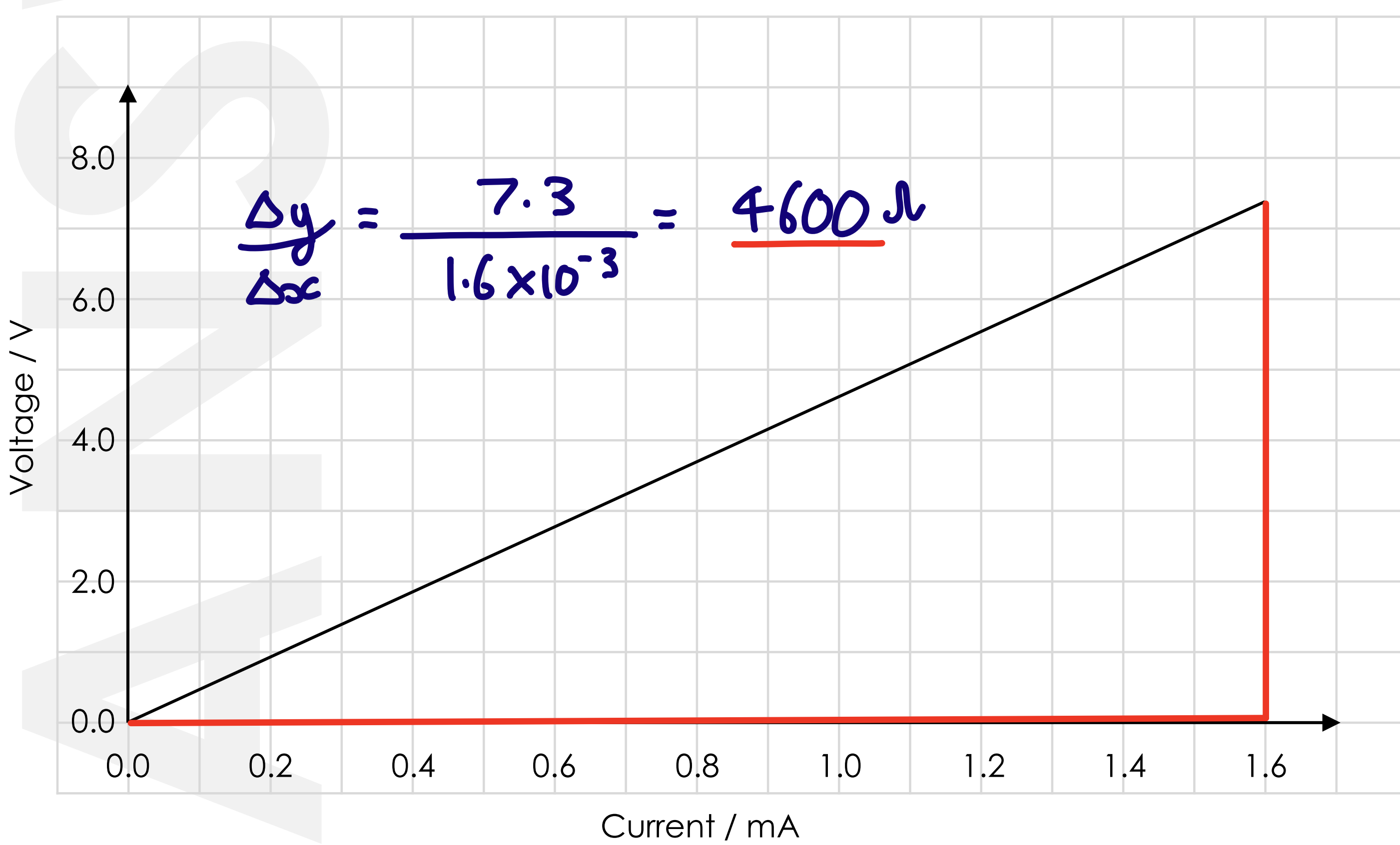
   Calculate the components of its weight **parallel** and **perpendicular** to the surface.

   $W_{perp} = W\cos\theta = 5.0\cos 17 = \underline{4.8}\ \mathrm{N}$

   $W_{par} = W\sin\theta = 5.0\sin 17 = \underline{1.5}\ \mathrm{N}$



3. Calculate the **gradient** of the line.



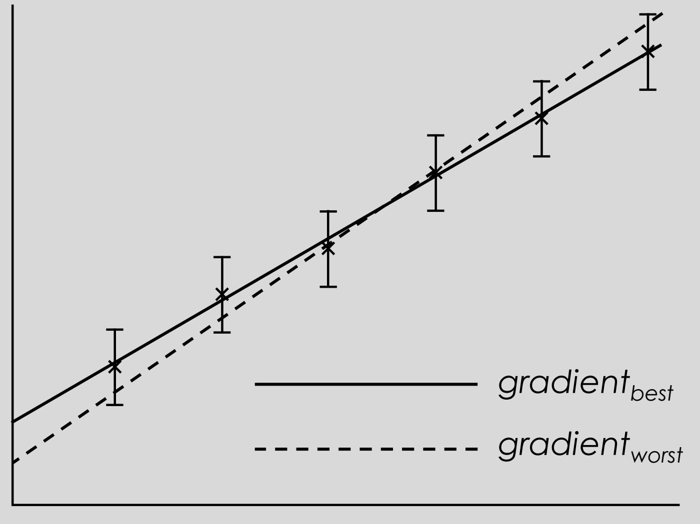
$\dfrac{\Delta y}{\Delta x} = \dfrac{7.3}{1.6\times10^{-3}} = \underline{4600}\ \Omega$

4^{th} December – Part 1

Percentage Uncertainty – Gradient

The percentage uncertainty in the gradient of a straight line graph can be calculated from the line of best fit and the gradient of the worst acceptable line.

$$\textit{percentage uncertainty} = \frac{|\,gradient_{best} - gradient_{worst}\,|}{gradient_{best}} \times 100\%$$



Note: The steepest or shallowest worst acceptable line can be drawn, as the modulus (positive value) is used. If there are error bars on the plotted data then the worst acceptable line should pass through all of these.

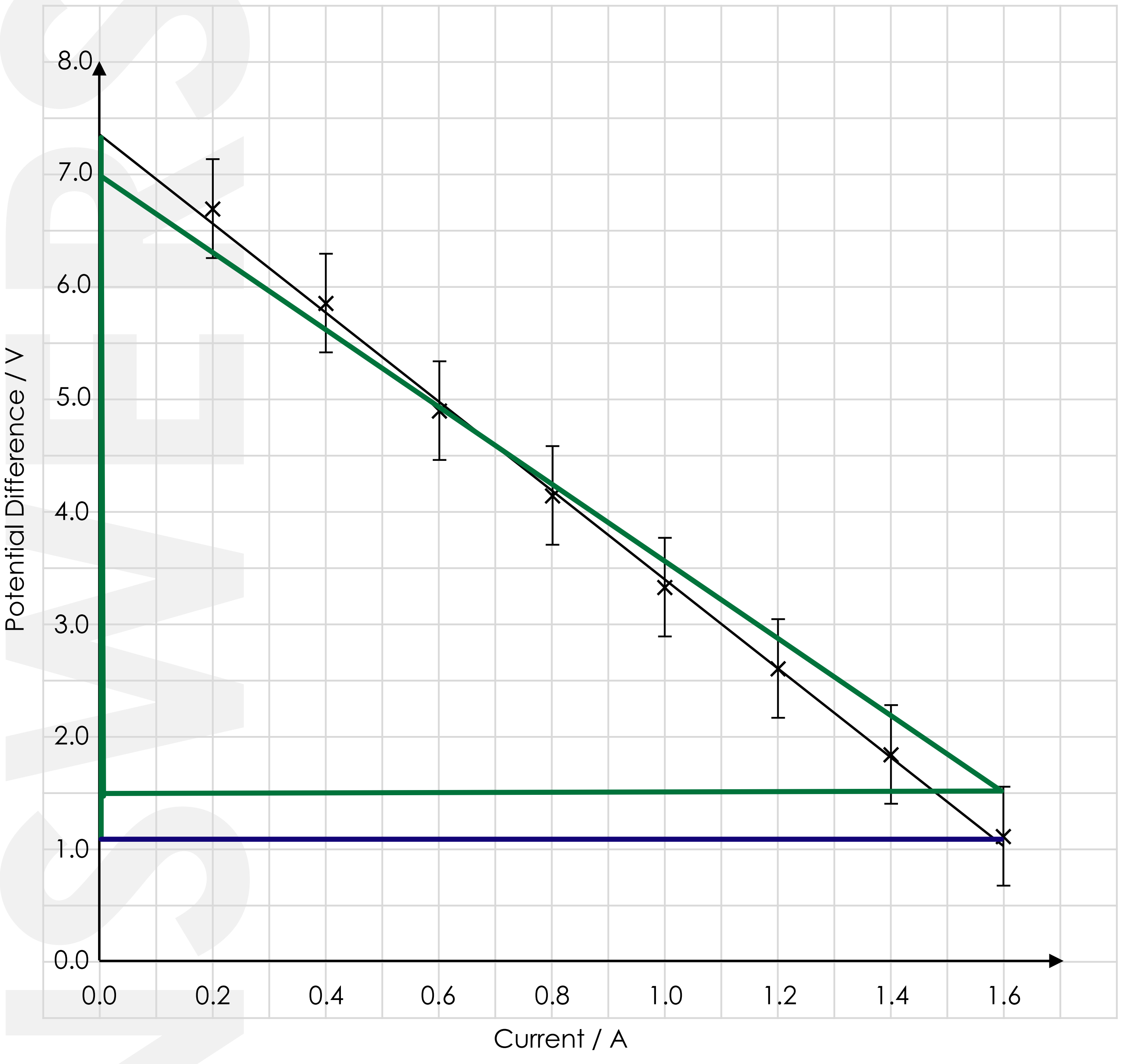
1. Complete the following table:

	Gradient$_{best}$	Gradient$_{worst}$	Percentage Uncertainty / %
a.	1.00	1.10	10
b.	9.62	9.84	2.3
c.	9.62	9.40	2.3
d.	9.62	8.87	7.8

4th December – Part 2

2

2. The following data was collected in an A Level practical investigation.



a. Calculate the gradient of the **line of best fit**

$$\frac{\Delta y}{\Delta x} = \frac{1.1 - 7.3}{1.6 - 0} = -3.875 \approx -3.9\ \Omega$$

b. Draw in a **worst acceptable** line and calculate the **gradient** of this

$$\frac{\Delta y}{\Delta x} = \frac{1.5 - 7.0}{1.6 - 0} = -3.438 \approx -3.4\ \Omega$$

c. Calculate the **percentage uncertainty** in the gradient

$$\frac{-3.9 - (-)3.4}{-3.9} \times 100 = 13\%$$

5th December

1 2 3

1. **Convert**:

   a. 1.00 eV to J

   $1.00 \times 1.60\times10^{-19} = \underline{1.60\times10^{-19}}\ J$

   b. 1.00 kWh to J

   $1.00 \times 1000 \times 3600 = \underline{3.60\times10^{6}}\ J$

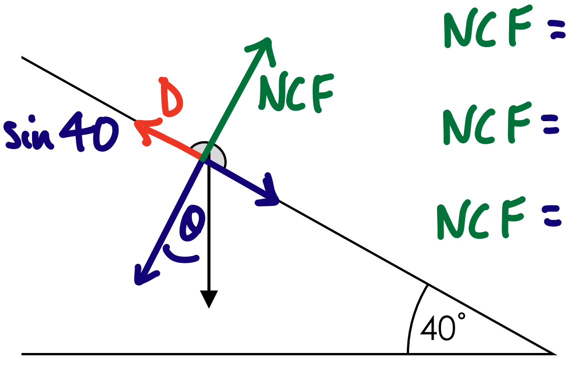
2. A 2.1 g raindrop runs down an angled window in a roof at a constant velocity of 11 cm s^{-1}.

   Calculate the **normal contact force** and the **drag**.

