1st April

1. Stationary waves can be produced in a piece of equipment called a Kundt's tube. This is a horizontal glass tube containing small dry particles such as cork dust or lycopodium powder. A loudspeaker is fitted into one end and can produce sound waves of different frequencies. A piston in the other end allows the length of air to be adjusted so that a loud sound occurs as the air and particles resonate.

a. Small piles of cork dust are seen in a resonating Kundt's tube. **Explain** if these are going to show positions of nodes or antinodes

Nodes, as this is where the amplitude of vibrations of the air inside the tube is at a minimum

b. In terms of λ, state how **far apart** the piles of dust will be

Node to a node is equal to half a wavelength $\therefore \frac{\lambda}{2}$

For a separate 1.20 m length tube, different frequency sound waves are introduced and the distances between piles of lycopodium powder measured.

c. Use the information in the table to calculate values for the **speed of sound** in air

Frequency / Hz	Distance / cm	Speed / m s^{-1}
493	34.2	337
392	45.2	354
459	37.0	340

$v = f\lambda$

$d = \frac{\lambda}{2}$

$v = 2fd$

d. Calculate the **mean** value for the speed and its **percentage uncertainty**

Mean = 344 ms^{-1}

$\%U = \frac{(354-337)\div 2}{344} \times 100 = 2.5\%$

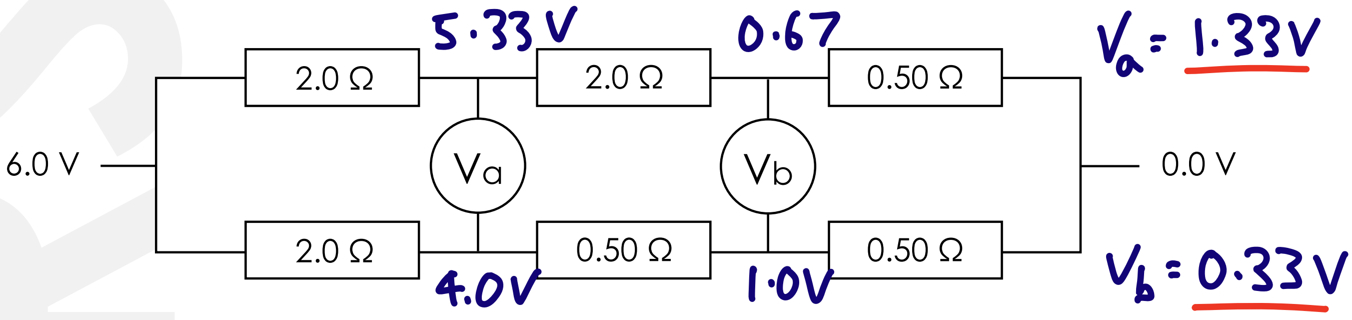
e. Find out what lycopodium powder is and what **properties** make it particularly suitable for use in the Kundt's tube

It stays dry and powdery, even in a moist environment

2nd April

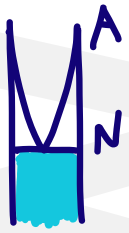
1 2 3

1. Calculate the **reading** on the high-resistance **voltmeters** V_a and V_b.



2. A student holds a vibrating tuning fork with frequency 425 Hz over a column of air formed in a vertical glass tube. They adjust the length of the air column by moving the glass tube vertically inside a measuring cylinder containing water. They first hear the air resonating when the length of air is 20 cm (at the fundamental frequency).

Calculate a value for the **speed of sound** from this data.



$L = \frac{\lambda}{4}$

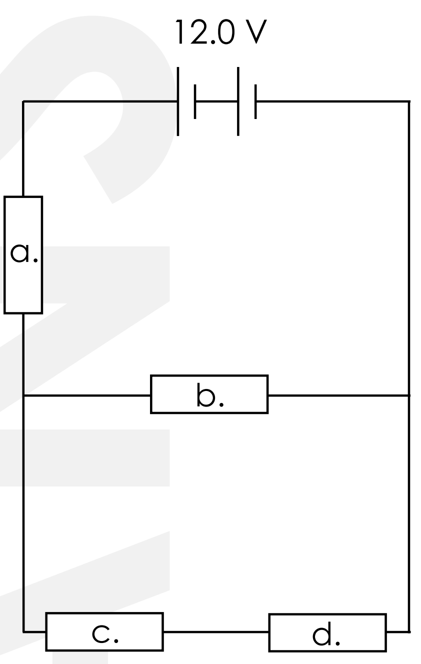
$v = f\lambda$

$v = 4fL = 4 \times 425 \times 0.20$

$v = 340 \text{ ms}^{-1}$

3. Complete the table for the **circuit below** (the battery has negligible internal resistance):

$V = IR \quad I = \frac{V}{R} \quad R = \frac{V}{I}$



Resistor	R / Ω	V / V	I / A
a.	10	4.0	0.40
b.	27	8.0	0.30
c.	60	6.0	0.10
d.	20	2.0	0.10

3rd April

1 2 3

1. A micrometer (giving readings with an absolute uncertainty of ± 0.01 mm) is used to measure the thickness of aluminium foil. This gives a value of 0.62 mm. Calculate the **percentage uncertainty** in this measurement and suggest how a **more accurate** value could be recorded.

$$\% U = \frac{0.01}{0.62} \times 100 = \underline{1.6\%}$$

2. Define:

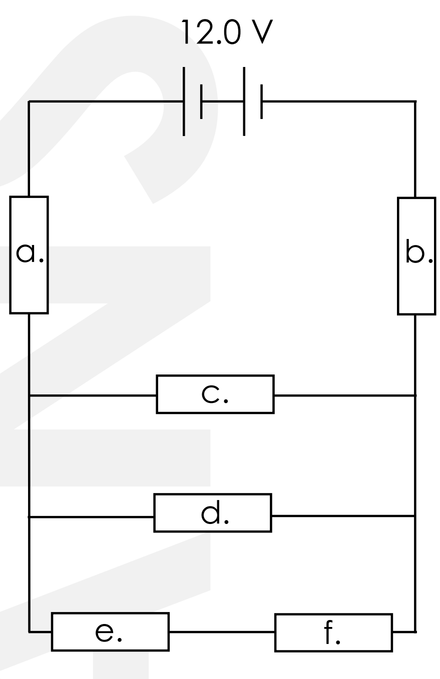
   a. A **standing** wave

   See the definition in the back of the book

   b. An **antinode**

3. Complete the table for the **circuit below** (the battery has negligible internal resistance):

$V = IR \quad I = \frac{V}{R} \quad R = \frac{V}{I}$

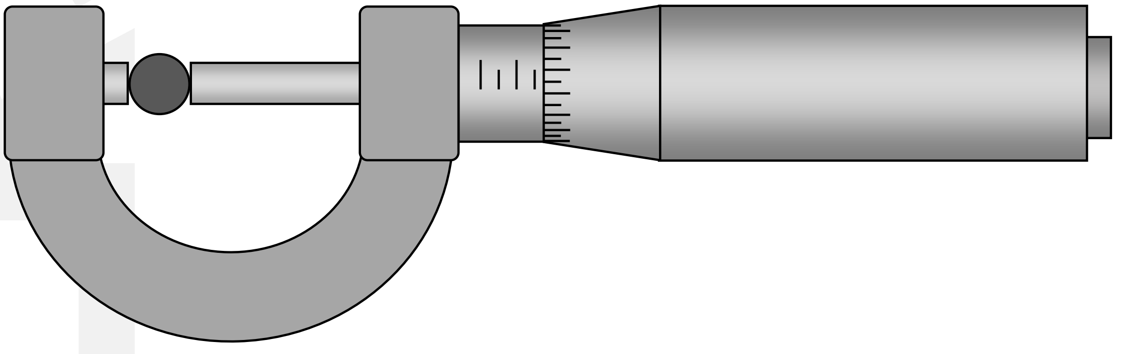


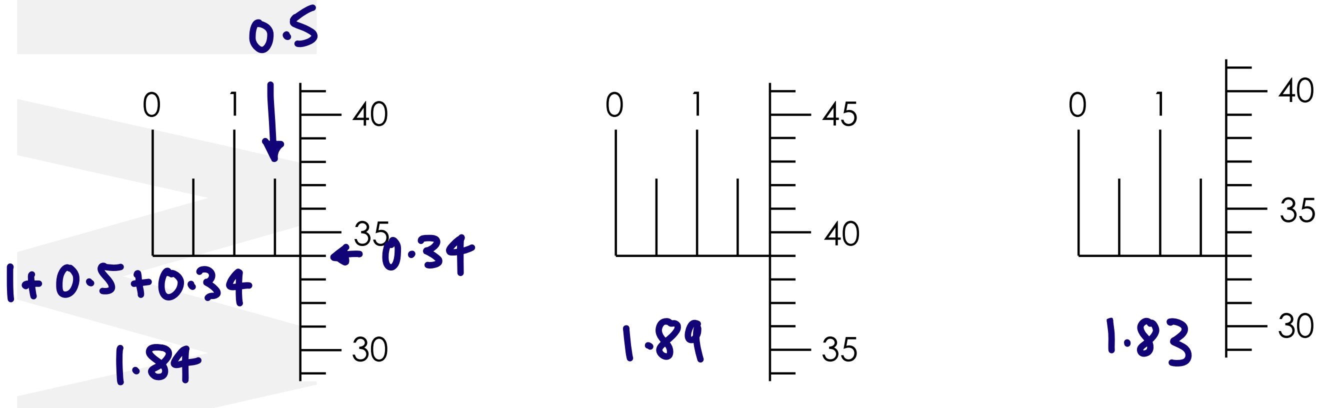
Resistor	R / Ω	V / V	I / A
a.	1.0	2.7	2.7
b.	2.0	5.4	2.7
c.	3.0	4.0	1.3
d.	4.0	4.0	1.0
e.	5.0	1.8	0.36
f.	6.0	2.2	0.36

Calculate all values to at least 3 s.f. as you're working through this type of question

4th April

1. A micrometer is used to measure the diameter of a wire. Three readings are taken to ensure that the wire is circular in cross-sectional area.





Calculate the:

a. Mean **diameter** in mm

$(1.84 + 1.89 + 1.83) \div 3 = \underline{1.85}$ mm

b. **Absolute uncertainty** in the diameter

$(1.89 - 1.83) \div 2 = \underline{\pm 0.03}$ mm

c. **Percentage uncertainty** in the diameter

$\%U = (0.03 \div 1.85) \times 100 = \underline{1.6\%}$

d. Cross-sectional **area** in m^2

$A = \pi d^2/4 = \pi \times (1.85 \times 10^{-3})^2 \div 4 = \underline{2.69 \times 10^{-6}}\ m^2$

e. **Percentage uncertainty** in the area

$2 \times 1.6 = \underline{3.2}\%$

f. **Uncertainty** in the area

3.2% of $2.69 \times 10^{-6}\ m^2$ is $\pm\ \underline{8.60 \times 10^{-8}}\ m^2$

5th April

1 2 3

1. A cell with an EMF of 12.0 V and internal resistance of 2.0 Ω is placed in series with a 22 Ω resistor.

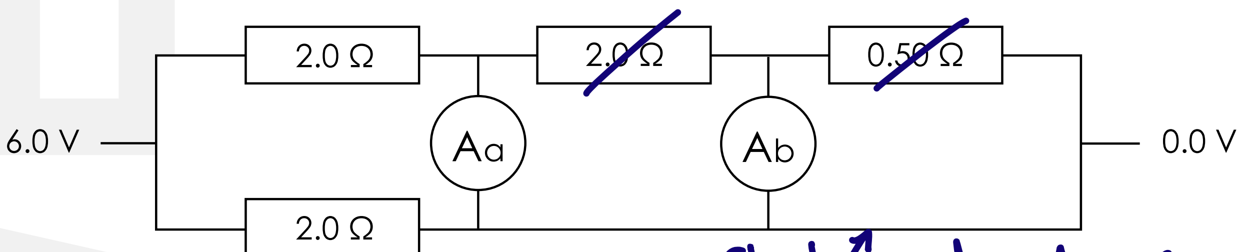
   Calculate the **percentage** of the power output wasted as thermally in the cell.

$P = I^2R$

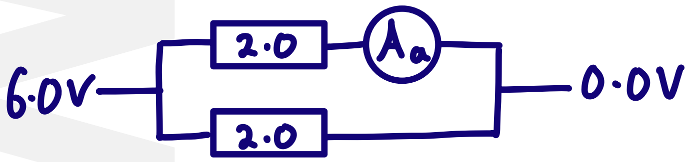
$\therefore P \propto R$

$$\eta = \frac{P_{cell}}{P_{total}} \times 100 = \frac{r}{r+R} \times 100 = \frac{2.0}{2.0+22} \times 100 = \underline{8.3\ \%}$$

2. Calculate the **reading** on the zero-resistance **ammeters** A_a and A_b.



Short circuit $\therefore A_b = 0.0A$



$$I = \frac{V}{R} = \frac{6.0}{2.0} = \underline{3.0A}$$

3. Calculate the **extension** produced if a 40 N load is applied to a 5.0 m length of steel wire with a Young modulus of 200 GPa and a diameter of 0.50 mm.

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

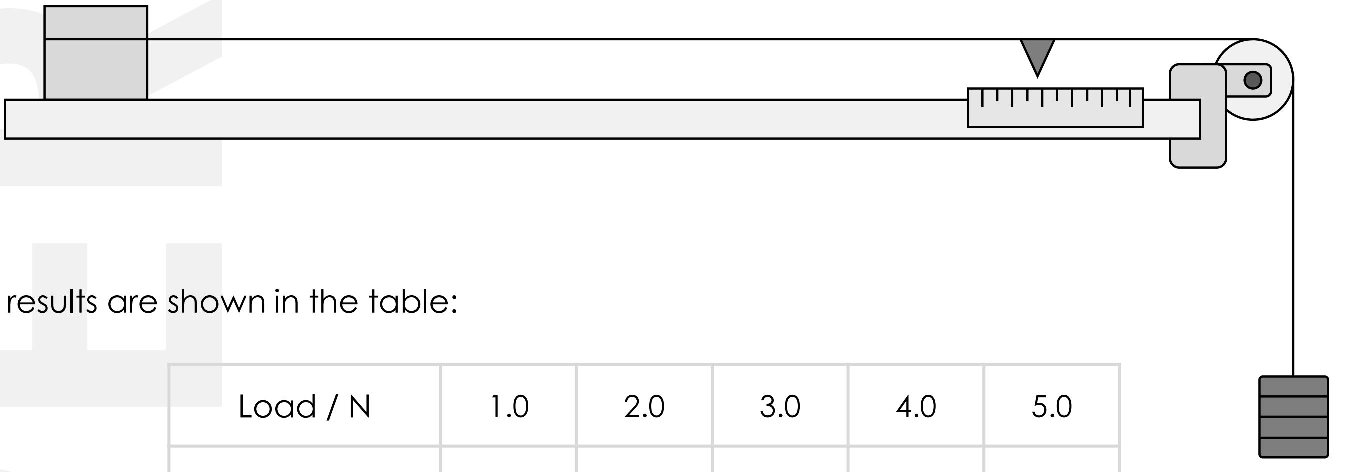
$$e = \frac{FL}{EA} \qquad A = \frac{\pi d^2}{4}$$

$$e = \frac{4FL}{E\pi d^2}$$

$$e = \frac{4 \times 40 \times 5.0}{200\times10^9 \times \pi \times (0.50\times10^{-3})^2} = \underline{5.1\times10^{-3}}\ m$$

6^{th} April

1. A 10.0 m copper wire of diameter 0.273 mm is clamped at one end and stretched (across a lab) and over a pulley at the other end using hanging masses. A pointer on the wire allows the extension to be measured.