Drag $= W\sin\theta$

$D = 2.1\times10^{-3}\times9.81\times\sin 40$

$D = \underline{1.3\times10^{-2}}\ N$



$NCF = W\cos\theta$

$NCF = 2.1\times10^{-3}\times9.81\times\cos 40$

$NCF = \underline{1.6\times10^{-2}}\ N$

3. A mountain bike, with tyres of outside diameter 29 inches, is travelling at 24 mph.

   1 mile = 1609 m 1 inch = 2.54 cm

   a. Calculate the **speed** of the bike in m s^{-1}

   $\frac{24\times1609}{3600} = 10.73 \approx \underline{11}\ m\,s^{-1}$

   b. Calculate how many **revolutions** each wheel makes per second

   $C = \pi d = \pi\times29\times0.0254 = 2.314\ m$

   $10.73\div2.314 = 4.64 \approx \underline{4.6}\ rev\ s^{-1}$

   c. Determine the **speed** of the tyre at the point where it meets the ground

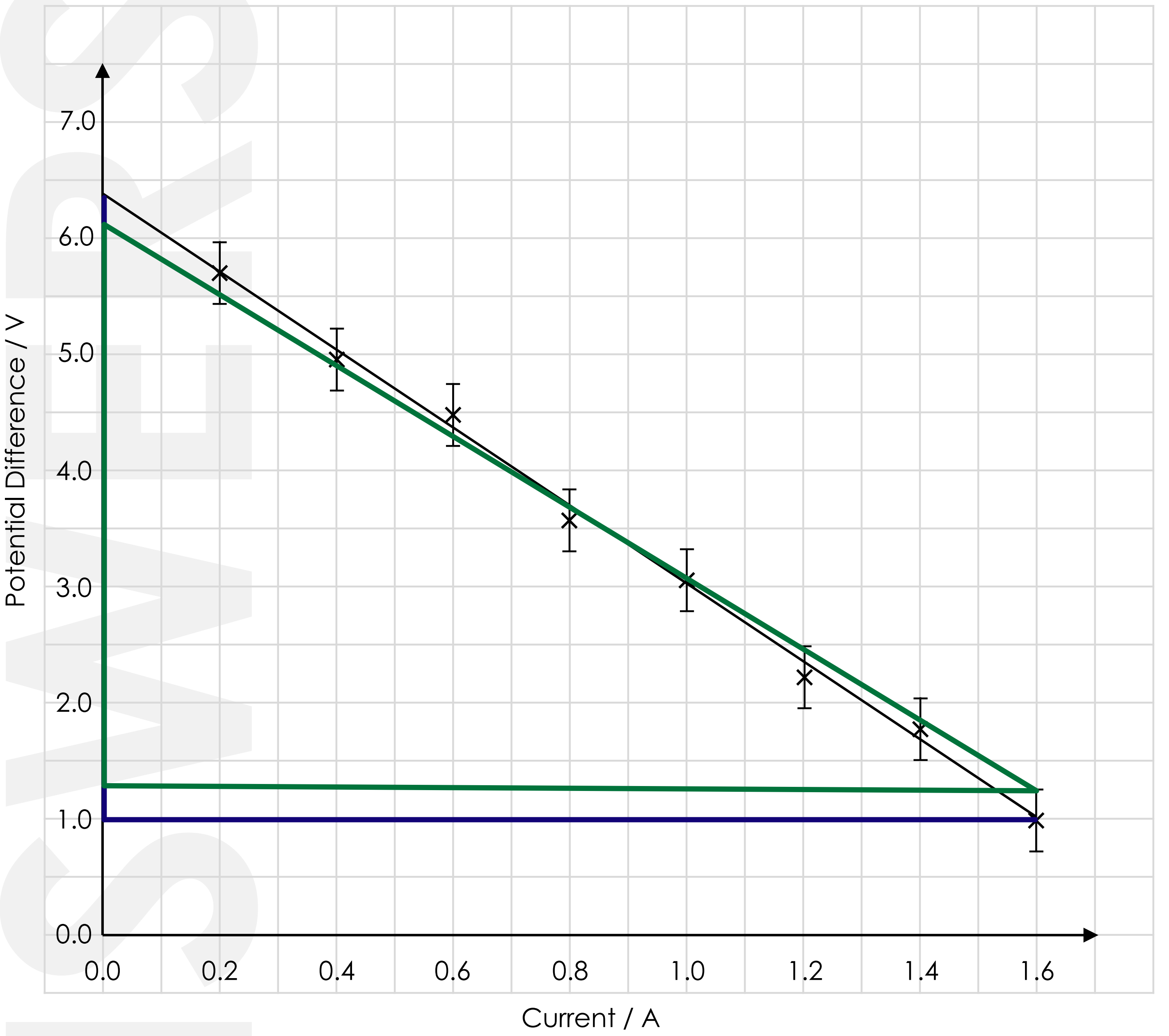
   $\underline{0}\ m\,s^{-1}$

   d. State where the tyre is travelling **fastest**

   <u>At the top</u>

6th December – Part 1

1. The following data was collected in an A Level practical investigation.



a. Calculate the gradient of the **line of best fit**

$$\frac{\Delta y}{\Delta x} = \frac{1.0 - 6.4}{1.6 - 0} = -3.375 \approx \underline{-3.4}$$

b. Draw in a **worst acceptable** line and calculate the **gradient** of this

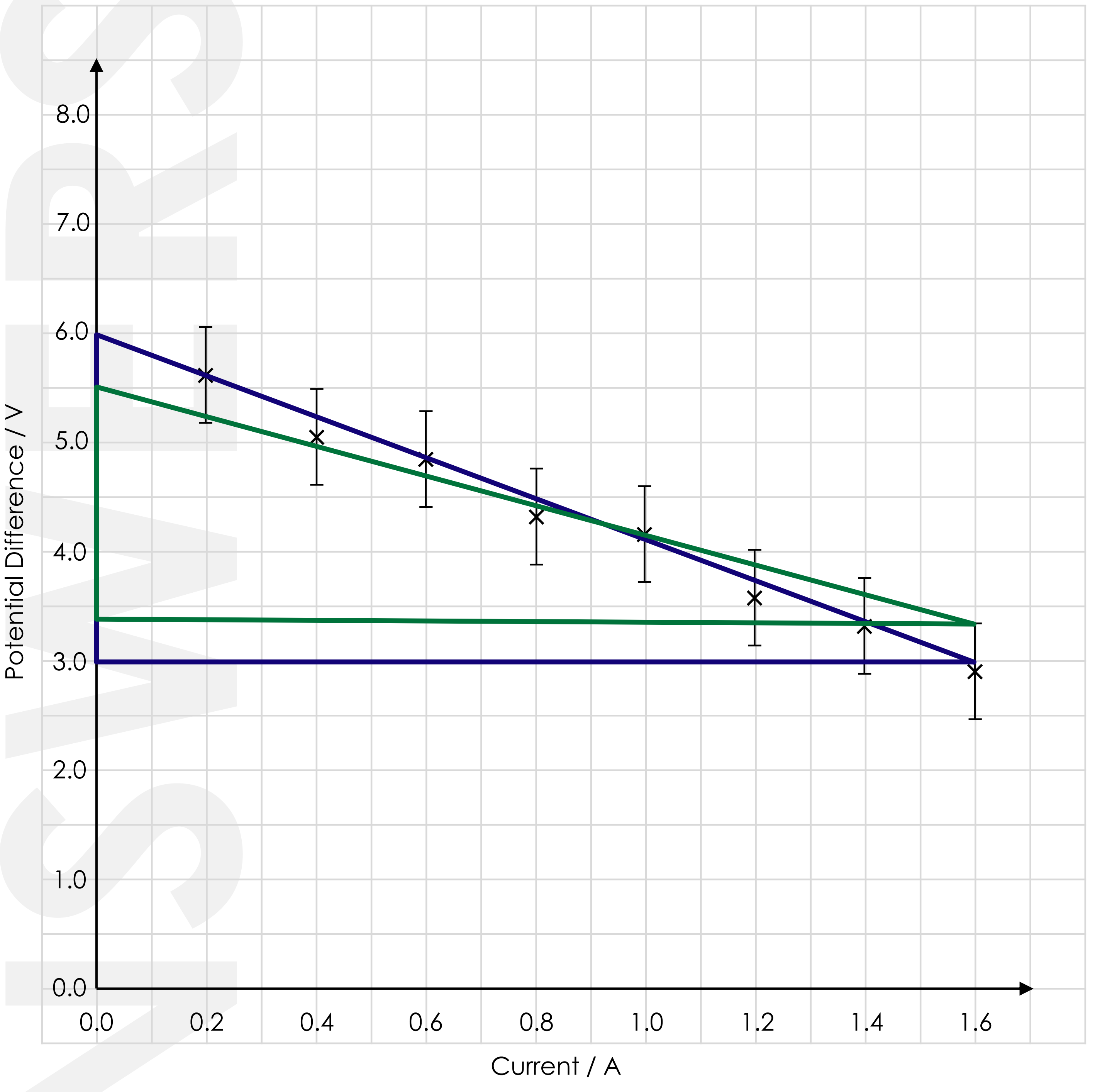
$$\frac{\Delta y}{\Delta x} = \frac{1.3 - 6.1}{1.6 - 0} = -3.00 \approx \underline{-3.0}$$

c. Calculate the **percentage uncertainty** in the gradient

$$\frac{-3.4 - (-)3.0}{-3.4} \times 100 \approx \underline{12\%}$$

6th December – Part 2

2. The following data was collected in an A Level practical investigation.



By drawing your own line of best fit and worst acceptable line, calculate the **percentage uncertainty** in the **gradient.**

$$m_{best} = \frac{3.0 - 6.0}{1.6 - 0} = -1.875$$

$$m_{worst} = \frac{3.4 - 5.5}{1.6 - 0} = -1.313$$

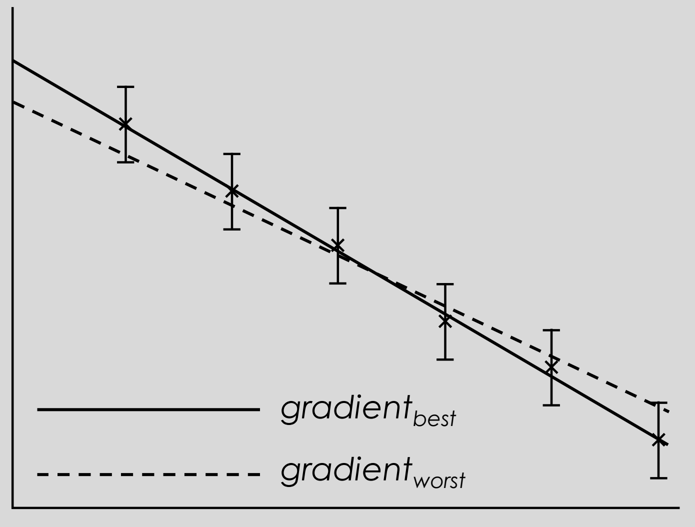
$$\frac{-1.875 - (-)1.313}{-1.875} = 30\%$$

7^{th} December – Part 1

Percentage Uncertainty – y-intercept

The percentage uncertainty in the y-intercept of a straight line graph can be calculated from the line of best fit and the intercept of the worst acceptable line.

$$\textit{percentage uncertainty} = \frac{|\,\textit{y-intercept}_{best} - \textit{y-intercept}_{worst}\,|}{\textit{y-intercept}_{best}} \times 100\%$$



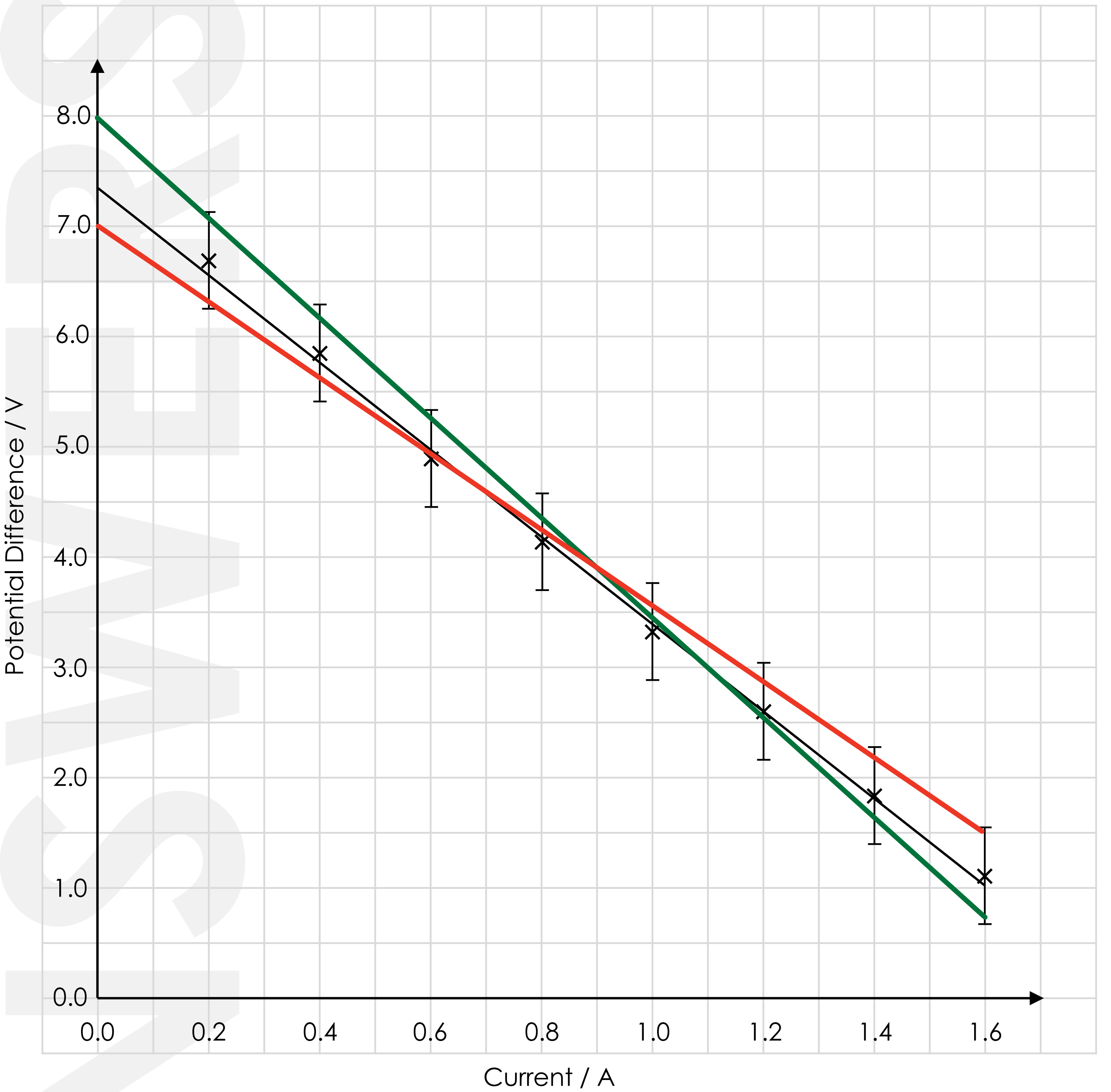
Note: The steepest or shallowest worst acceptable line can be used. If there are error bars on the plotted data then the worst acceptable line should pass through all of these.

1. Complete the following table:

	Y-intercept$_{best}$	Y-intercept$_{worst}$	Percentage Uncertainty / %
a.	1.00	1.10	10
b.	6.0	6.2	3.3
c.	6.0	5.6	6.7
d.	42.0	38.5	8.3

7th December – Part 2

2. The following data was collected in an A Level practical investigation.



The y-intercept of the line of best fit is equal to 7.3 V.

a. Draw in a **worst acceptable** line and determine the **y-intercept** of this line

7.0V or 8.0V

b. Calculate the **percentage uncertainty** in the y-intercept

From 4.1% to 9.6% depending on your worst acceptable line.

8th December

1 2 3

1. **Convert**:

   a. 1.00 J to eV

   $1.00 \div 1.60\times10^{-19} = \underline{6.25\times10^{18}}\ eV$

   b. 1.00 J to kWh

   $1.00 \div 1000 \times 3600 = \underline{2.78\times10^{-7}}\ kWh$

2. **Estimate** the:

   a. Mass of an adult male human

   About $\underline{80}$ kg

   b. The speed of a runner

   About $\underline{6}\ m s^{-1}$

   c. The mass of a family car

   About $\underline{1500}$ kg

   d. The kinetic energy of a running cat

   $m \approx 4\ kg \quad v \approx 5\ ms^{-1}$ $\quad E_K \approx \frac{1}{2}\times 4 \times 5^2 \approx \underline{50\ J}$

3. An L16 81 mm mortar is fired at 225 m s^{-1} at an angle of 70 degrees to the horizontal.

   Calculate how **far** the mortar bomb will travel horizontally before it hits the ground, listing any assumptions made.

$\rightarrow$ $s = ?$

$v = 225 \cos 70 = 76.95\ ms^{-1}$

$t_2 = 2\times t_1 = 43.105\ s$

$\uparrow$

$s =$

$u = 225 \sin 70 = 211.43\ ms^{-1}$

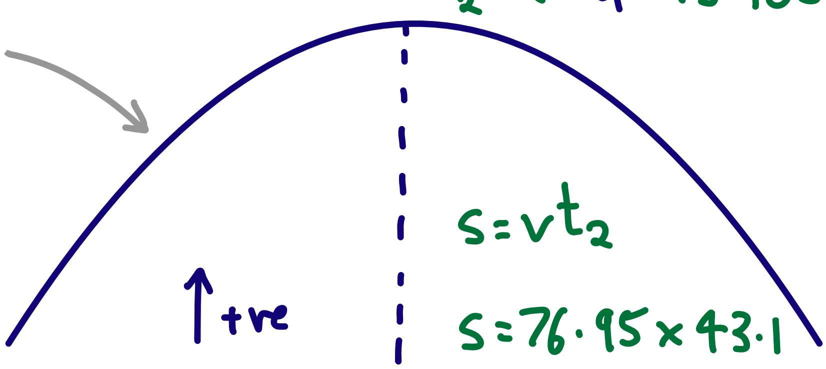
$v = 0$

$a = -9.81\ ms^{-2}$

$t_1 = ?$

$t_1 = \frac{v-u}{a} = \frac{0-211.43}{-9.81}$

$t_1 = 21.55\ s$



$\uparrow$ +ve

$s = vt_2$

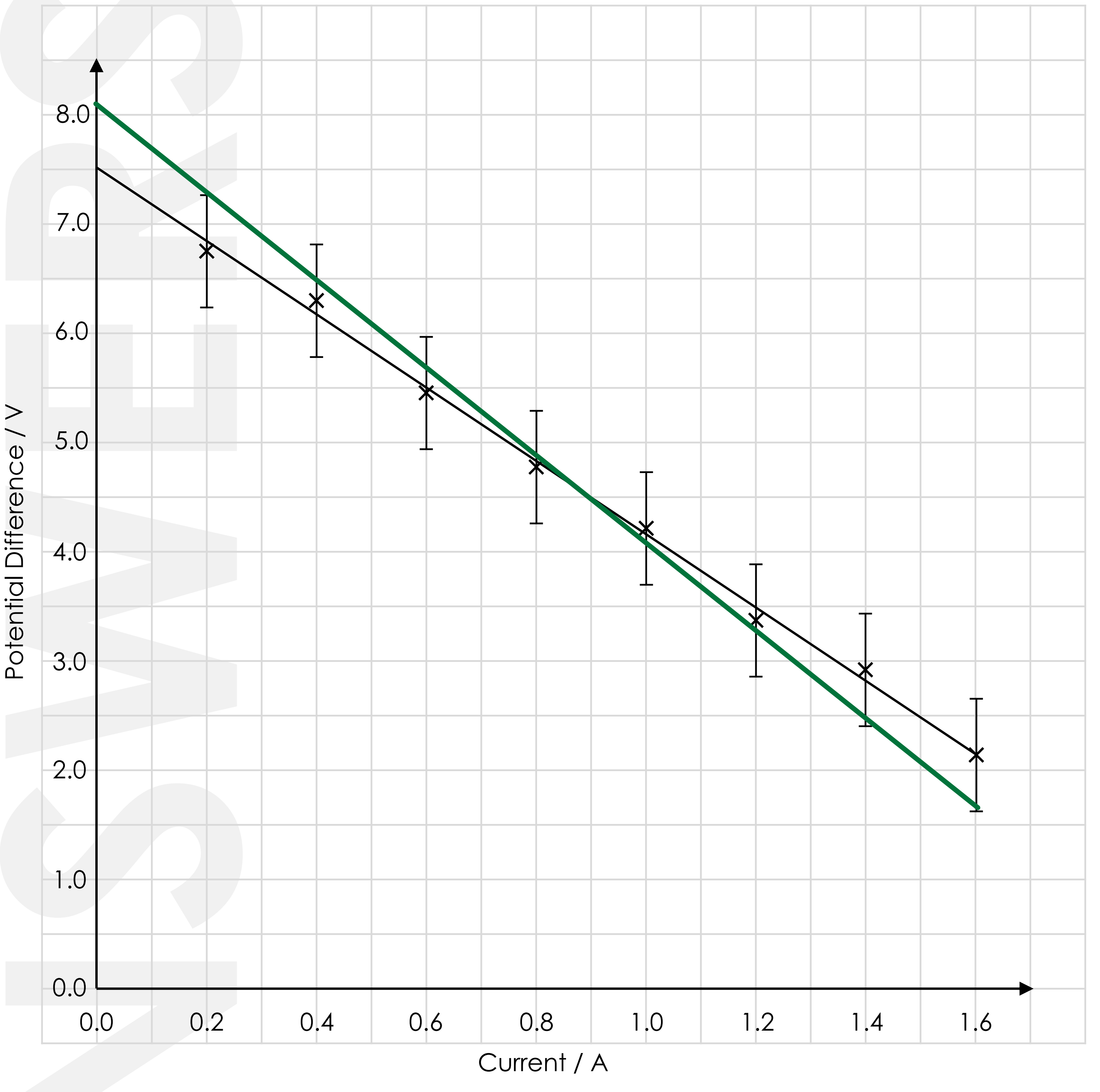
$s = 76.95 \times 43.1$

$s = 3317 \approx \underline{3.3}\ km$

9th December – Part 1

1

1. The following data was collected in an A Level practical investigation.



a. Determine the y-intercept of the **line of best fit**

7.5V

b. Draw in a **worst acceptable** line and determine the **y-intercept** of this line