The results are shown in the table:

Load / N	1.0	2.0	3.0	4.0	5.0
Extension / mm	1.4	2.8	4.3	5.7	7.1

a. Use the data to **plot a graph**

b. Calculate the **gradient** with an appropriate unit

$$\text{Gradient} = \frac{5.0-0}{7.1-0} = 0.70 \text{ N mm}^{-1}$$

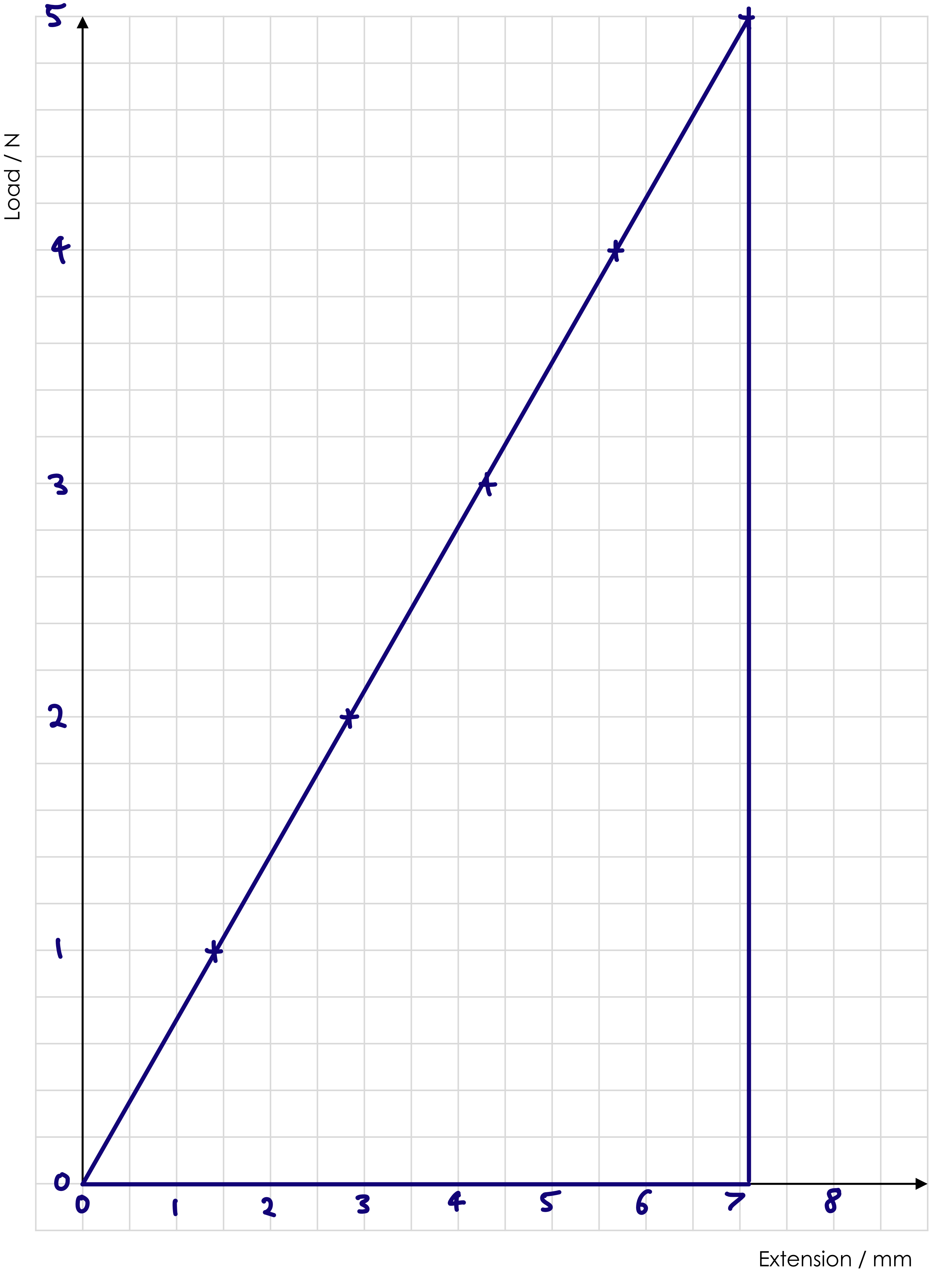
c. Use the gradient from your graph and values given in the question to calculate a value for the **Young modulus** of copper in GPa

$$E = \frac{FL}{eA} \qquad A = \frac{\pi d^2}{4}$$

$$E = \frac{F}{e} \cdot \frac{4L}{\pi d^2} = \text{Gradient} \times \frac{4 \times 10.0}{\pi \times (0.273 \times 10^{-3})^2}$$

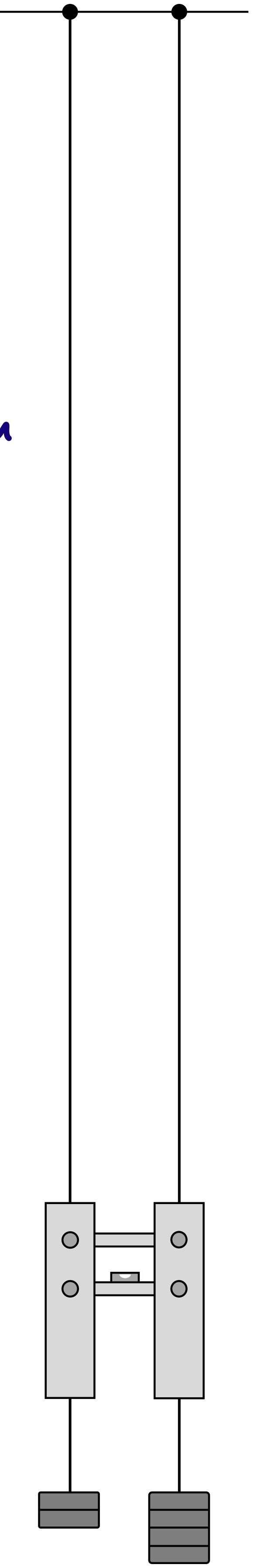
$$E = 120 \text{ GPa}$$

6th April



7th April – Part 1

1



1. An alternative method to determine the Young modulus for a material is to use Searle's apparatus. In this case, a steel vertical wire can be loaded with masses up to 10.0 kg. A second reference wire, also made from steel, hangs next to the test wire and (in this example) has a vernier scale allowing measurement of the extension produced to the nearest 0.01 mm.

   The diameter of the test wire is recorded, in mm, as 0.37, 0.38, 0.38 and 0.36.

   a. Calculate the **average diameter** and its **absolute uncertainty**

   $0.37\ mm = 3.7 \times 10^{-4}\ m$

   $(0.38 - 0.36) \div 2 = \pm 0.01\ mm = 1 \times 10^{-4}\ m$

   b. Calculate the **percentage uncertainty** in the diameter

   $$\%U = \frac{0.01}{0.37} \times 100 = 2.7\%$$

   c. Suggest the **piece of equipment** that could have recorded these measurements

   Micrometer

   d. Describe how these measurements of the diameter are taken to **improve accuracy**

   Repeated, at different points and in different directions to check it's circular

   e. Calculate the **cross-sectional area** with its **uncertainty**

   $$A = \frac{\pi d^2}{4} = \frac{\pi \times (3.7 \times 10^{-4})^2}{4} = 1.1 \times 10^{-7}\ m^2$$

   $$1.1 \times 10^{-7} \times \left(\frac{2 \times 2.7}{100}\right) = \pm 5.8 \times 10^{-9}\ m^2$$

   $(\%A = 2 \times \%d)$

7th April – Part 2

1

1. A graph of load against extension is drawn using the recorded data and shows a directly proportional relationship.

   f. If the Young modulus of steel is 210 GPa and the wire was initially 2.00 m long, calculate the expected **extension** for a 10.0 kg mass hung on the wire

$$e = \frac{FL}{EA} = \frac{10.0 \times 9.81 \times 2.00}{210 \times 10^{9} \times 1.1 \times 10^{-7}} = 8.5 \times 10^{-3}\ \text{m}$$

   g. Explain two **safety precautions** to allow this practical to be undertaken safely

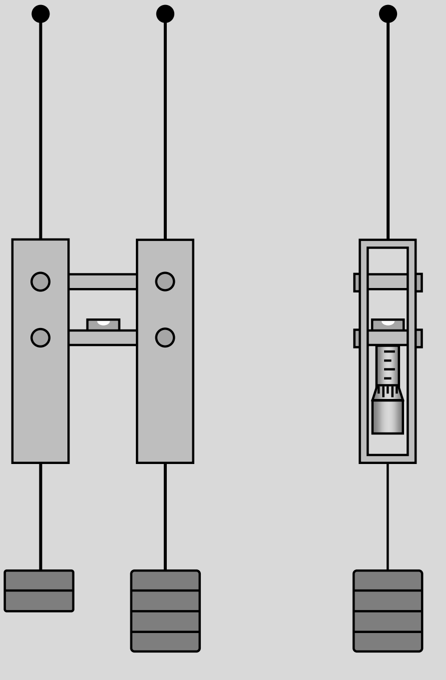
- Eye protection, in case wire snaps into eye
- Cushion, in case they fall on the floor

Searle's Apparatus

Some schools have this equipment that can be used to measure the Young / Young's modulus of a material.

There are a few different types available. Some have a simple linear vernier scale between the two wires. Others have a spirit level that can be adjusted until it is perfectly level (as illustrated to the right).

When the test wire is loaded it will extend slightly, the spirit level can then be adjusted until it is once again horizontal using the screw gauge which shows the distance moved. This allows accurate measurements of extension to be recorded.



8th April

1 2 3

1. Measurements were taken to investigate a piece of nichrome wire. Calculate the **percentage uncertainty** in the calculated value of **resistivity**:

$\rho = \frac{RA}{L}$

$\rho = \frac{R\pi d^2}{4L}$

Quantity	Percentage Uncertainty
Resistance	1.9 %
Length	0.3 %
Diameter	2.2 %

$\%\rho = \%R + (2 \times \%d) + \%L = 1.9 + (2 \times 2.2) + 0.3$
$= 6.6\%$

2. Define:

   a. Tensile **strain**

   b. **Young modulus**

3. An annealed copper wire has a diameter of 0.500 mm. The resistivity of this copper is 1.77×10^{-8} Ωm.

   Calculate the **length** of this wire that has a resistance of 10.0 Ω.

$L = \frac{R\pi d^2}{4\rho} = \frac{10.0 \times \pi \times (0.500 \times 10^{-3})^2}{4 \times 1.77 \times 10^{-8}}$

$L = 111\text{ m}$

ANSWERS

9th April

1. A student is determining the resistivity of nichrome. They are using a wire with SWG value 30 which has a diameter of 0.315 mm. They use a multimeter set up as an ohmmeter which can record resistance to the nearest ohm to record the following data:

Length / cm	20	40	60	80	100
Resistance / Ω	3	5	8	10	12

a. Plot a **graph** of resistance against length on the axes to the right. Include **error bars** for the values of resistance

b. Calculate the **gradient** of the line of best fit and, using the error bars, calculate the **percentage uncertainty** in the gradient

$$\text{Gradient}_{best} = \frac{12.5-0}{1.0-0} = 12.5\ \Omega m^{-1}$$

$$\text{Gradient}_{worst} = \frac{11-2.2}{1.0-0} = 8.8\ \Omega m^{-1}$$

$$\%U = \left|\frac{best - worst}{best}\right| \times 100 = \left|\frac{12.5-8.8}{12.5}\right| \times 100 = 30\%$$

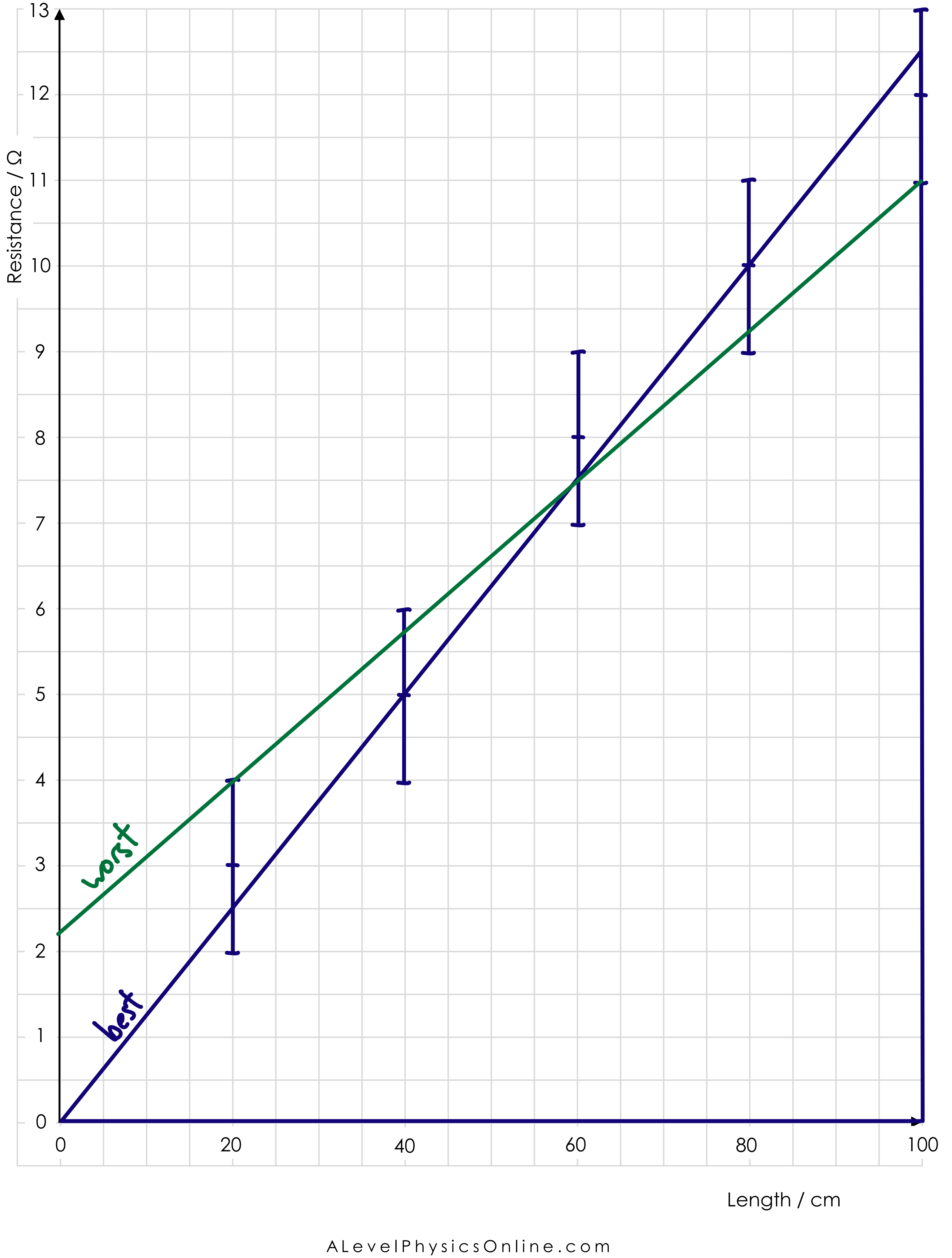
c. Using the value for your gradient and the diameter given above (assuming zero percentage uncertainty in this value), calculate a **resistivity** value for nichrome including its **uncertainty**

$$\rho = \frac{RA}{L} = \frac{R}{L}\cdot A = \text{gradient} \times A = 12.5 \times \frac{\pi \times (0.315\times10^{-3})^2}{4}$$

$$\rho = 9.7\times10^{-7}\ \Omega m$$

30% of $9.7\times10^{-7}\ \Omega m$ is $\pm\ 2.9\times10^{-7}\ \Omega m$

9th April

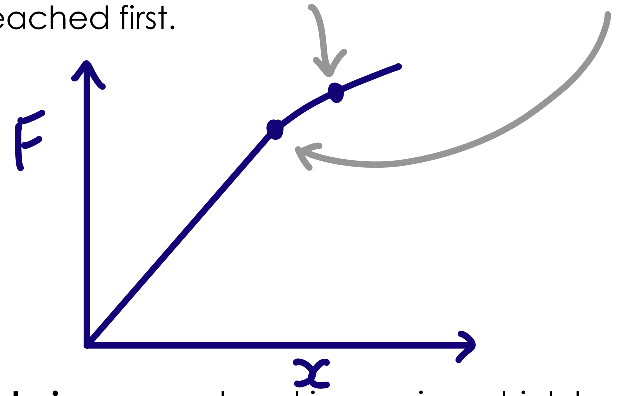


Resistance / Ω
Length / cm
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
20
40
60
80
100
worst
best

10th April

1 2 3

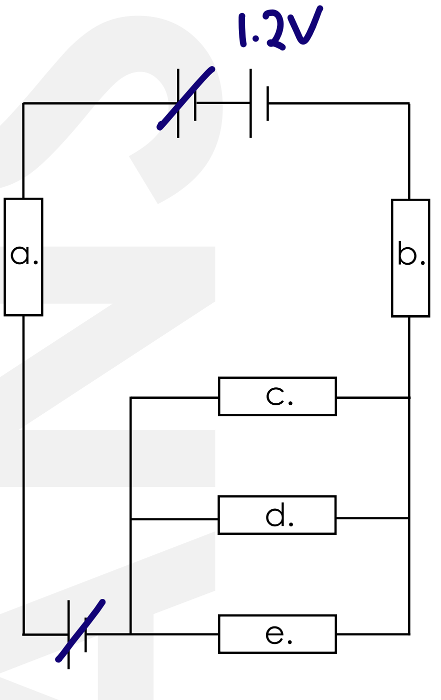
1. Explain the difference between the **elastic limit** and the **limit of proportionality** and state which one usually is reached first.



2. Calculate the **elastic strain energy** stored in a spring which has been subject to a tensile force of 200 N resulting in an extension of 0.75 m

$$E_e = \frac{1}{2}Fx = \frac{1}{2} \times 200 \times 0.75 = \underline{75}\ J$$

3. Complete the table for the **circuit below** (each cell has negligible internal resistance and an EMF of 1.2 V):



Resistor	R / Ω	V / mV	I / mA
a.	10	700	70
b.	6.0	420	70
c.	5.0	78	16
d.	5.0	78	16
e.	2.0	78	39

11th April

1 2 3

1. Write down the **value** and **units** for the following:

   a. The rest mass of an electron 9.11×10^{-31} kg

   b. The charge on an electron -1.60×10^{-19} C

   c. Planck constant 6.63×10^{-34} Js

2. Describe, in terms of material properties, what is meant by:

   a. **Brittle**

   b. **Hard**

   c. **Stiff**

3. A metal wire of original length 3.5 m and a diameter of 0.90 mm is extended by 13 cm when a force of 100 N is applied. Calculate:

   a. The tensile **strain**

$$\varepsilon = \frac{x}{L} = \frac{0.13}{3.5} = 0.037$$

   b. The tensile **stress**

$$\sigma = \frac{F}{A} = \frac{4F}{\pi d^2} = \frac{4 \times 100}{\pi \times (0.90 \times 10^{-3})^2}$$

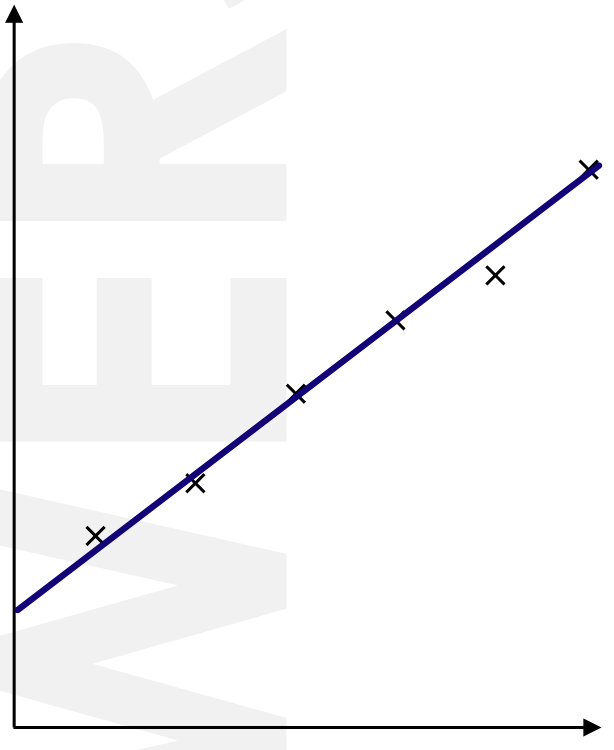
$$\sigma = 1.6 \times 10^{8} \text{ Pa}$$

12th April – Part 1

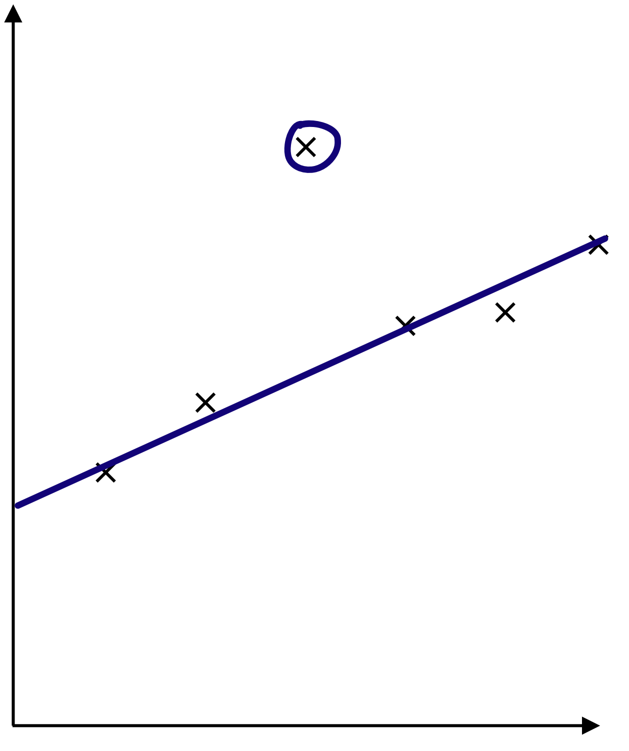
1

1. Draw in a **line of best fit** for the following data:

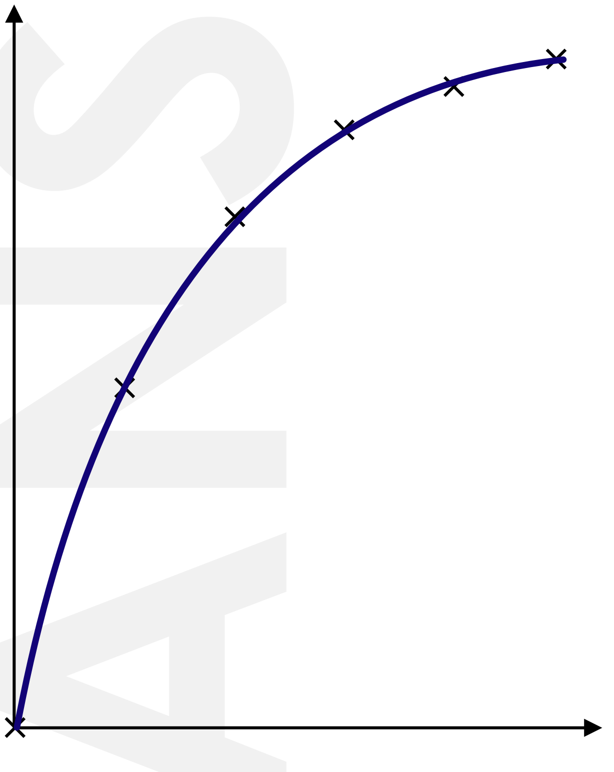
a.



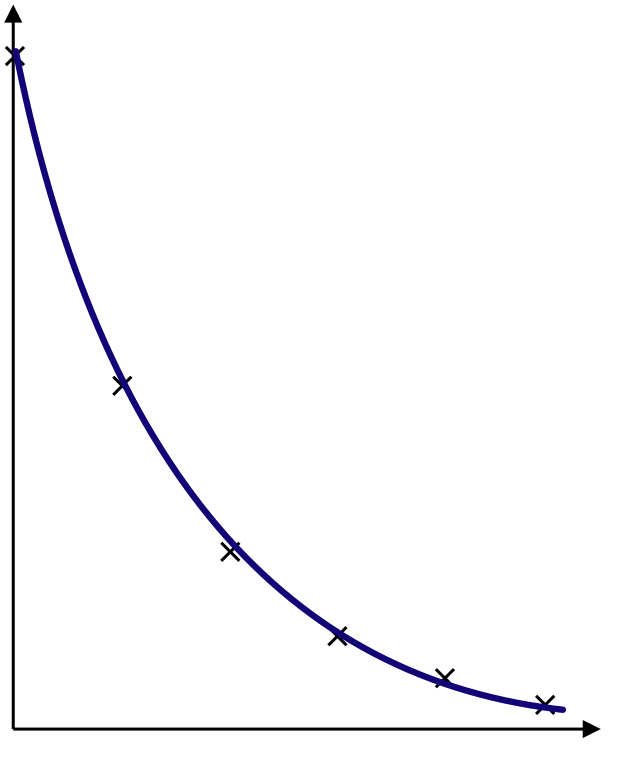
b.



c.



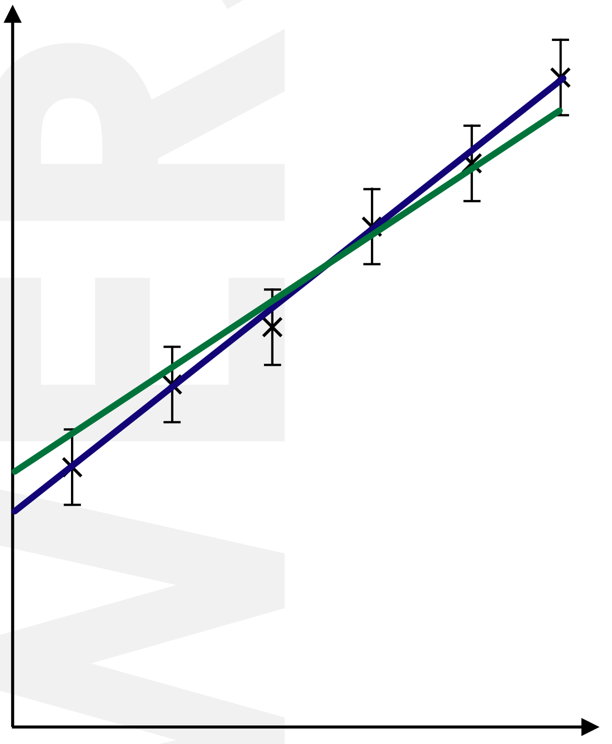
d.