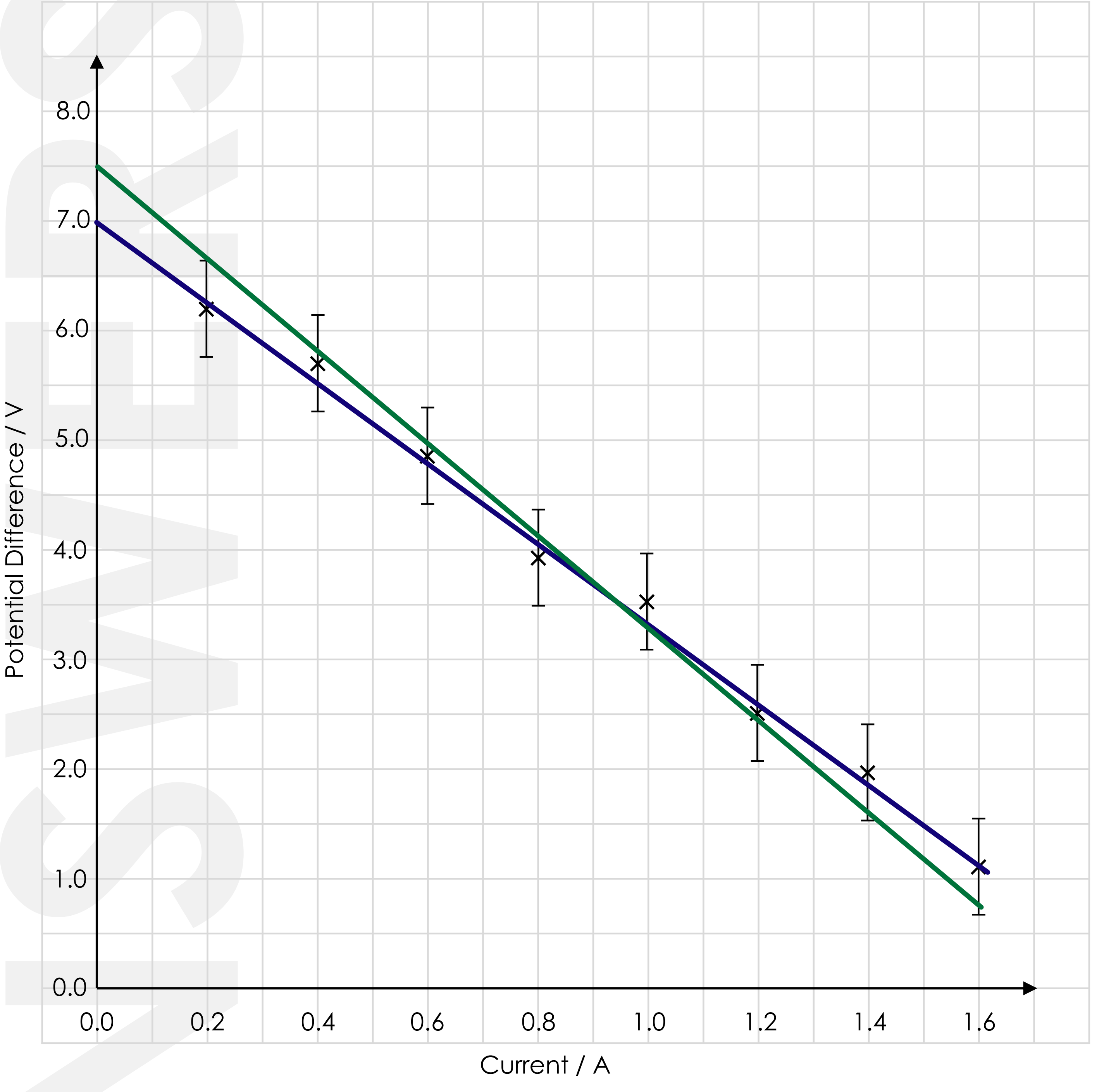
8.1V

c. Calculate the **percentage uncertainty** in the y-intercept

$$\frac{8.1 - 7.5}{7.5} \times 100 = 8.0\%$$

9th December – Part 2

2. The following data was collected in an A Level practical investigation.



Calculate the **percentage uncertainty** in the **y-intercept**.

$$\frac{7.5 - 7.0}{7.0} \times 100 = 7.1\%$$

10^{th} December

1. **Convert**:

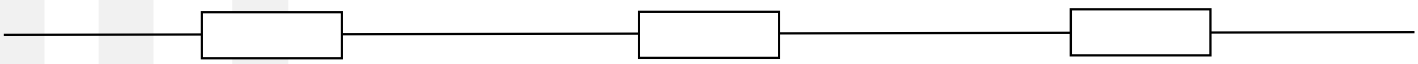
   a. 1.00 eV to kWh

   $$\frac{1.60\times10^{-19}}{3.60\times10^{6}} = \underline{4.44\times10^{-26}}\ \text{kWh}$$

   b. 6.50 TeV to J

   $$6.50\times10^{12}\times1.60\times10^{-19} = \underline{1.04\times10^{-6}}\ \text{J}$$

2. The following resistors are connected in series.



$R_1 = 47 \pm 0.2\ \Omega$ $R_2 = 10 \pm 0.5\ \Omega$ $R_3 = 47 \pm 0.1\ \Omega$

   a. Calculate their **combined** resistance

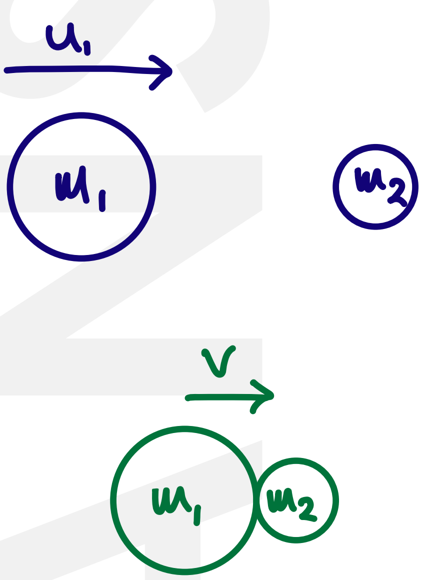
   $$R_T = R_1 + R_2 + R_3 = 47 + 10 + 47 = \underline{104}\ \Omega$$

   b. Calculate the **total uncertainty** in this value

   $$0.2 + 0.5 + 0.1 = \underline{\pm0.8}\ \Omega$$

3. A lioness of mass 140 kg is travelling at 22 m s^{-1} when she collides with a stationary baby zebra of mass 45 kg. Following the collision, they move off together.

   Calculate their **speed** following the collision.



$$P_{before} = P_{after}$$

$$P_{before} = m_1u_1 + m_2u_2$$
$$= (140\times22) + 0$$
$$= 3080\ \text{kg m s}^{-1}$$

$$P_{after} = (m_1+m_2)v$$

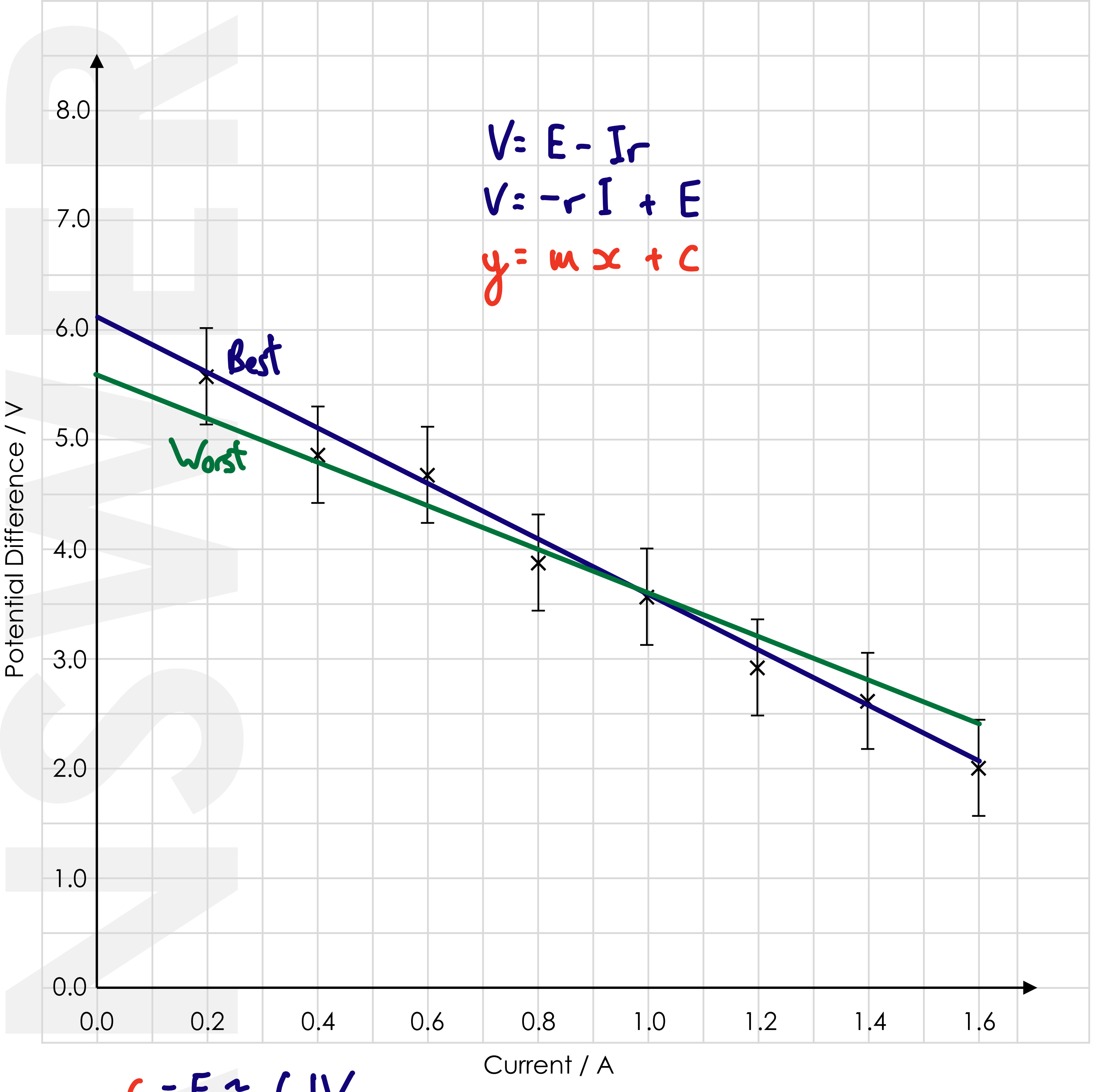
$$3080 = 185\times v$$

$$v = \frac{3080}{185} = 16.65 \approx \underline{17}\ \text{ms}^{-1}$$

11th December

1. An investigation was carried out to calculate the internal resistance of a cell. For the following data, the y-intercept is equal to the EMF. ‘E’ (sometimes the symbol ‘ε’ is also used) of the cell and the negative value of the gradient is equal to the internal resistance ‘r’.

   Calculate the values of **E** and **r** and the **percentage uncertainty** in the EMF.