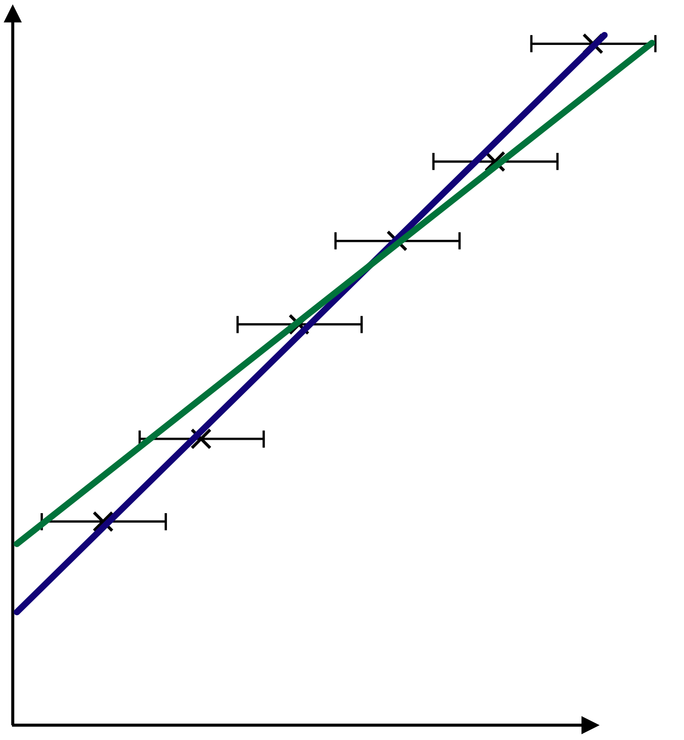
12th April – Part 2

2. Draw in a '**line of best fit**' and a '**worst acceptable**' line that passes through the error bars for the following data:

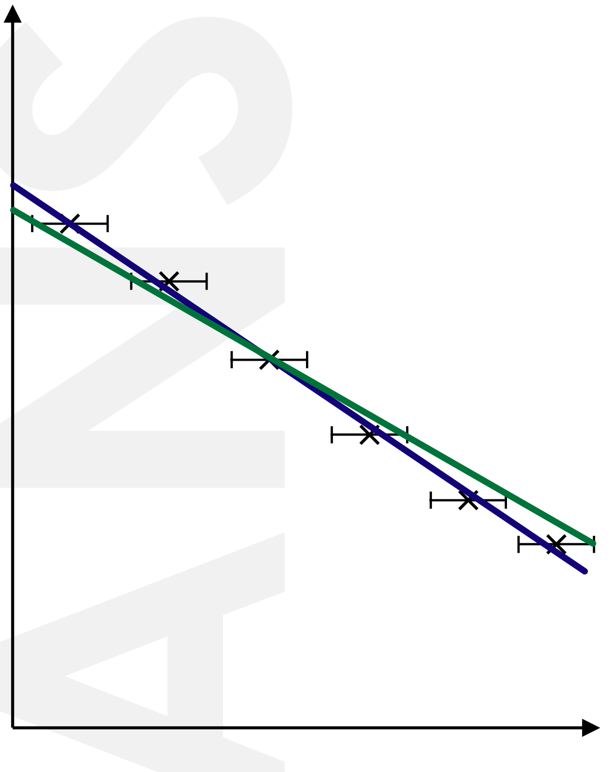
a.



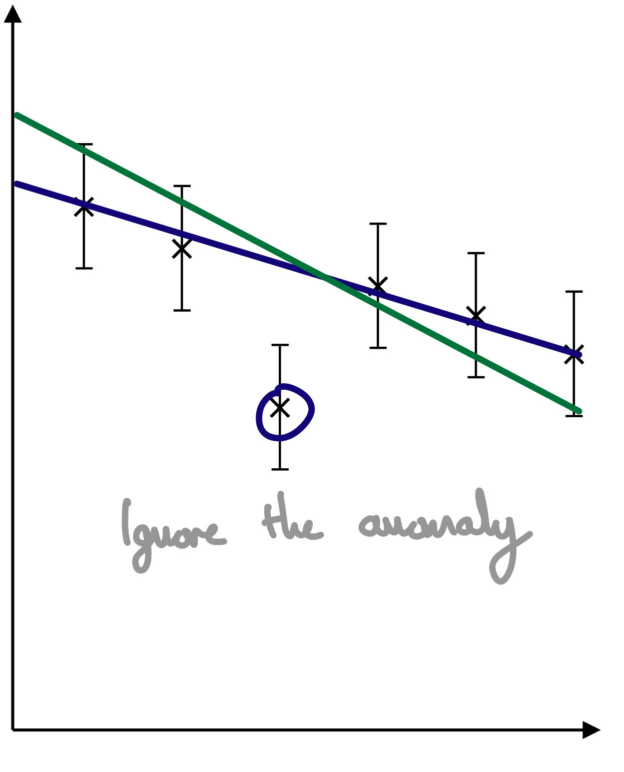
b.



c.



d.



13^{th} April

1 2

1. A 24.0 cm spring extends to 30.0 cm when a force of 7.0 N is applied. Calculate:

   a. The **spring constant**

   $$k = \frac{F}{x} = \frac{7.0}{0.060} = \underline{1.2 \times 10^{2}}\ N m^{-1}$$

   b. The **elastic strain energy** stored in the spring

   $$E_e = \frac{1}{2} F x = \frac{1}{2} \times 7.0 \times 0.060 = \underline{0.21}\ J$$

2. Complete the following table:

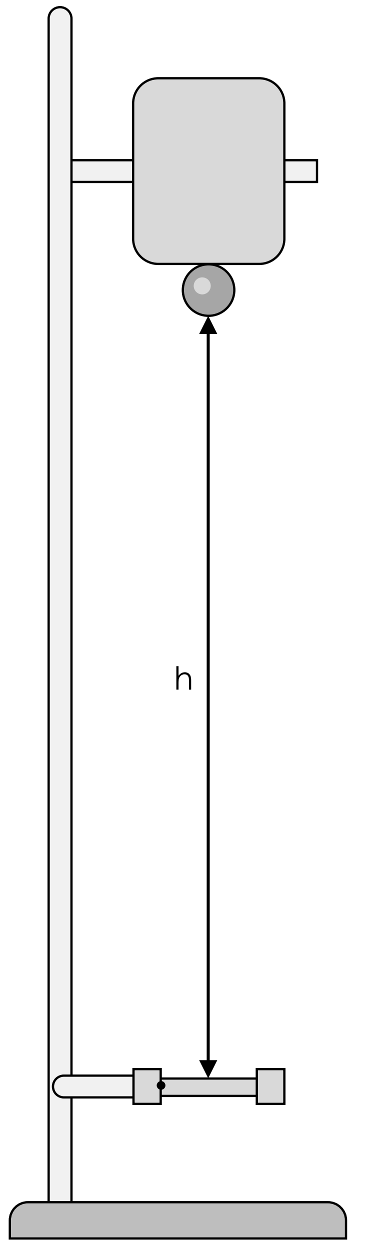
	Quantity	Unit	SI Base Units
a.	Mass	kg	kg
b.	Displacement	m	m
c.	Time	s	s
d.	Velocity	$m\,s^{-1}$	$m\,s^{-1}$
e.	Acceleration	$m\,s^{-2}$	$m\,s^{-2}$
f.	Momentum	$kg\,m\,s^{-1}$	$kg\,m\,s^{-1}$
g.	Force	N	$kg\,m\,s^{-2}$
h.	Energy	J	$kg\,m^{2}\,s^{-2}$
i.	Current	A	A
j.	Charge	C	As
k.	Potential difference	V	$kg\,m^{2}\,s^{-3}\,A^{-1}$
l.	Resistance	R	$kg\,m^{2}\,s^{-3}\,A^{-2}$
m.	Temperature	°C or K	K

14th April

1

1. A spherical steel ball bearing is held by an electromagnet vertically above a trap door switch. When a switch is pressed, the current to the electromagnet is switched off and the ball drops. Pressing the switch also turns starts a digital timer. When the ball bearing hits the trap door switch this opens a second circuit which stops the stop clock.

   The procedure is repeated for several heights and a mean time is calculated for each height.



Height / m	Mean time / s	Time^2 / s^2
0.30	0.29	0.084
0.60	0.37	0.14
0.90	0.45	0.20
1.20	0.52	0.27
1.50	0.57	0.32

   a. Complete the **table**

   b. Plot a **graph** of time^2 against height

   c. Calculate the **gradient**

   $$\text{Gradient} = \frac{0.32 - 0.02}{1.50 - 0} = \underline{0.20}\ s^2\,m^{-1}$$

   d. Use the gradient value to determine a value for **g**, the acceleration of free fall

   $s = h$
   $u = 0$
   v
   $a = g$
   t

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

   $h = \frac{1}{2}gt^2$

   $g = 2\frac{h}{t^2}$

   $\text{Gradient} = \frac{t^2}{h}$

   $g = 2 \times \left(\frac{1}{\text{Gradient}}\right)$

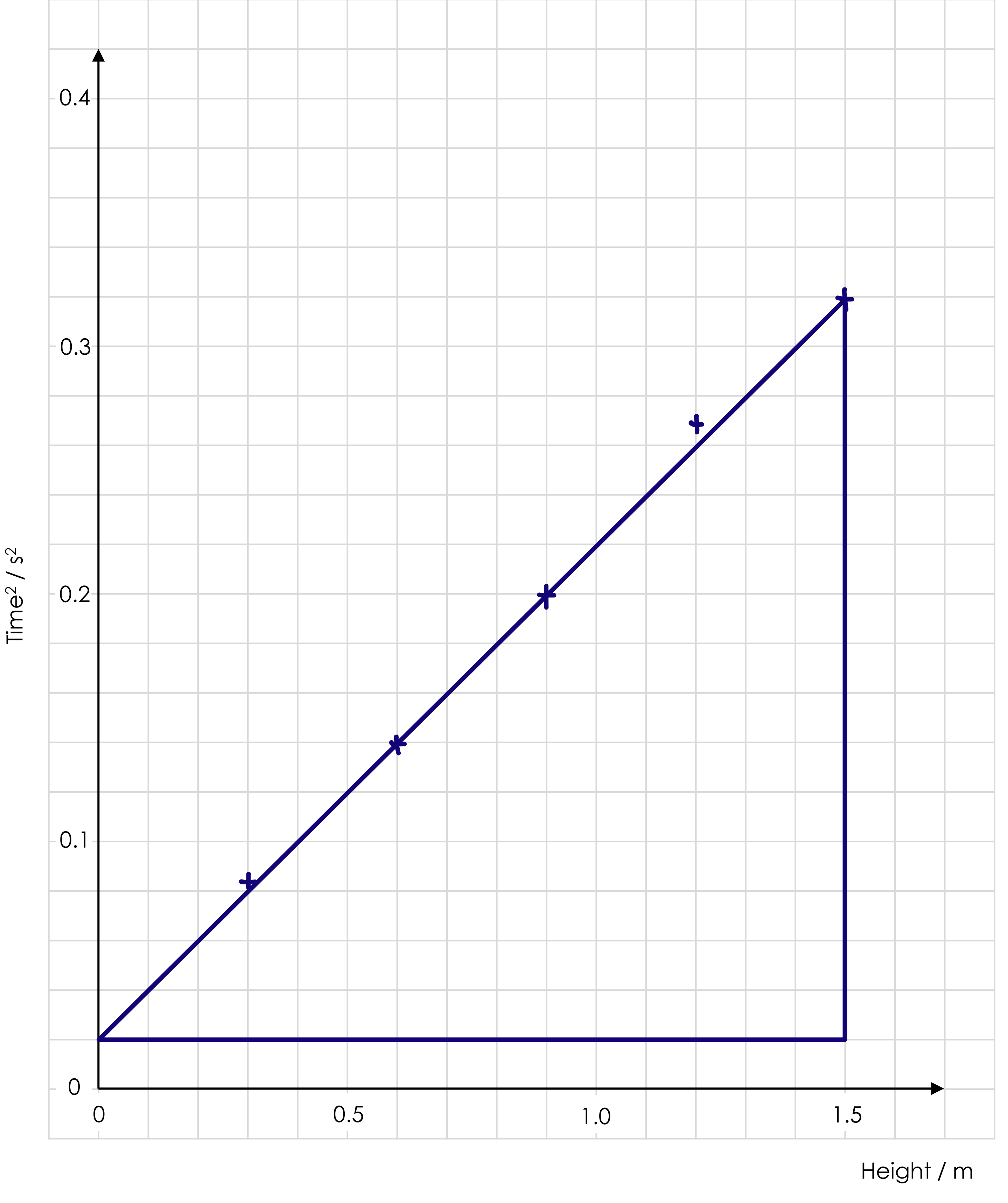
   $g = \frac{2}{0.20}$

   $g = \underline{10}\ ms^{-2}$

   e. Suggest a **reason** the line on the graph does not pass through the origin

   Systematic error in timing

14th April

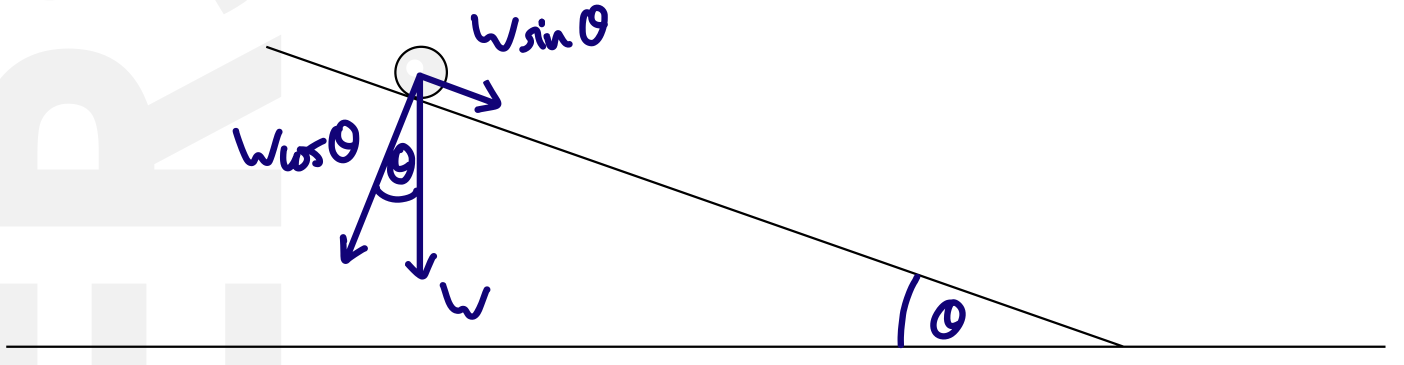


15^{th} April

1

1. A large marble is placed on a smooth slope as shown. The slope is at an angle θ to the horizontal.

   a. Add labels to show the weight, W, and components of the weight parallel and perpendicular to the slope, Wsinθ and Wcosθ, respectively.



A student investigates the acceleration of the marble by recording three repeat values for the time it takes the marble to roll 30 cm down the slope from rest.

   b. Calculate the **mean time** and use one of the suvat equations to calculate the **acceleration** in the table below

Angle of slope / °	Time 1 / s	Time 2 / s	Time 3 / s	Mean Time / s	Acceleration / m s^{-2}	g sinθ / m s^{-2}
15	0.47	0.51	0.52	0.50	2.4	2.5
30	0.37	0.35	0.36	0.36	4.6	4.9
45	0.32	0.28	0.31	0.30	6.7	6.9
60	0.28	0.28	0.26	0.27	8.2	8.5

$s = \cancel{ut} + \frac{1}{2}at^2$ $\quad a = 2s/t^2$

   c. Complete the last column by calculating values of **g sinθ** (where g = 9.81 N kg^{-1})

   d. **Compare** the values in the last two columns

$a < g\sin\theta$

   e. Suggest a factor that is likely to **reduce** the measured acceleration compared to the theoretical acceleration in this experiment

Friction on the slope

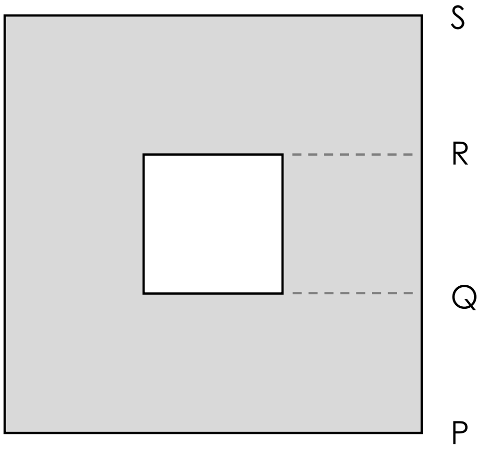
16th April

1. A student is using a light gate and a double interrupt card to find a value for the acceleration due to gravity.

   The light gate is clamped so that the light beam is horizontal. The double interrupt card is shown in the diagram to the right. The square outer card has sides of length 15.0 cm and a 5.0 cm square hole in the centre.