$c = E \approx \underline{6.1V}$

$c_{worst} \approx 5.6\,V$

$\frac{6.1 - 5.6}{6.1} \times 100 = \underline{8.2}\,\%$

$m = \frac{2.1 - 6.1}{1.6 - 0} = -2.5$

$m = -r \qquad r = \underline{2.5}\,\Omega$

12th December

1. Complete the following **nuclear** equations:

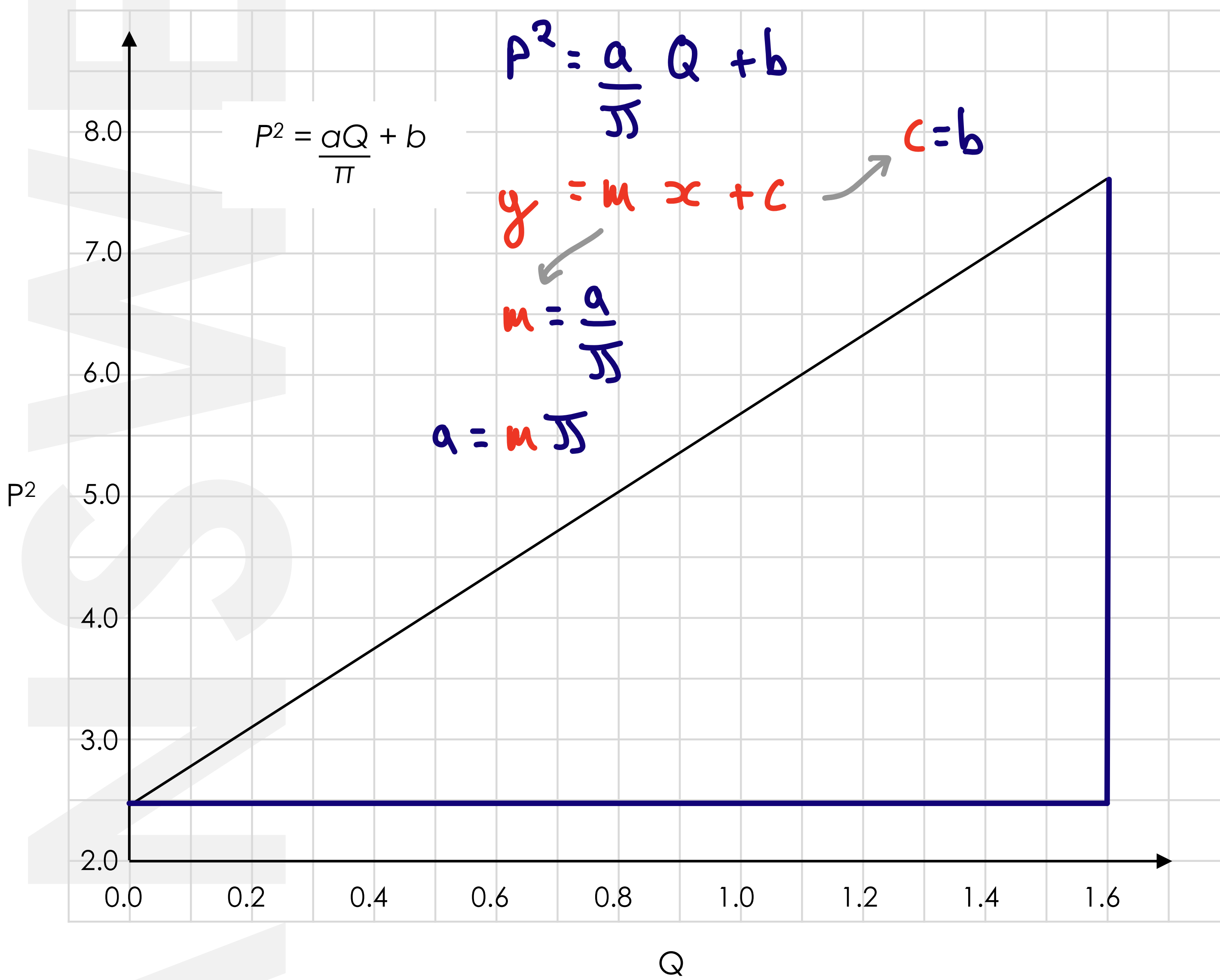
a. $^{239}_{94}Pu \longrightarrow {}^{235}_{92}U + {}^{4}_{2}a$

b. $^{187}_{75}Re \longrightarrow {}^{187}_{76}Os + {}^{0}_{-1}\beta + \bar{\nu}_e$

c. $^{60}_{27}Co \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}Y$

d. $^{13}_{4}Be \longrightarrow {}^{12}_{4}Be + {}^{1}_{0}n$

2. Determine the values of **a** and **b** using the gradient and y-intercept.



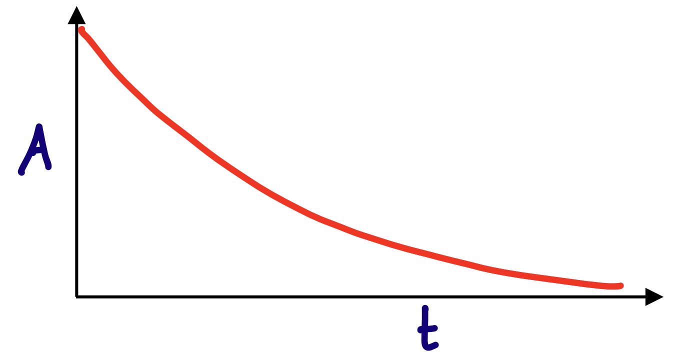
$m = \frac{7.6 - 2.5}{1.6 - 0} = 3.1875$

$c = b = \underline{2.5}$

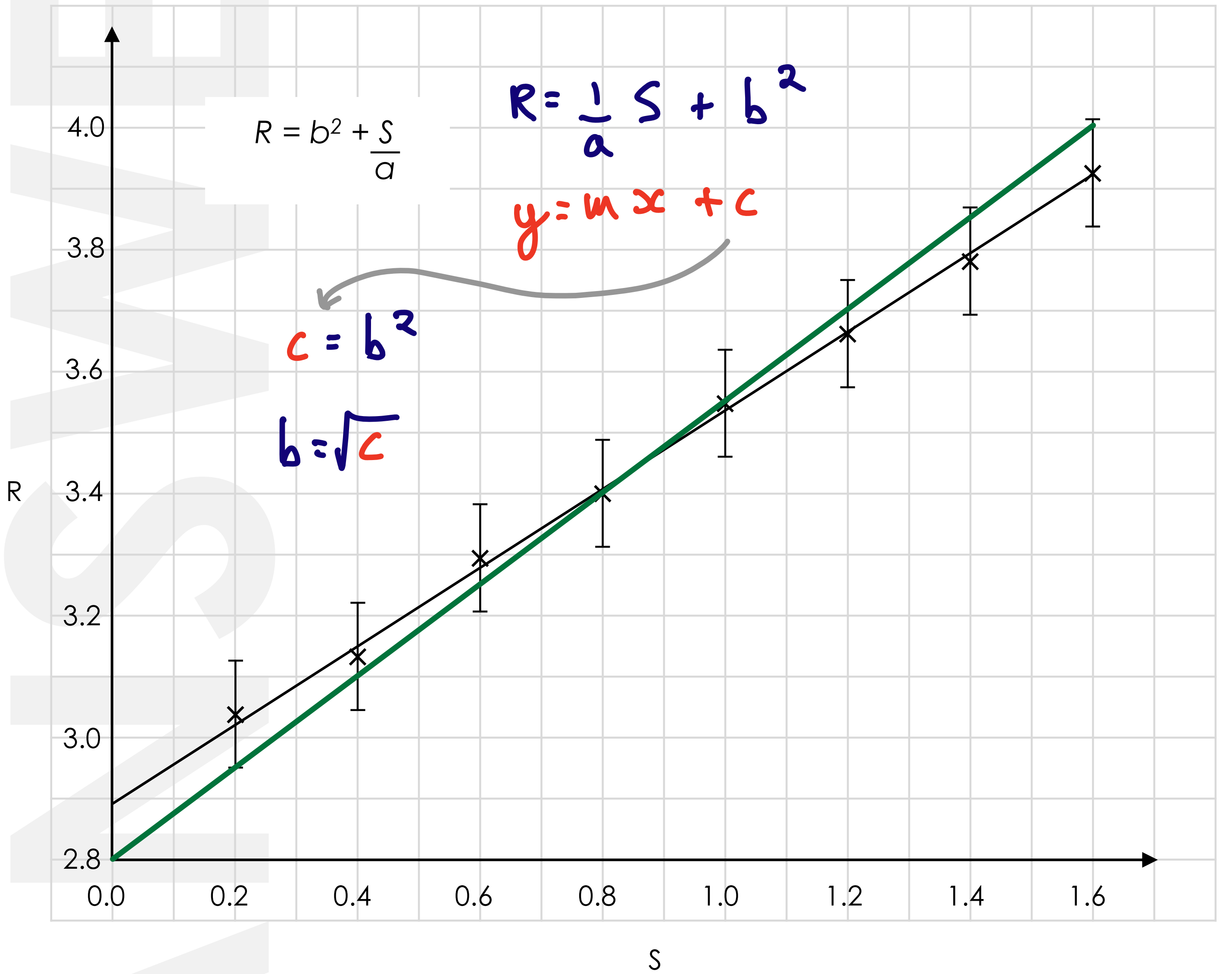
$a = m\pi = 3.1875 \times \pi = \underline{10}$

13th December

1. Sketch a graph showing the **activity** of a radioactive sample against time.



2. Determine the value of the constant **b** and the **percentage uncertainty** in this value.



$C_{worst} = 2.8$

$C_{best} = 2.9$

$b = \sqrt{2.9} = 1.7$

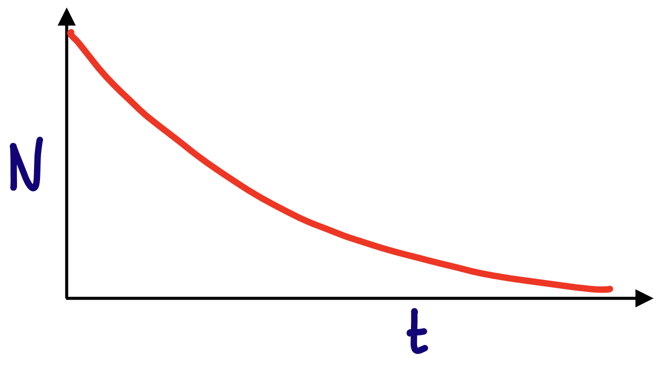
$\%C = \frac{2.9 - 2.8}{2.9} \times 100 = 3.448\%$

$b = \sqrt{C}$ $\quad \%b = \%C \div 2 = \frac{3.448}{2} = 1.7\%$

14th December

1 2

1. Sketch a graph showing the **number of nuclei** of a radioactive sample with time.



2. **Complete** the following table:

	Quantity	Symbol	Unit
a.	Acceleration	a	ms^{-2}
b.	Capacitance	C	farad, F
c.	Charge	Q	C
d.	Displacement	s or x	m
e.	Electromotive force	E or $\mathcal{E}$	V
f.	Gravitational potential	V or V_g	$J\,kg^{-1}$
g.	Gravitational field strength	g	$N\,kg^{-1}$
h.	Intensity	I	Wm^{-2}
i.	Magnetic flux	ϕ	Wb
j.	Magnetic flux density	B	T
k.	Potential difference	V	V
l.	Pressure	p	Pa
m.	Radius	r	m
n.	Resistance	R	Ω
o.	Resistivity	ρ	Ωm
p.	Specific latent heat	L	$J\,kg^{-1}$
q.	Strain	ε	–
r.	Stress	σ	Pa
s.	Temperature	T or θ	K or $°C$

15th December

1 2 3

1. Three lamps of resistance 5.0 Ω , 10 Ω and 20 Ω are in parallel with a cell of e.m.f 6.0 V. Calculate the **total current** drawn from the battery. Assume the cell has negligible internal resistance.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{5.0} + \frac{1}{10} + \frac{1}{20} \qquad R_T = 2.857\,\Omega$$

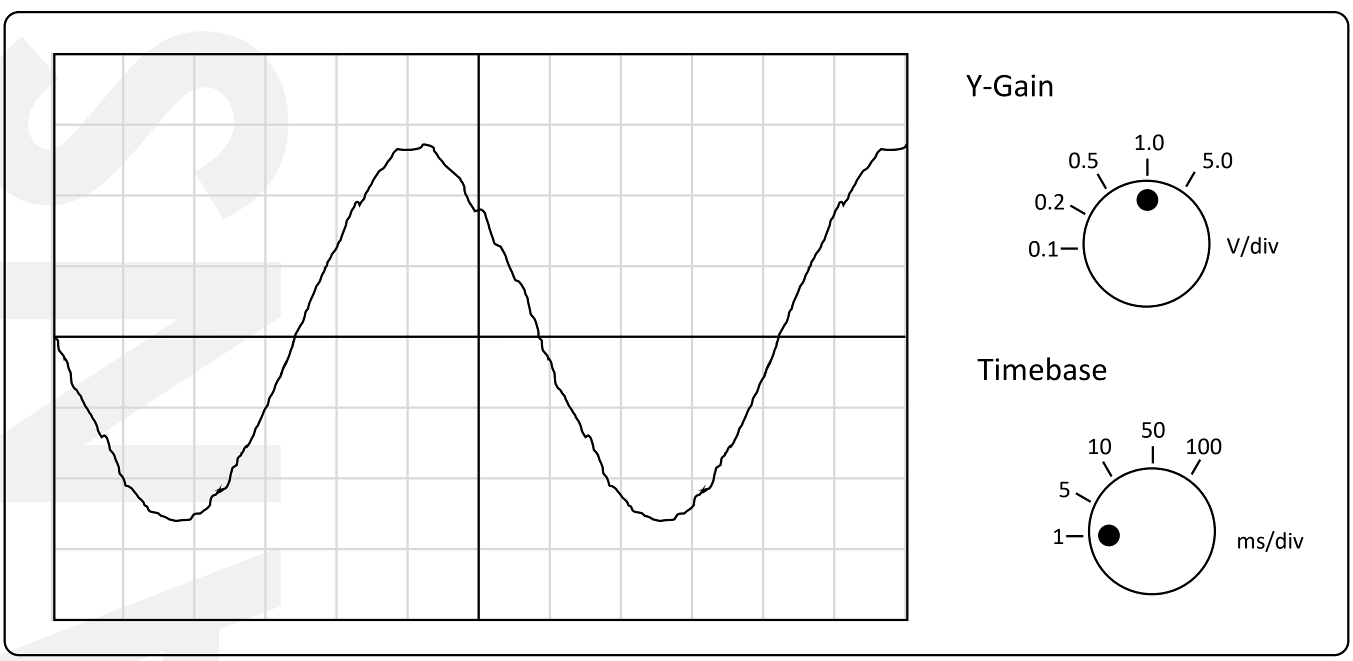
$$I = \frac{V}{R_T} = \frac{6.0}{2.857} = \underline{2.1}\,A$$