   The first time recorded by a data logger as the card between P and Q interrupts the beam is 100 ms

   A short time later a time of 34 ms is recorded as the card between R and S passes through the light gate.



   Calculate the:

   a. The **initial velocity** as the bottom strip of card (PQ) interrupts the beam

   $$u = \frac{s}{t} = \frac{0.050}{0.100} = \underline{0.50}\ ms^{-1}$$

   b. The **final velocity** as the top strip of card (RS) interrupts the beam

   $$V = \frac{s}{t} = \frac{0.050}{0.034} = \underline{1.47}\ ms^{-1}$$

   c. The **acceleration** of the card

   $s = 0.10\ m$
   $u = 0.50\ ms^{-1}$
   $v = 1.47\ ms^{-1}$
   $a = g$
   t

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

   $$g = \frac{v^2 - u^2}{2s} = \frac{1.47^2 - 0.50^2}{2 \times 0.10}$$

   $$g = \underline{9.6}\ ms^{-2}$$

   d. Suggest two **advantages** of attaching small masses along the bottom edge of the double interrupt card before it is dropped

17th April

1 2 3

1. A wire of original length 1.7 m and diameter 240 μm extends by 3.0 cm when tensioned by a force of 29 N. Calculate:

   a. The **elastic strain energy** stored in the wire

   $E_e = \frac{1}{2}Fx = \frac{1}{2} \times 29 \times 0.030 = \underline{0.44}\ \text{J}$

   b. The **stiffness** of the wire

   $k = \frac{F}{x} = \frac{29}{0.030} = \underline{970}\ \text{Nm}^{-1}$

2. Define:

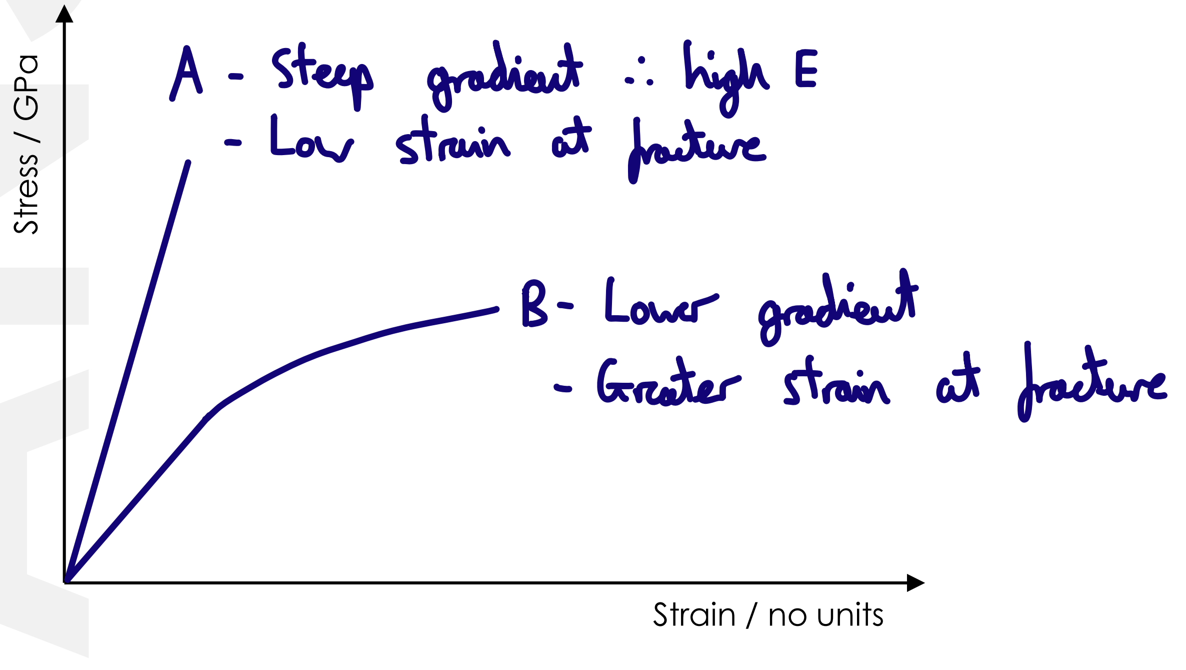
   a. **Acceleration**

   b. **Gravitational field strength**

3. Sketch, and explain, the shape of lines on the stress-strain graph for:

   a. Line A: a **brittle** material with a **high** Young modulus value

   b. Line B: a **tough** material with a **lower** Young modulus value



18th April

1 2 3

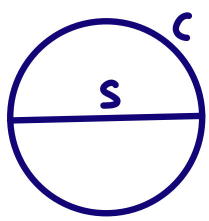
1. Write the **unit** more commonly used for these quantities (shown in their base units):
   a. s^{-1} Hz
   b. $kg\ m\ s^{-2}$ N
   c. $kg\ m^2\ s^{-2}$ J

2. A jogger runs at an average speed of $3.0\ m\ s^{-1}$. They go for a 10 minute run. Calculate:
   a. The **distance** they run in 10 minutes

   $x = vt = 3.0 \times 10 \times 60 = \underline{1800}\ m$

   b. The magnitude of their **displacement** if they run around a 400 m circular track

   $\frac{1800}{400} = 4.5$ laps



   $c = \pi s$

   $s = \frac{400}{\pi} = 127 = \underline{1.3 \times 10^2}\ m$

3. An average value for the gravitational field strength on Earth is $9.81\ N\ kg^{-1}$ which results in an acceleration of free fall of $9.81\ m\ s^{-2}$.
   a. Assuming there is no air resistance, calculate the **velocity** of a 2.8 kg house brick 60 s after it is dropped from a stationary helium balloon and how **far** it has fallen
      i. **Velocity**

      ↓ s
      $u = 0\ ms^{-1}$
      v
      $a = 9.81\ ms^{-2}$
      $t = 60\ s$

      $v = \cancel{u} + at = 9.81 \times 60 = \underline{590}\ ms^{-1}$

      ii. **Displacement**

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

      $s = \frac{1}{2} \times 9.81 \times 60^2 = 17658 = \underline{1.8 \times 10^4}\ m$

   b. Explain whether it is sensible to **neglect** air resistance in examples like this

   No!

19th April

1. Write the **unit** more commonly used for these quantities (shown in their base units):

   a. kg m^2 s^{-2} J

   b. kg m^2 s^{-3} $J s^{-1} = W$

   c. A s C

2. A rock of mass 0.20 kg falls from rest at a height of 15 m above the surface of the Moon.

   Calculate the **velocity** of the rock as it hits the Moon's surface.

   s = 15 m
   u = 0 $m s^{-1}$
   v =
   a = 1.6 $m s^{-2}$
   t

   $v^2 = \cancel{u^2} + 2as$

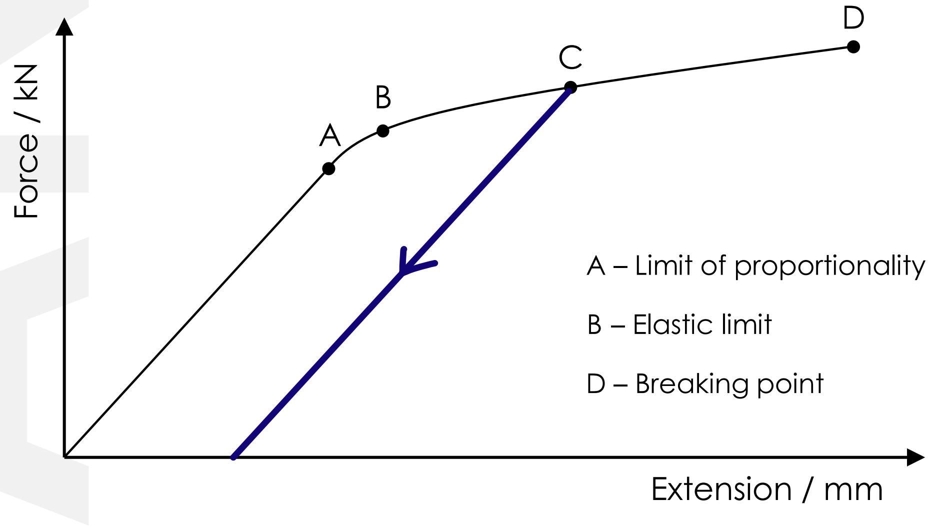
   $v = \sqrt{2 \times 1.6 \times 15} = 6.9 \text{ m s}^{-1}$

3. The graph below shows the force-extension graph typical of a sample of metal when subjected to a tensile force.

   a. Describe what would happen if the force was **removed** at **point C** as the metal was unloaded

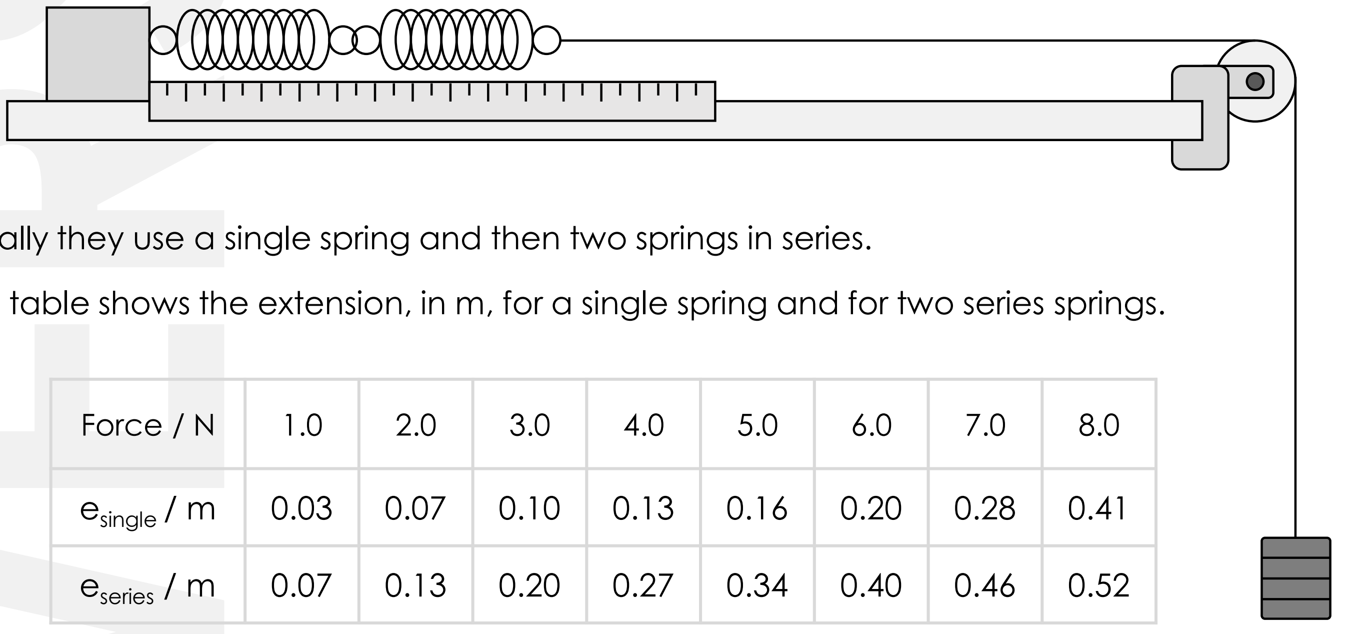
   Some plastic deformation

   b. Sketch the line on the graph to show this **unloading**



20th April – Part 1

1. A student is measuring the extension, e, when a force is applied to combinations of identical springs.

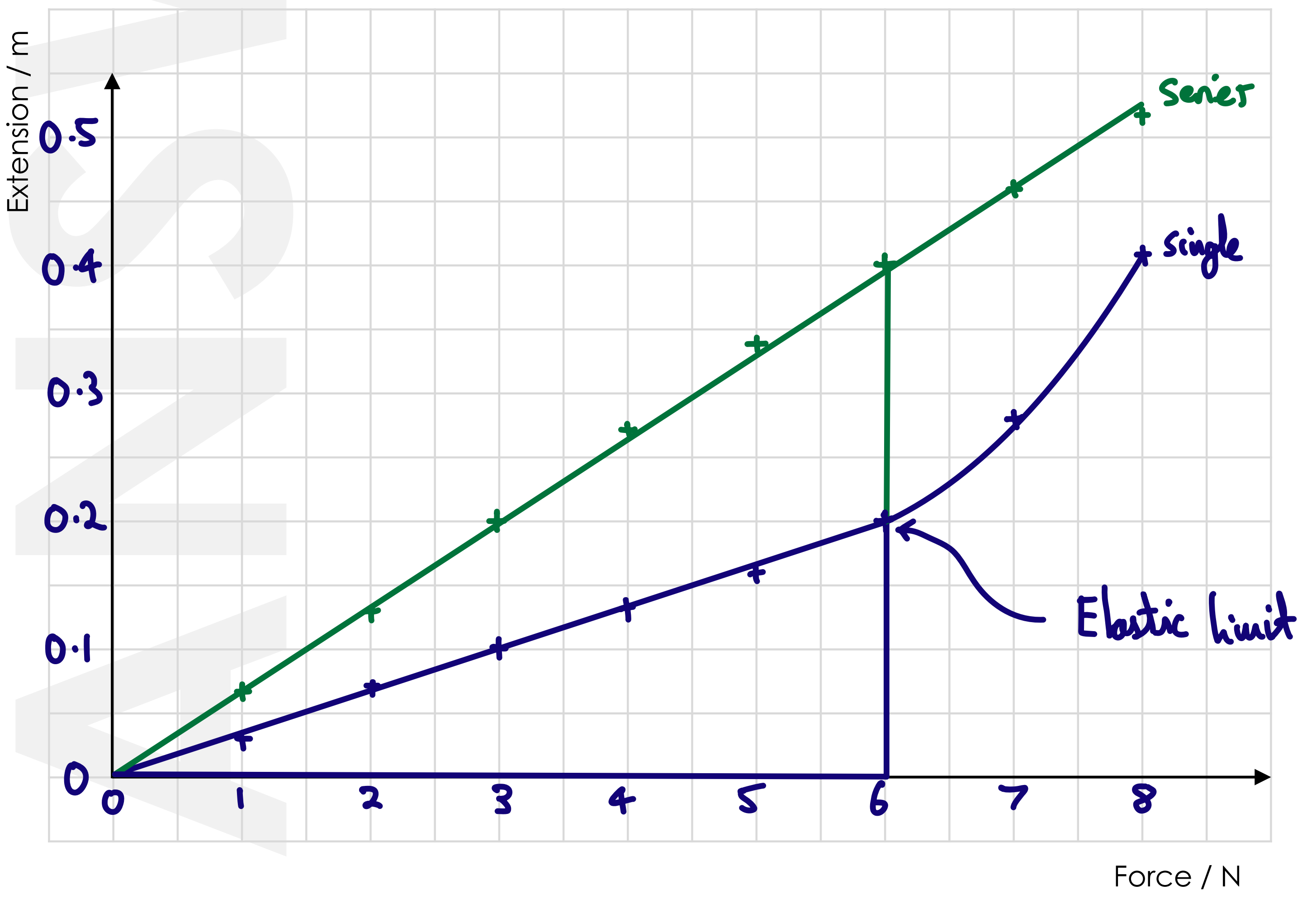


Initially they use a single spring and then two springs in series.

The table shows the extension, in m, for a single spring and for two series springs.

Force / N	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
e_{single} / m	0.03	0.07	0.10	0.13	0.16	0.20	0.28	0.41
e_{series} / m	0.07	0.13	0.20	0.27	0.34	0.40	0.46	0.52

a. Plot the data on the **graph** below and draw **lines of best fit**



20th April – Part 2

1. b. Calculate values of the **spring constant** for:

i. The **single** spring

$$k = \frac{F}{e} = \frac{1}{\text{Gradient}} = 30\ \text{Nm}^{-1}$$

ii. **Two springs** in **series**

$$= 15\ \text{Nm}^{-1}$$

c. From the graph, determine the **elastic limit** of the springs used

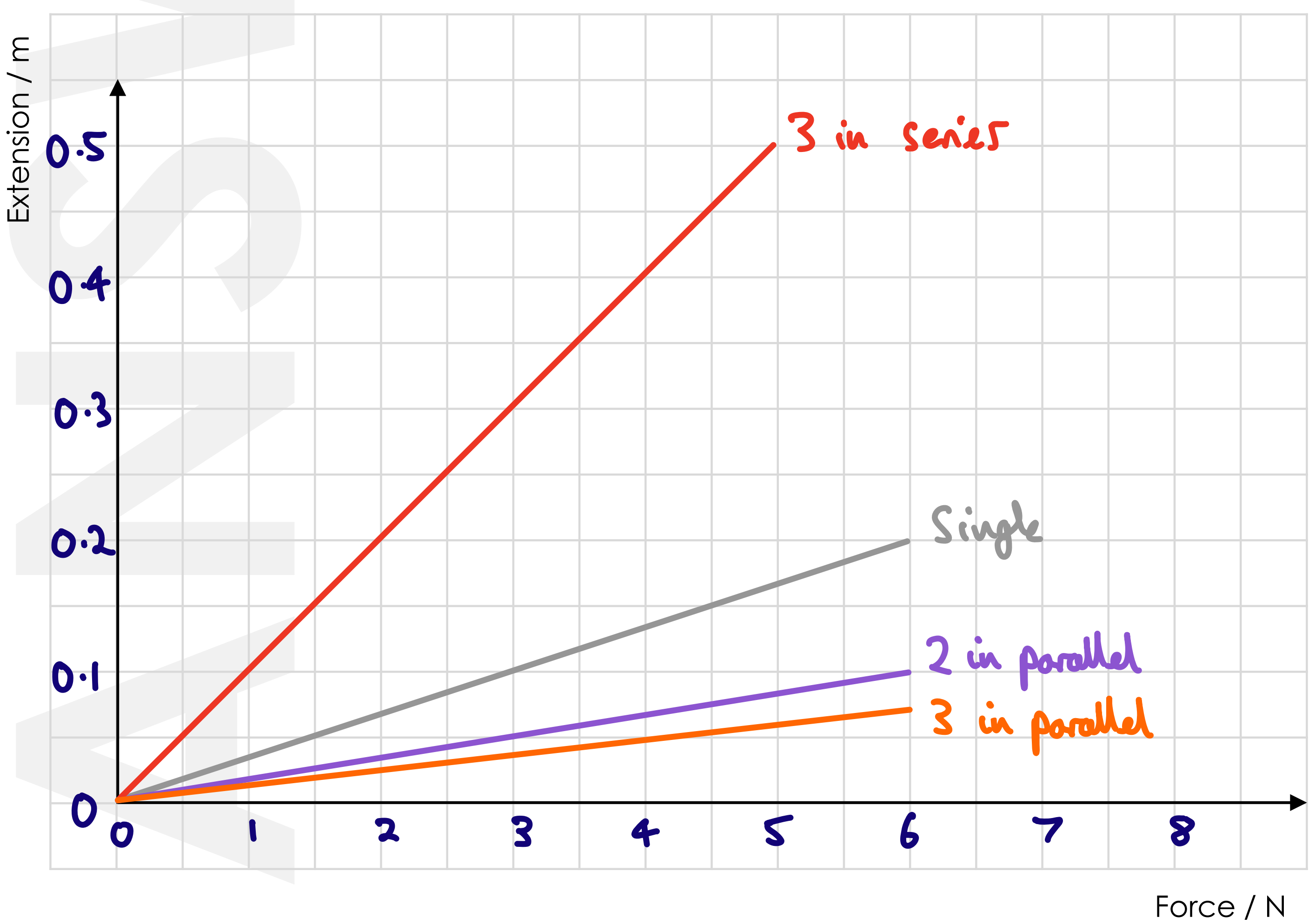
6.0N

d. Predict the value of the combined spring constant for **two springs in parallel**

$2 \times$ part b. i. $= 2 \times 30 = 60\ \text{Nm}^{-1}$

e. Sketch and label a **force-extension** graph for

i. Two springs in parallel ii. Three springs in parallel iii. Three springs in series



21st April

1	2	3

1. One of Newton's laws is often mistakenly given simply as the equation F = ma.

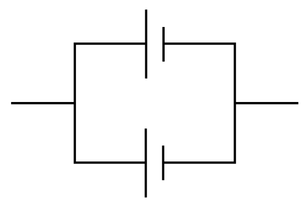
   State **Newton's second law** in full.

   $F \propto \frac{\Delta p}{\Delta t}$

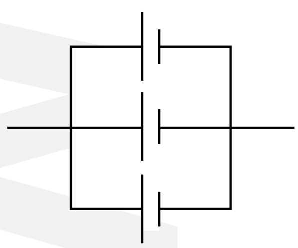
2. In the diagrams below, each cell has an EMF of 1.2 V and negligible internal resistance. Calculate the **total EMF** for each battery below:

   a. $1.2 + 1.2 = 2.4V$

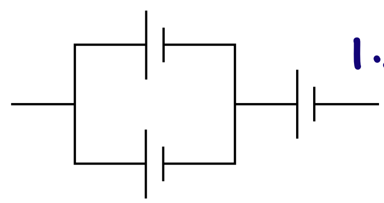
   

   b. 

   $1.2V$

   c. 

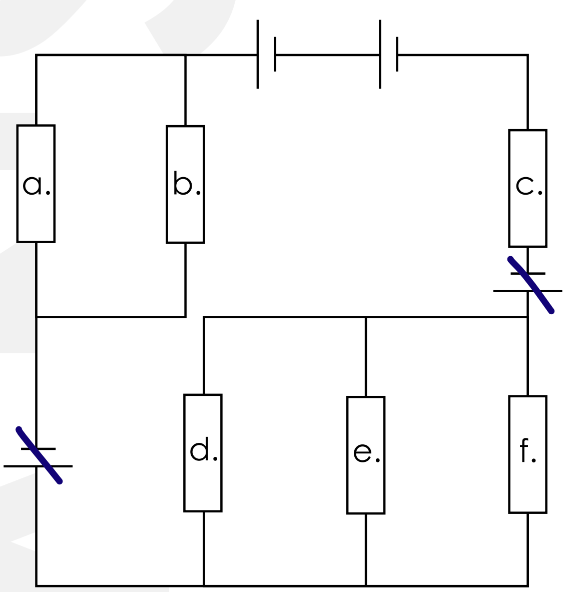
   $1.2V$

   d. 

   $1.2 + 1.2 = 2.4V$

3. In the circuit below, where each cell has negligible internal resistance and an EMF of 1.2 V, all the resistors are identical and have a resistance of 10 Ω.

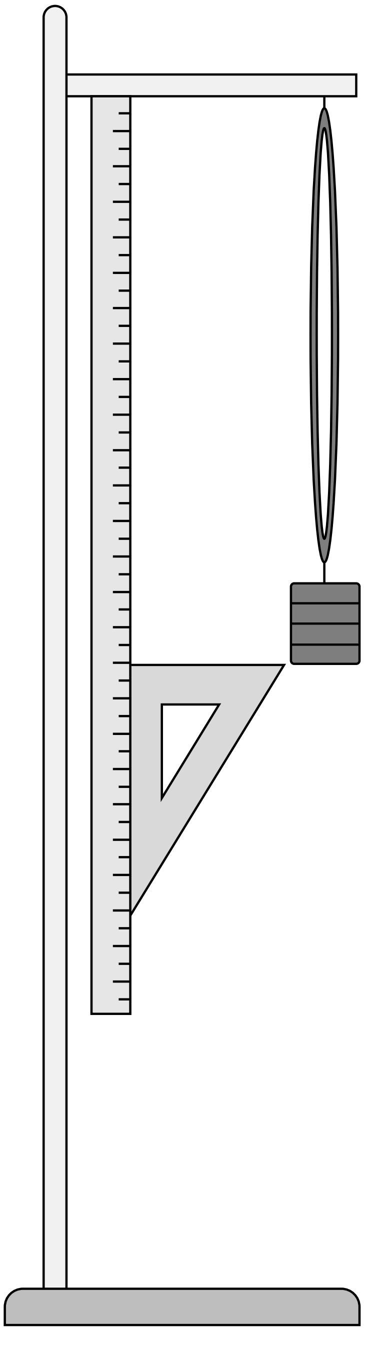
   Complete the **table**.



Resistor	V / V	I / mA
a.	0.66	66
b.	0.66	66
c.	1.3	130
d.	0.44	44
e.	0.44	44
f.	0.44	44

22nd April

1. A thick rubber band was hung on a clamp and stand. Extension values were then measured using a ruler and set square as it was loaded, and then unloaded, with masses.



   a. Explain why the use of a set square helps to improve the **accuracy** of the results taken

   b. Plot the **loading** and **unloading curve** for the rubber band using the data below

	Extension / m	
Load / N	Loading	Unloading
0.0	0.00	0.00
5.0	0.01	0.03
10.0	0.03	0.08
15.0	0.05	0.13
20.0	0.08	0.19
25.0	0.13	0.24
30.0	0.20	0.27
35.0	0.27	0.29
40.0	0.30	0.30

   c. Use your graph to estimate the **area** enclosed between the two curves

$\approx 7.26 - 5.10 = 2.16 \quad = 2.2\ J$

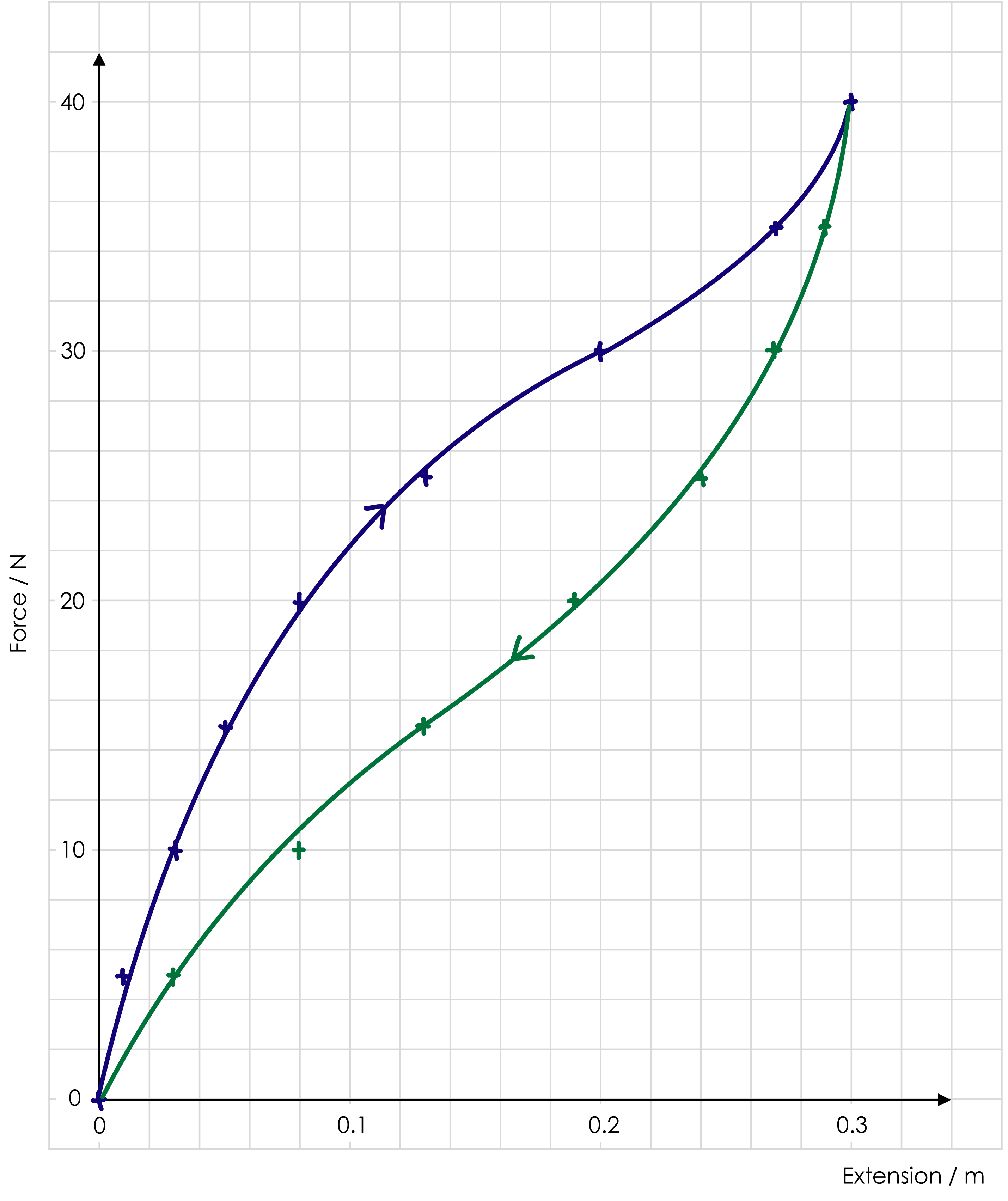
   d. Describe what this area **represents**

Energy dissipated thermally

   e. Explain the significance of the graph starting and finishing at the **origin**

Elastic behaviour

22nd April



23rd April

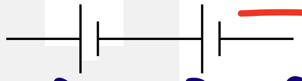
1. The velocity of a 420 g football reduces from 20 m s^{-1} to 0 m s^{-1} in a time of 400 ms.