2. Calculate the **specific charge** (charge per unit mass) of a proton.

$m_p = 1.67 \times 10^{-27}$ kg and $Q_p = +1.60 \times 10^{-19}$ C

$$\frac{Q}{m} = \frac{1.60\times10^{-19}}{1.67\times10^{-27}} = \underline{9.58\times10^{7}}\ C\,kg^{-1}$$

3. Determine the **amplitude** (in V) and **frequency** of the signal on this oscilloscope trace.



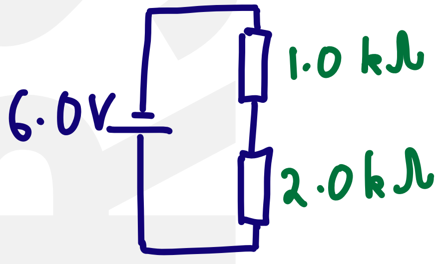
$$A: 2.8 \times 1.0 = \underline{2.8}V \qquad f = \frac{1}{T} = \frac{1}{6.8\times1\times10^{-3}} = 147 \approx \underline{150}\,Hz$$

16th December

1 2 3

1. A potential divider consists of a 1.0 kΩ resistor and a 2.0 kΩ resistor. The input potential difference to the potential divider is 6.0 V.

   Calculate the **potential difference** across the 1.0 kΩ resistor.



Ratio of 1:2

$V \propto R$

$V = \underline{2.0\,V}$

2. Calculate the **specific charge** of an electron.

   $m_e = 9.11 \times 10^{-31}$ kg and $Q_e = -1.60 \times 10^{-19}$ C

$$\frac{Q}{m} = \frac{1.60 \times 10^{-19}}{9.11 \times 10^{-31}} = \underline{1.76 \times 10^{11}}\ C\,kg^{-1}$$

3. Calculate the **internal resistance** of a battery of e.m.f 12 V if its terminal p.d falls to 10 V when it supplies a current of 2.0 A.

$$E = V + Ir$$

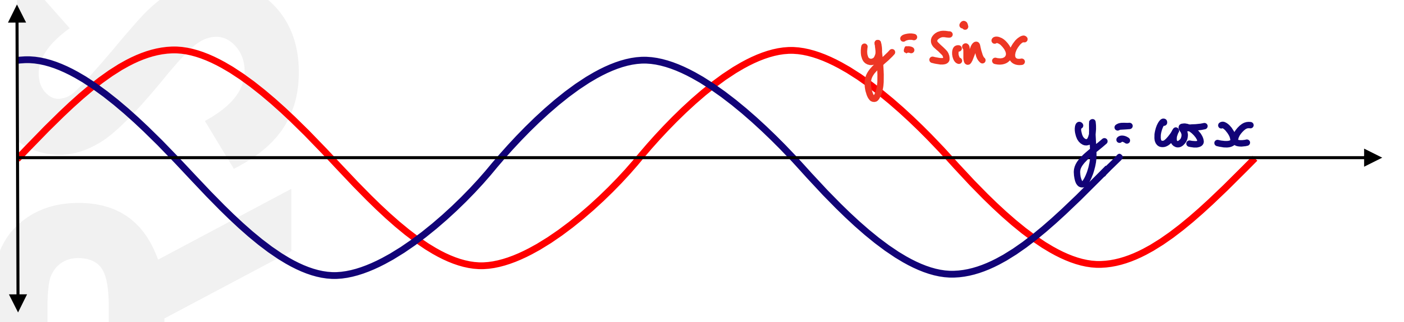
$$r = \frac{E - V}{I}$$

$$r = \frac{12 - 10}{2.0}$$

$$r = \underline{1.0}\,\Omega$$

17th December

1. **Sketch** graphs of *y* = *cos x* and *y* = *sin x* on the same axis.



2. **Complete** the following table:

	Quantity	Symbol	Unit
a.	Activity	A	Bq
b.	Amplitude	A	metre, m
c.	Area	A	m^2
d.	Critical angle	θ_c or c	$^\circ$
e.	Density	ρ	$kg\ m^{-3}$
f.	Half-life	$t_{1/2}$	s
g.	Magnetic flux	ϕ	Wb
h.	Magnetic flux density	B	T
i.	Period	T	s
j.	Planck's constant	h	J s
k.	Refractive index	n	—
l.	Resistance	R	Ω
m.	Resistivity	ρ	Ωm
n.	Temperature	T or θ	K or °C
o.	Time	t	s
p.	Time constant	τ	s
q.	Wavelength	λ	m
r.	Work function	ϕ	eV or J
s.	Young modulus	E	Pa

18th December

1 2 3

1. Calculate the **specific charge** of a neutron.

$m_n = 1.67 \times 10^{-27}$ kg and $Q_n = 0$ C

$$\frac{Q}{m} = \frac{0}{1.67 \times 10^{-27}} = \underline{0}\ C\ kg^{-1}$$

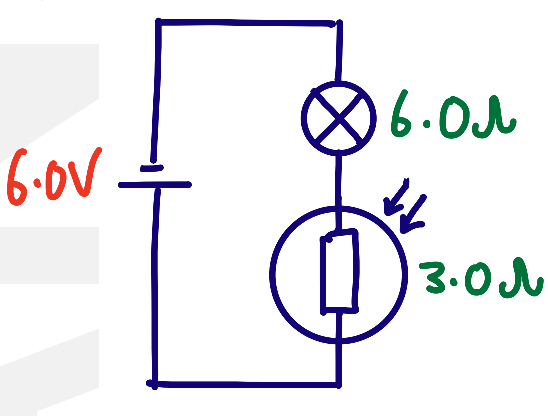
2. The volume of a piece of granite is measured by placing it in a measuring cylinder containing water. The level of the water raises from 100 ml to 158 ml. The mass of the rock is 88 g.

   Calculate the **density** of the rock.

$$\rho = \frac{m}{V} = \frac{88 \times 10^{-3}}{(158-100)\times 10^{-6}} = 1517 \approx \underline{1500}\ kg\ m^{-3}$$

3. A battery of negligible internal resistance supplies an e.m.f of 6.0 V to an LDR and a bulb in series with the battery. The LDR has a resistance of 3.0 Ω and the bulb has a resistance of 6.0 Ω.

   Calculate the **potential difference** across the bulb.



Ratio of 2:1

$V \propto R$

$V = \underline{4.0}V$

19th December

1 2

1. A lamp has a current of 200 mA flowing through it and a resistance of 20 Ω. Calculate the **power** of the lamp.

$$P = I^2 R = (200\times10^{-3})^2 \times 20 = \underline{0.80}\,W$$

2. **Complete** the following table:

	Quantity	Symbol	Unit
a.	Angular velocity	ω	rad s^{-1}
b.	Boltzmann's constant	k	m^2 kg s^{-2} K^{-1}
c.	Force	F	N
d.	Gravitational constant	G	N m^2 kg^{-2}
e.	Gravitational field strength	g	N kg^{-1}
f.	Gravitational potential	V or V_g	J kg^{-1}
g.	Gravitational potential energy	E_p	J
h.	Planck's constant	h	J s
i.	Refractive index	n	—
j.	Specific heat capacity	c	J kg^{-1} K^{-1}
k.	Specific latent heat	L	J kg^{-1}
l.	Speed of light	c	m s^{-1}
m.	Spring constant	k	N m^{-1}
n.	Strain	ε	—
o.	Stress	σ	Pa
p.	Weight	W	N
q.	Work done	W	J
r.	Work function	ϕ	eV or J
s.	Young modulus	E	Pa

20th December

1 2 3

1. A stick is thrown directly upwards in the air and takes 1.80 s to reach its maximum height.

   Calculate the **speed** the stick was thrown at.

   s
   $u = ?$
   $v = 0\ \text{m s}^{-1}$
   $a = -9.81\ \text{m s}^{-2}$
   $t = 1.80\ \text{s}$

   $v = u + at$
   $u = v - at$
   $u = 0 - (-)9.81 \times 1.80$
   $u = 17.658 = 17.7\ \text{m s}^{-1}$

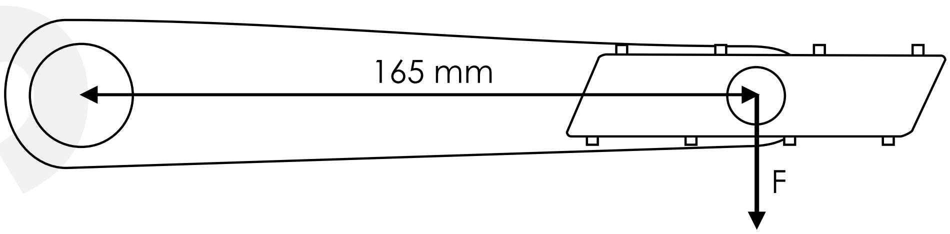
2. A gas is stored at a pressure of 480 kPa in an expandable container of initial volume 1.5 m^3.

   Calculate the final **pressure** if the volume slowly increases to 12 m^3 at a constant temperature.

   $p_1V_1 = p_2V_2$

   $p_2 = p_1\dfrac{V_1}{V_2} = 480 \times \dfrac{1.5}{12} = 60\ \text{kPa}$

3. A force is applied to a pedal on a mountain bike that is 165 ± 1 mm from the axis of rotation. The torque (moment) is measured with a sensor as 300 Nm ± 2%.



   Calculate the **force** applied and the **total percentage uncertainty** in this value.

   $M = Fs \qquad F = \dfrac{M}{s} = \dfrac{300}{0.165} = 1818 = 1.82\ \text{kN}$

   $\%M = 2\%$

   $\%s = \dfrac{1}{165} \times 100 = 0.60\%$

   $\%F = \%M + \%s$
   $\%F = 2 + 0.60$
   $\%F = 2.6\%$

21^{st} December

1 2 3

1. A metal wire of original length 1.6 m is extended by 4.1 mm when a force is applied.

   Calculate the **strain** in the wire.

$$\varepsilon = \frac{\Delta L}{L} = \frac{0.0041}{1.6} = 2.6 \times 10^{-3}$$

2. A plaster is submerged under 2.00 m of water in the deep end of a swimming pool.

   Calculate the additional **pressure** on this object due to the water above it.

$\rho_{water} = 997\ \text{kg m}^{-3}$

$$\Delta p = \rho g \Delta h = 997 \times 9.81 \times 2.00$$

$$\Delta p = 19561 = 19.6\ \text{kPa}$$

3. The e.m.f of a battery is 4.5 V. When a 10 Ω resistor is connected in series to the battery, the terminal potential difference drops to 4.2 V.