   Calculate the **average force** applied to the football.

$$F = \frac{\Delta p}{\Delta t} = \frac{(0.420 \times 20)}{400 \times 10^{-3}} = \underline{21}\ \text{N}$$

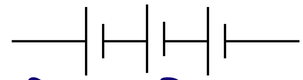
2. Each cell has an EMF of 1.2 V and internal resistance of 0.30 Ω. Calculate the **total EMF** and **internal resistance** for the batteries below:

a. $1.2 + 1.2 = \underline{2.4}\ \text{V}$



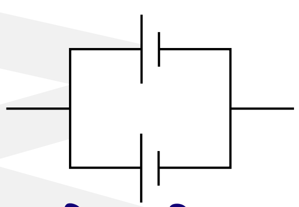
$0.30 + 0.30 = \underline{0.60}\ \Omega$

b. $1.2 + 1.2 + 1.2 = \underline{3.6}\ \text{V}$



$0.30 + 0.30 + 0.30 = \underline{0.90}\ \Omega$

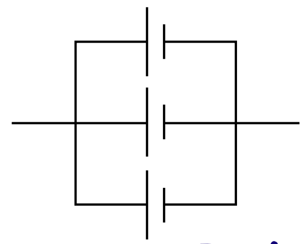
c.



$\underline{1.2}\ \text{V}$

$0.30 \div 2 = \underline{0.15}\ \Omega$

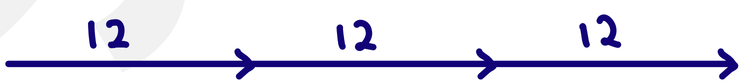
d.



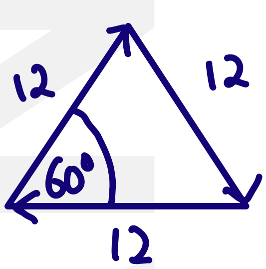
$\underline{1.2}\ \text{V}$

$0.30 \div 3 = \underline{0.10}\ \Omega$

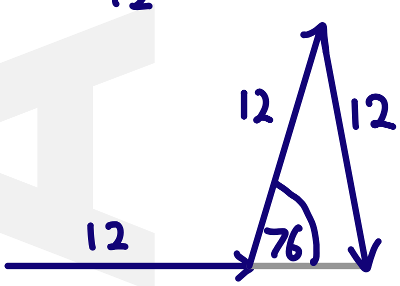
3. Three forces, each of 12 N, can be exerted in any direction. Sketch the configuration (including angles) that will give the **maximum** magnitude force, the **minimum** force and a force **halfway** between these two values.



$= \underline{36}\ \text{N}$



$= \underline{0}\ \text{N}$

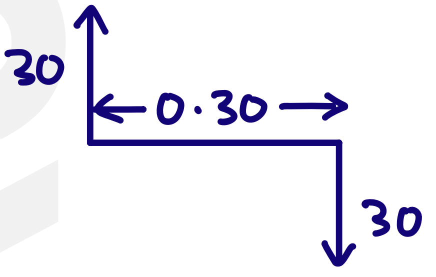


$= \underline{18}\ \text{N}$

This is just one of many ways that 18 N could be achieved

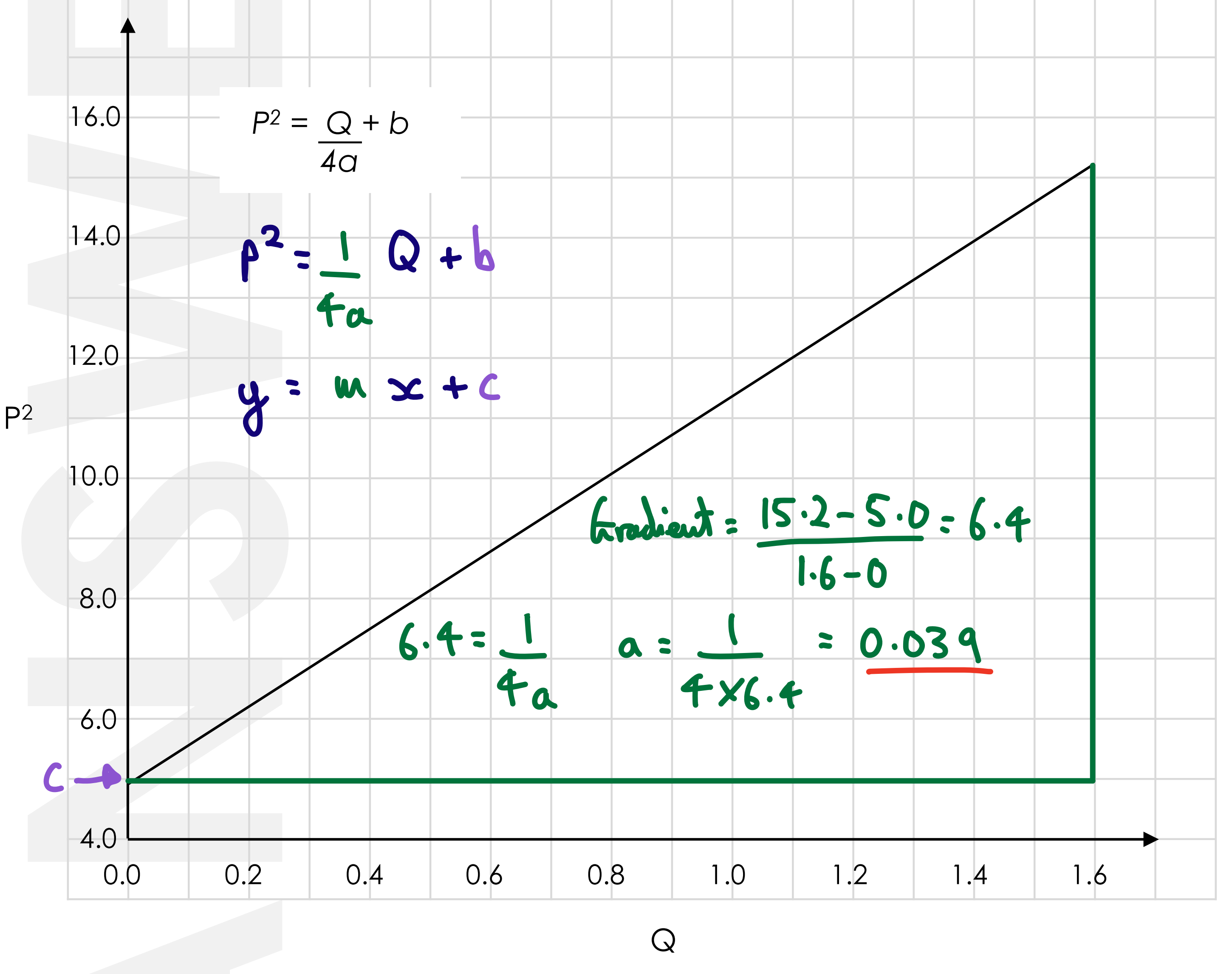
24th April

1. Calculate the **moment of a couple** of two 30 N forces acting in opposite directions on opposite sides of a steering wheel with a diameter of 30 cm.



$M = Fd = 30 \times 0.30 = \underline{9.0}\ \text{Nm}$

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



$P^2 = \frac{Q}{4a} + b$

$p^2 = \frac{1}{4a} Q + b$

$y = m x + c$

$\text{Gradient} = \frac{15.2 - 5.0}{1.6 - 0} = 6.4$

$6.4 = \frac{1}{4a}$ $\quad a = \frac{1}{4 \times 6.4} = \underline{0.039}$

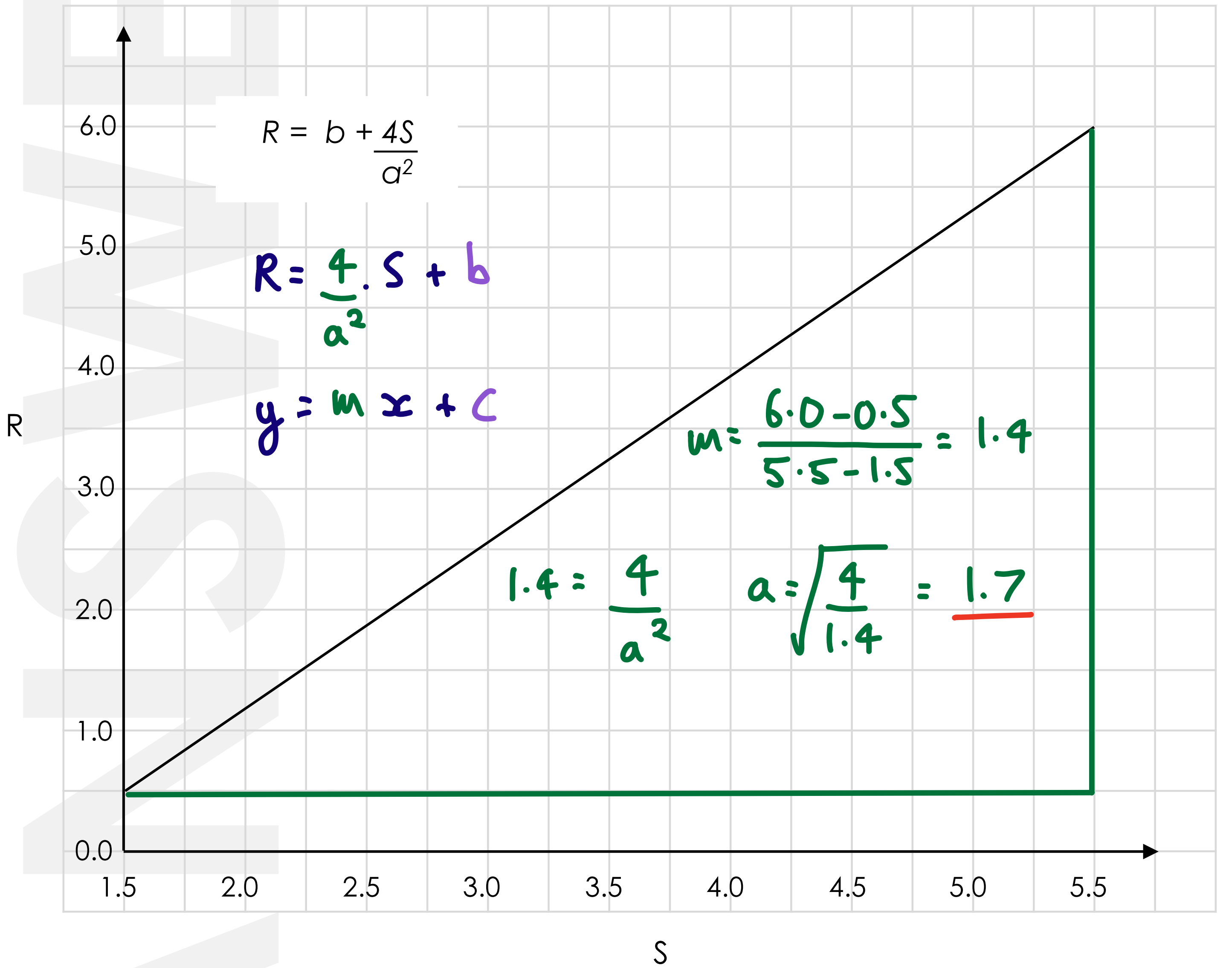
$b = \text{y-intercept} = \underline{5.0}$

25th April

1 2

1. Write the **unit** more commonly used for these quantities (shown in their base units):
   a. kg m^2 s^{-2} J
   b. A s C
   c. kg m^2 s^{-3} A^{-1} $JC^{-1} = V$

2. Determine the values of **a** and **b** using the gradient and values from the graph.



$R = \frac{4}{a^2} . S + b$

$y = m x + c$

$m = \frac{6.0 - 0.5}{5.5 - 1.5} = 1.4$

$1.4 = \frac{4}{a^2}$ $a = \sqrt{\frac{4}{1.4}} = \underline{1.7}$

$y = mx + c$ $c = y - mx = 0.5 - (1.4 \times 1.5)$

$c = -1.6$ $\therefore$ $b = \underline{-1.6}$

26th April

1 2 3

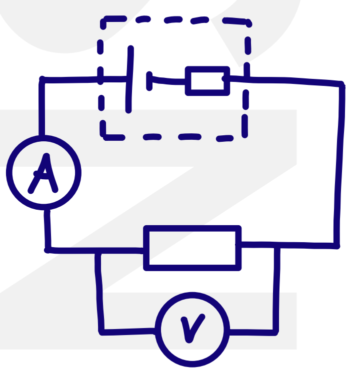
1. Write the **unit** more commonly used for these quantities expressed in their base units:
   a. kg m^{-1} s^{-2} $\quad Nm^{-2} = Pa$
   b. kg m^2 s^{-3} A^{-1} $\quad V$
   c. kg m^2 s^{-3} A^{-2} $\quad VA^{-1} = \Omega$

2. Define:
   a. **Elastic** behaviour
   b. **Plastic** behaviour

3. A cell is connected in series with an ammeter and a resistor. A voltmeter is connected in parallel with the resistor. The readings on the two meters are 0.25 A and 1.875 V.

   The resistor is then replaced with one of a different value and the readings change to 0.50 A and 1.750 V.

   Calculate the values of the **EMF** and the **internal resistance** of the cell.