   Calculate the **internal resistance** of the battery.

$$I = \frac{V}{R} = \frac{4.2}{10} = 0.42\ \text{A}$$

$$E = V + Ir$$

$$r = \frac{E - V}{I} = \frac{4.5 - 4.2}{0.42} = 0.71\ \Omega$$

22nd December

1. A piece of SWG* 25 copper wire is 1.00 m long and has a diameter of 0.508 mm.

*Standard Wire Gauge

Quantity	Value
Resistivity	$1.72 \times 10^{-8}\ \Omega\ m$
Charge carrier density	$8.49 \times 10^{28}\ m^{-3}$
Density	$8900\ kg\ m^{-3}$
Young modulus	130 GPa
Ultimate tensile strength	210 MPa
Poisson's ratio	0.33
Specific heat capacity	$385\ J\ kg^{-1}\ K^{-1}$
Melting point	1083 ˚C
Boiling point	2562 ˚C

Table 1: Data for copper

Use the data in Table 1 to calculate:

a. The **mass** of the wire

$$m = \rho V = \rho \frac{\pi d^2 l}{4} = \frac{8900 \times \pi \times (0.508 \times 10^{-3})^2 \times 1.00}{4}$$

$$m = \underline{1.80 \times 10^{-3}}\ kg$$

b. The **tensile force** that would cause the wire to break

$$\sigma_{UTS} = \frac{F_{max}}{A} \qquad F_{max} = \sigma_{UTS} A = \sigma_{UTS} \frac{\pi d^2}{4}$$

$$F_{max} = \frac{210 \times 10^6 \times \pi \times (0.508 \times 10^{-3})^2}{4} = \underline{42.6}\ N$$

23rd December

1. A piece of SWG 25 copper wire is 1.00 m long and has a diameter of 0.508 mm.

Quantity	Value
Resistivity	1.72×10^{-8} Ω m
Charge carrier density	8.49×10^{28} m^{-3}
Density	8900 kg m^{-3}
Young modulus	130 GPa
Ultimate tensile strength	210 MPa
Poisson's ratio	0.33
Specific heat capacity	385 J kg^{-1} K^{-1}
Melting point	1083 ˚C
Boiling point	2562 ˚C

Table 1: Data for copper

Use the data in Table 1, and your previous answers, to calculate:

a. The **resistance** of the wire

$$R = \frac{\rho L}{A} = \frac{4\rho L}{\pi d^2} = \frac{4 \times 1.72\times10^{-8} \times 1.00}{\pi \times (0.508\times10^{-3})^2} = \underline{0.0849\ \Omega}$$

b. The **change in temperature** when a current of 250 mA flows for 30 seconds

$$\Delta E = mc\Delta\theta \qquad E = Pt = I^2Rt$$

$$I^2Rt = mc\Delta\theta$$

$$\Delta\theta = \frac{I^2Rt}{mc} = \frac{0.250^2 \times 0.0849 \times 30}{1.80\times10^{-3} \times 385} = \underline{23.0\ K}$$

From yesterday

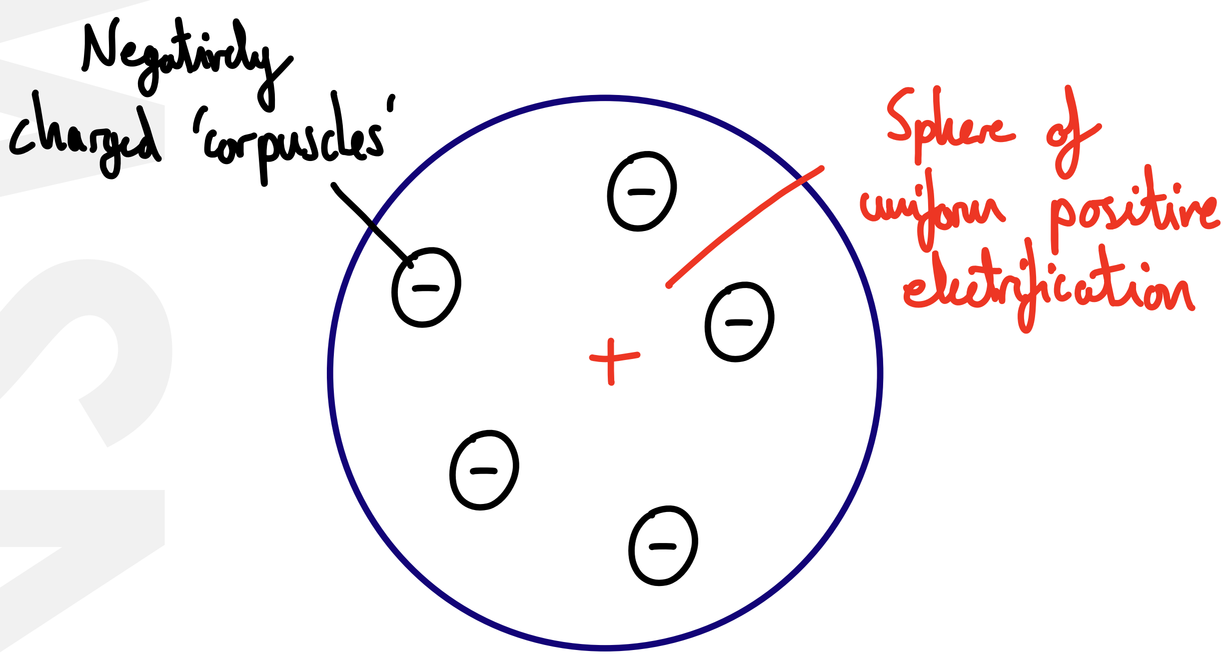
24th December

1 2

1. Calculate the **relative mass** of an electron if its mass is 9.11 x 10^{-31} kg and a proton's mass is 1.67 x 10^{-27} kg, providing that the relative mass of a proton is exactly 1.

$$\frac{m_e}{m_p} = \frac{9.11 \times 10^{-31}}{1.67 \times 10^{-27}} = \underline{5.46 \times 10^{-4}} \quad \left(\frac{1}{1833}\right)$$

2. Describe, with the aid of a labelled diagram, Sir Joseph John Thomson's **plum pudding** model of the atom.

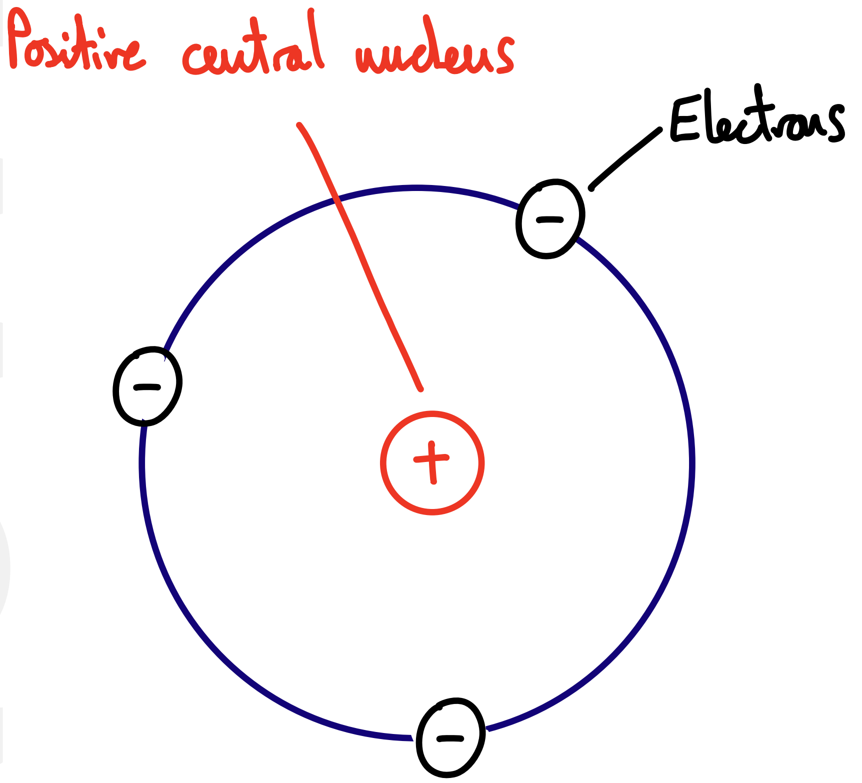


25th December

1. A free neutron undergoes beta minus decay with a half-life of just over 10 minutes. Write an **equation** describing this process.

$$ {}^{1}_{0}n \rightarrow {}^{0}_{-1}\beta + {}^{1}_{1}p + \bar{\nu}_e $$

2. Briefly describe, with the aid of a diagram, Ernest Rutherford's **nuclear** model of the atom and the experiments carried out by Hans Geiger and Ernest Marsden.



Most alpha particles passed through ∴ mostly empty space.

Some alpha particles deflected by more than 90° ∴ nucleus must have a positive charge.

26^{th} December

1. A piece of SWG 25 copper wire is 1.00 m long and has a diameter of 0.508 mm.

Quantity	Value
Resistivity	1.72×10^{-8} Ω m
Charge carrier density	8.49×10^{28} m^{-3}
Density	8900 kg m^{-3}
Young modulus	130 GPa
Ultimate tensile strength	210 MPa
Poisson's ratio	0.33
Specific heat capacity	385 J kg^{-1} K^{-1}
Melting point	1083 ˚C
Boiling point	2562 ˚C

Table 1: Data for copper

Use the data in Table 1, and your previous answers, to calculate:

a. The **extension** when a 100 N tensile load is applied

$$E = \frac{\sigma}{\varepsilon} = \frac{F/A}{e/L} = \frac{FL}{eA}$$

$$e = \frac{FL}{EA} = \frac{4FL}{E\pi d^2} = \frac{4 \times 100 \times 1.00}{130\times10^9 \times \pi \times (0.508\times10^{-3})^2} = \underline{3.80\times10^{-3}}\ \text{m}$$

b. The **electron drift velocity** when a p.d. of 1.50 V is applied across the ends of the wire*

$$I = Anev \qquad I = \frac{V}{R} \qquad A = \frac{\pi d^2}{4}$$

*This is not covered in the AQA spec

$$\frac{V}{R} = \frac{\pi d^2 nev}{4}$$

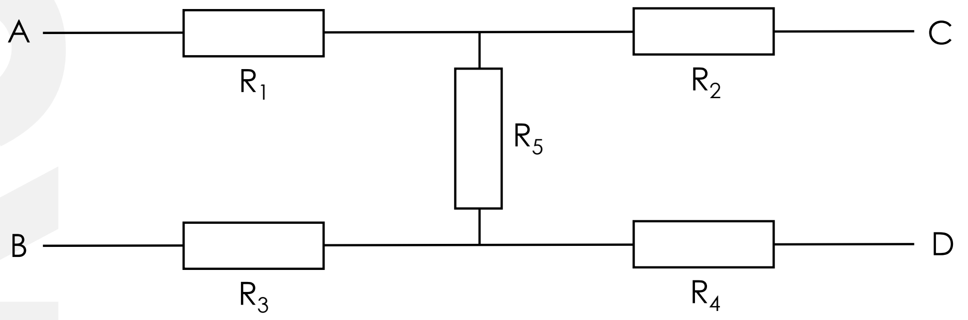
$$v = \frac{4V}{R\pi d^2 ne}$$

$$v = \frac{4 \times 1.50}{0.0849 \times \pi \times (0.508\times10^{-3})^2 \times 8.49\times10^{28} \times 1.60\times10^{-19}}$$

$$v = \underline{6.42\times10^{-3}}\ \text{m s}^{-1}$$

27th December

1. The following procedure is used to find the value of the resistance R_5.



A potential difference of 1.5 V is connected in turn across various points in the arrangement.

- With 1.5 V applied across terminals AC a current of 37.5 mA flows
- With 1.5 V applied across terminals BD a current of 25 mA flows
- With 1.5 V applied across terminals AB a current of 30 mA flows
- With 1.5 V applied across terminals CD a current of 15 mA flows

a. Write down three **equations** for the total resistance between BD, AB and CD in terms of R_1, R_2, R_3, R_4 and R_5

$R_{AC} = R_1 + R_2$ $\qquad$ $R_{BD} = R_3 + R_4$

$R_{AB} = R_1 + R_3 + R_5$ $\qquad$ $R_{CD} = R_2 + R_4 + R_5$

b. Calculate the **resistance** between AC, BD, AB and CD

$R_{AC} = \frac{V}{I} = \frac{1.5}{0.0375} = 40\,\Omega$ $\qquad$ $R_{BD} = \frac{V}{I} = \frac{1.5}{0.025} = 60\,\Omega$

$R_{AB} = \frac{V}{I} = \frac{1.5}{0.030} = 50\,\Omega$ $\qquad$ $R_{CD} = \frac{V}{I} = \frac{1.5}{0.015} = 100\,\Omega$

c. Determine the **value** of resistor R_5

$R_{AB} + R_{CD} - R_{AC} - R_{BC}$

$\cancel{R_1} + \cancel{R_3} + R_5 + \cancel{R_2} + \cancel{R_4} + R_5 - \cancel{R_1} - \cancel{R_2} - \cancel{R_3} - \cancel{R_4} = 2R_5$

$50 + 100 - 40 - 60 = 50\,\Omega$ $\qquad$ $2R_5 = 50\,\Omega$

$R_5 = \underline{25\,\Omega}$

Adapted from a BPhO question from the 2010 Year 12 Challenge

28th December

1 2 3

1. Calculate the **specific charge** of a helium nucleus.

$m_{He} = 6.646 \times 10^{-27}$ kg

$$\frac{Q}{m} = \frac{2 \times 1.60 \times 10^{-19}}{6.646 \times 10^{-27}} = 4.81 \times 10^{7} \ C\,kg^{-1}$$

2. Five measurements of the diameter of a wire are made: 1.10 mm, 1.05 mm, 1.02 mm, 1.11 mm and 1.12 mm.

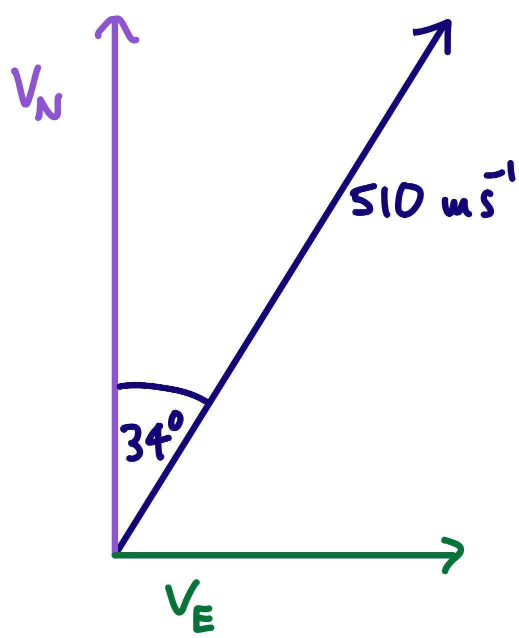
Calculate the **mean** diameter and its **absolute certainty**.

1.08 mm

$$\tfrac{1}{2}\text{ range} = \frac{1.12 - 1.02}{2} = \pm\, 0.05 \text{ mm}$$

3. An F-35B Lightning jet flies at Mach 1.5 (510 m s^{-1}) on a bearing of 034˚.

Draw a sketch diagram and calculate the **components** of velocity in the northerly and easterly directions.



$V_N = 510 \cos 34°$

$V_N = 423$ m s^{-1}

$V_E = 510 \sin 34°$

$V_E = 285$ m s^{-1}

29th December

1 2 3

1. Calculate the **activity** of a sample, that had an original activity of 1000 Bq, after 3 half-lives.

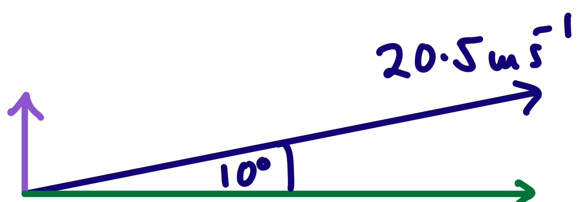
$$A = \frac{1000}{2^3} = \underline{125}\ \text{Bq}$$

2. A tennis ball is hit at an initial velocity of 20.5 m s^{-1} at an angle of 10.0 degrees above the horizontal.

   Calculate the **horizontal** and **vertical** components of the tennis ball's velocity.

$V_v = 20.5 \sin 10$

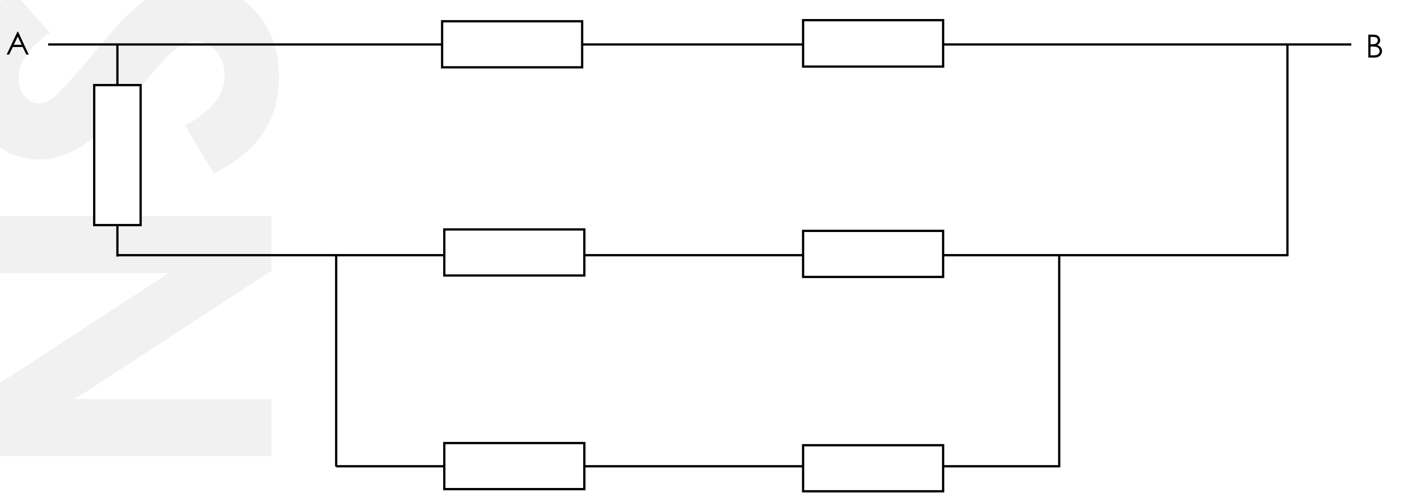
$V_v = \underline{3.56}\ \text{m s}^{-1}$

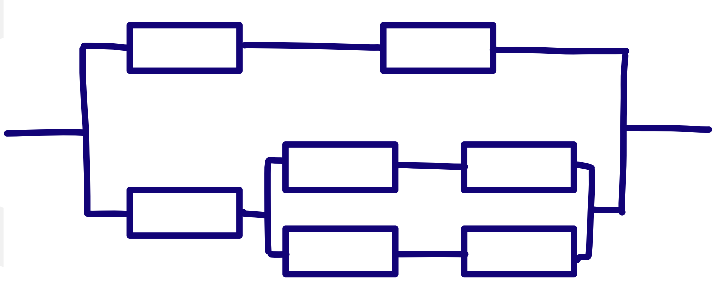


$V_h = 20.5 \cos 10 = \underline{20.2}\ \text{m s}^{-1}$

3. Each identical resistor in the network has a resistance of R.

   Calculate the **combined resistance** between A and B in terms of R.





$R_T = \underline{R}$

30th December

1. Write down the following **values** (from memory if possible):

    a. Mass of an electron 9.11×10^{-31} kg

    b. Mass of a neutron 1.67×10^{-27} kg

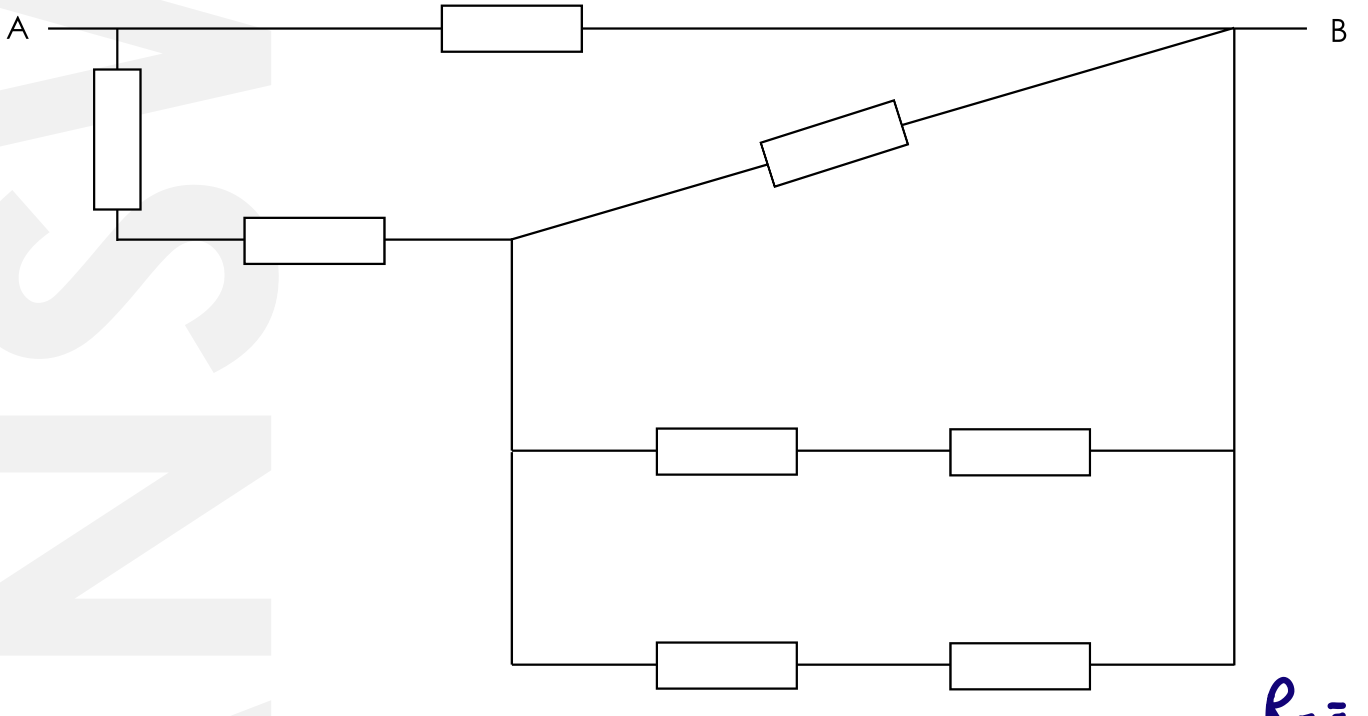
    c. Charge of a proton $+1.60 \times 10^{-19}$ C

    d. One electronvolt in joules 1.60×10^{-19} J

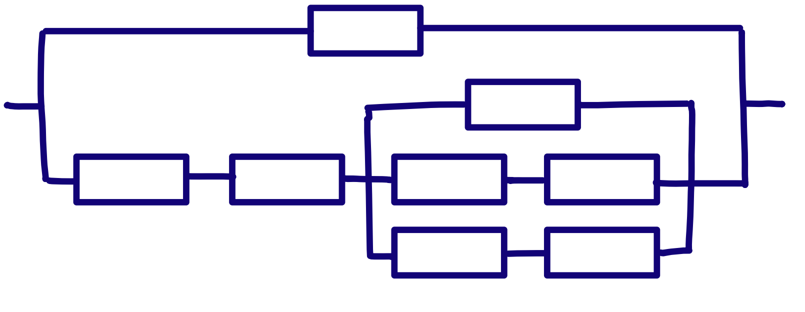
    e. Wavelength of red light 620 – 700 nm

2. Each identical resistor in the network has a resistance of R.

    Calculate the **combined resistance** between A and B in terms of R.



$R_T = \frac{5}{7}R$



31st December

1

1. Using the graph below:

   a. Calculate the **maximum positive acceleration** $\approx 2.3\ m s^{-2}$

   b. Estimate the **displacement** between 3.5 s and 8.0 s $\approx 35\ m$