0.25 A
1.875 V
$E = V + Ir$
$E = 1.875 + 0.25r$
$2E = 3.750 + 0.50r$ ①

0.50 A
1.750 V
$E = V + Ir$
$E = 1.750 + 0.50r$ ②

① − ② $\quad 2E - E = 3.750 + 0.\cancel{50}r - 1.750 - 0.\cancel{50}r$
$E = 2.00\,V$

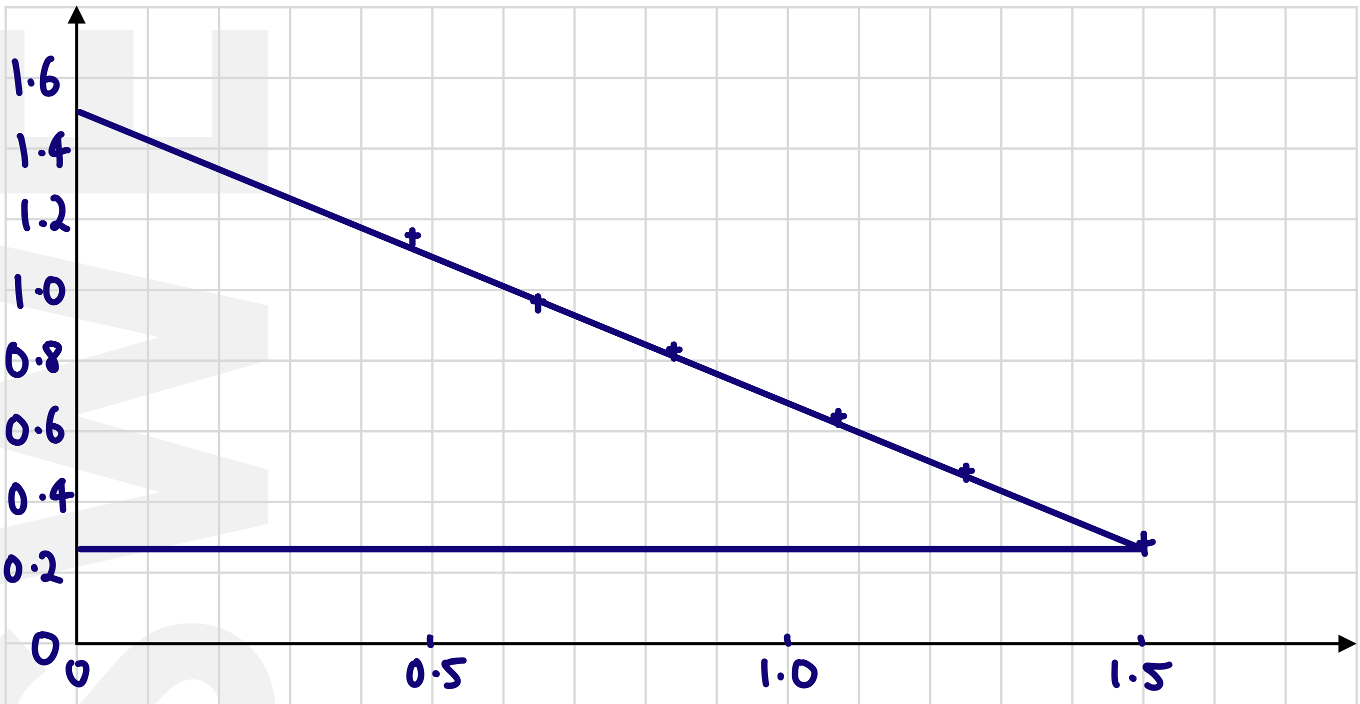
$r = \frac{E - V}{I} = \frac{2.00 - 1.875}{0.25} = 0.50\,\Omega$

27th April

1. A student connects a cell in series with a variable resistor and an ammeter. They connect a voltmeter in parallel with the cell. They alter the value of the variable resistor and obtain the results below.

Terminal PD / V	0.30	0.50	0.64	0.83	0.98	1.17
Current / A	1.50	1.25	1.07	0.83	0.65	0.47

a. **Plot the data** below, with the current on the x-axis



b. Calculate the **gradient** and **intercept** of the graph and state what these values **represent**

Gradient = $\frac{0.25 - 1.5}{1.5 - 0}$ = -0.83 = $-r$ ($r = 0.83\ \Omega$)

y-intercept = 1.5 = E (EMF = 1.5V)

c. State the values of the **intercept** and **gradient** you would expect in the following cases:

i. Two of the same cells in **series**

$c = 3.0$ $m = -1.7$

ii. Two of the same cells in **parallel**

$c = 1.5$ $m = -0.42$

28th April

1

1. A student is investigating the power output from a resistor connected to a battery that is made up of four cells in series, each with EMF 1.50 V and internal resistance 1.50 Ω.

   a. Write down the **EMF** and **internal resistance** of the battery

   $4 \times 1.50 = 6.00\text{ V}$ $\quad\quad$ $4 \times 1.50 = 6.00\,\Omega$

   b. State the **equation** used to calculate power output when a component has a current, I, passing through it and a potential difference, V, across it

   $P = VI$

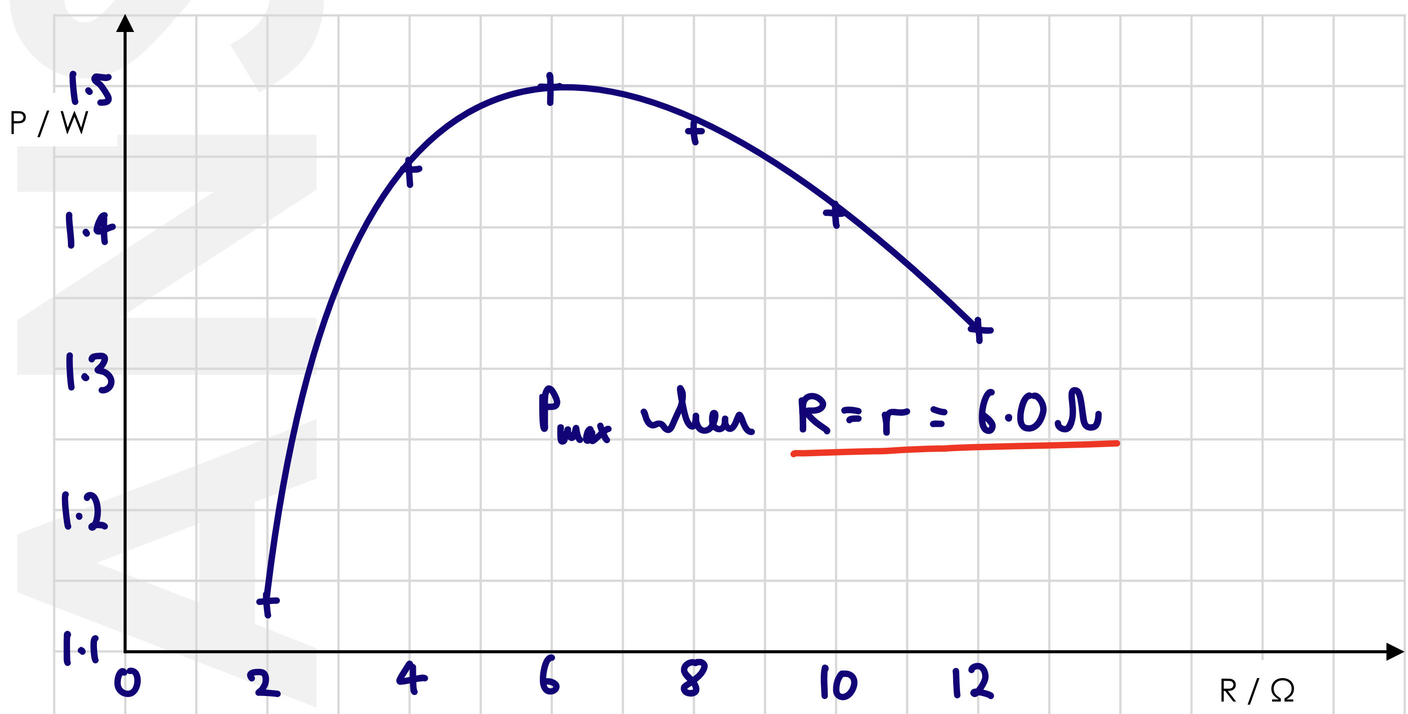
   The student attaches the battery to an ammeter and a variable resistor in series. They then change the value of the external resistance, R, in the circuit.

   c. Complete the table below by calculating the **total resistance** in the circuit, the **current**, the terminal PD, and the **power** output in the external part of the circuit. The first column is already completed

   $E = I(R+r)$ $\quad$ $I = E \div (R+r)$ $\quad$ $V = E - Ir$

External resistance, R / Ω	2.00	4.00	6.00	8.00	10.0	12.0
Total resistance (R + r) / Ω	8.00	10.00	12.00	14.00	16.00	18.00
Current / A	0.750	0.600	0.500	0.429	0.375	0.333
Terminal PD / V	1.50	2.40	3.00	3.43	3.75	4.00
Power / W $P = VI$	1.13	1.44	1.50	1.47	1.41	1.33

   d. Use the data in the table to **plot a graph** of power against external resistance, R, and deduce from your line of best fit the value of R for **maximum power**

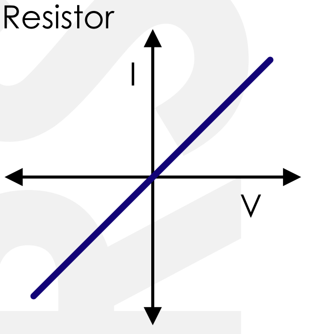


29th April

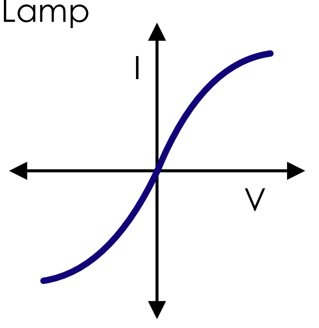
1 2 3

1. Sketch the **IV characteristics** of a:

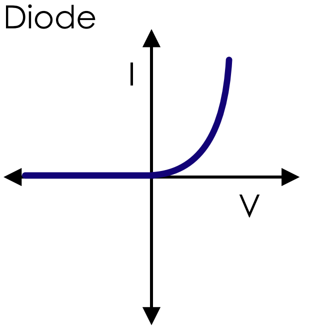
a. Resistor



b. Lamp



c. Diode

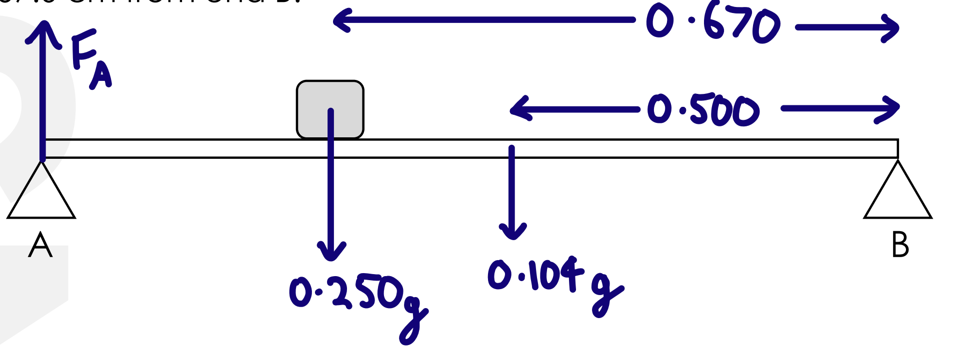


2. Define:

a. **Ohm's law**

b. **Resistance**

3. A uniform 104 g metre ruler is supported at each end by triangular pieces of metal at points A and B as shown in diagram below. A 250 g mass is supported with the centre of mass exactly 67.0 cm from end B.



a. Calculate the total **anti-clockwise** moment of the ruler and mass about the point B

$\overset{\curvearrowleft}{M} = (0.250 \times 9.81 \times 0.670) + (0.104 \times 9.81 \times 0.500) = \underline{2.15}$ Nm

b. Calculate the **force** provided by support A

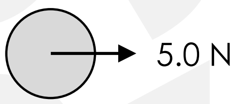
$\overset{\curvearrowright}{M} = \overset{\curvearrowleft}{M}$ $\quad F_A \times 1.00 = 2.15$ $\quad F_A = \underline{2.15}$ N

30th April

1 2 3

1. Calculate the **work done** by the forces in the diagrams below if the object moves 1.5 m to the right.

a.

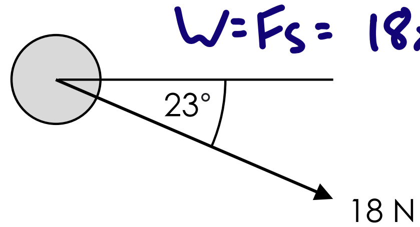


$W = Fs = 5.0 \times 1.5 = \underline{7.5}\ J$

b.

$W = Fs = 18 \times \cos 23 \times 1.5$

$= \underline{25}\ J$



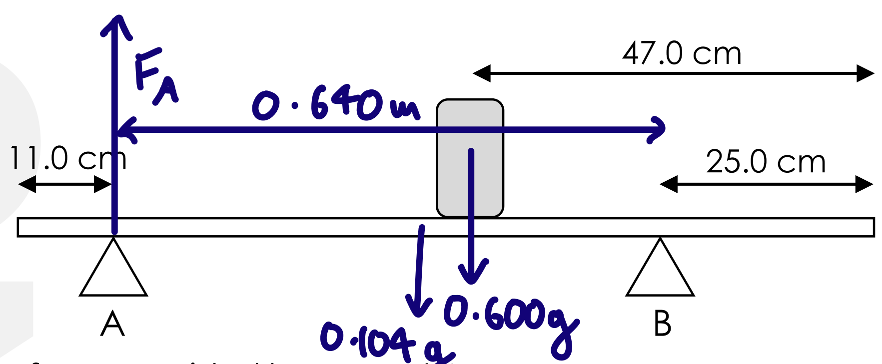
2. A high jumper runs at 8.0 m s^{-1}. They take off jumping vertically into the air, and their kinetic energy as they leave the ground is 65 % of their kinetic energy in their run up. Calculate how **high** they could they jump if they have a mass of 75 kg.

$E_k \rightarrow = \frac{1}{2}mv^2 = \frac{1}{2} \times 75 \times 8.0^2 = 2400\ J$

$E_k \uparrow = 0.65 \times 2400 = 1560\ J$

$E_p = E_k \uparrow \qquad h = \frac{1560}{75 \times 9.81} = \underline{2.1}\ m$

3. A uniform 104 g metre ruler is supported by triangular pieces of metal at A and B. It supports a 600g mass as shown below.



a. Calculate the **force** provided by support A

$\overset{\curvearrowright}{M} = \overset{\curvearrowleft}{M} \qquad F_A \times 0.640 = (0.104 \times 9.81 \times 0.250) + (0.600 \times 9.81 \times 0.220)$

(Moments about B)

$F_A = \underline{2.42}\ N$

b. Calculate the **force** provided by support B

$F\uparrow = F\downarrow \qquad 2.42 + F_B = (0.104 + 0.600) \times 9.81$

$F_B = \underline{4.48}\ N$