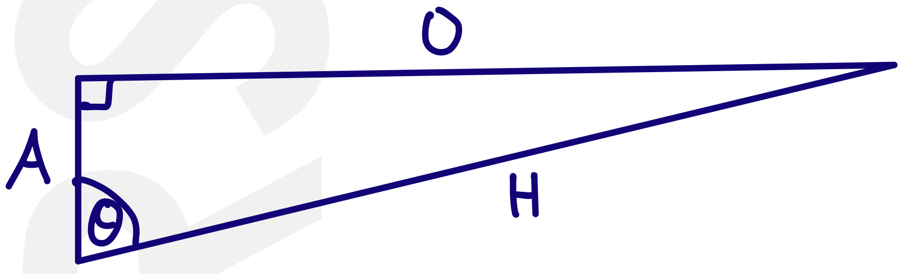
1st November

1 2 3

1. Calculate the **angle**, θ, in a triangle with a hypotenuse of length 1.2 m and an opposite side length of 1.0 m.



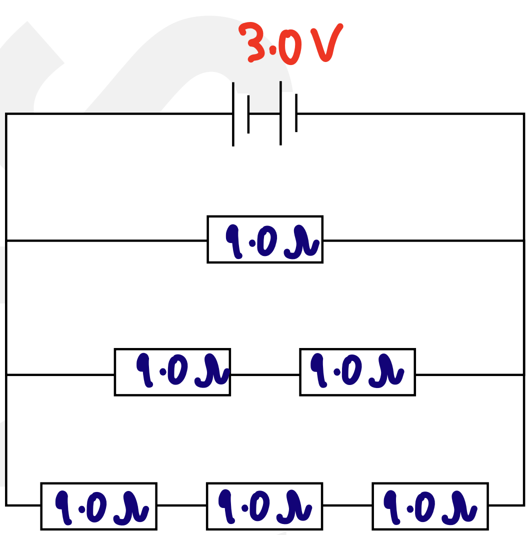
$$\sin\theta = \frac{O}{H}$$

$$\theta = \sin^{-1}\left(\frac{1.2}{1.0}\right) = \underline{56°}$$

2. Write down the **units** for:

   a. Potential difference — volt, V
   b. Resistivity — ohm metre, Ωm
   c. Capacitance — farad, F
   d. Momentum — kg m s^{-1}
   e. Electromotive force — volt, V
   f. Magnetic flux density — tesla, T

3. In the circuit below are six identical 9.0 Ω resistors and a battery of e.m.f 3.0 V. Calculate the total **energy transferred per second** in this circuit.



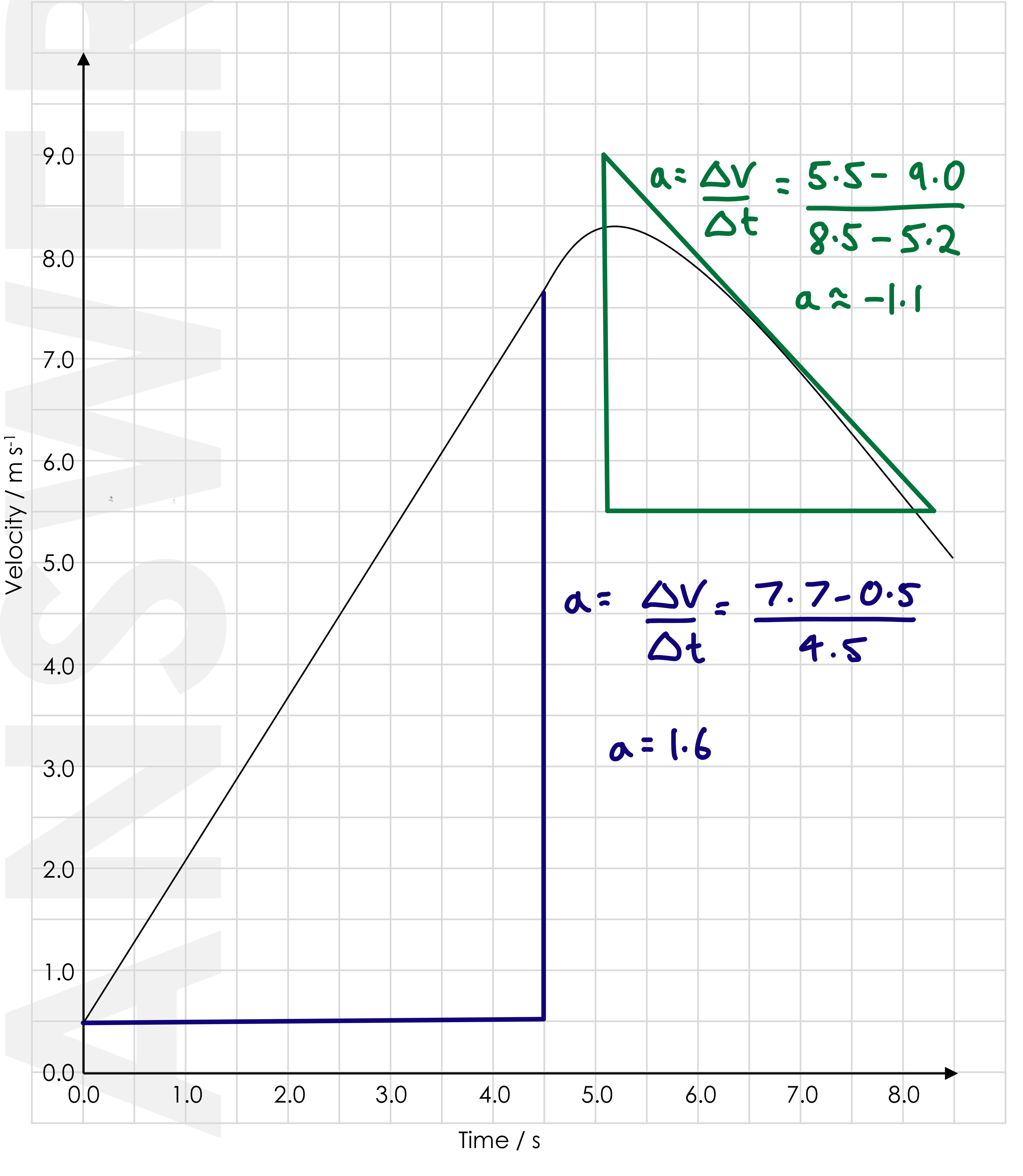
$$\frac{1}{R_T} = \frac{1}{9.0} + \frac{1}{(9.0+9.0)} + \frac{1}{(9.0+9.0+9.0)}$$

$$R_T = 4.909$$

$$P = \frac{V^2}{R_T} = \frac{3.0^2}{4.909} = 1.833 \approx \underline{1.8}\,W$$

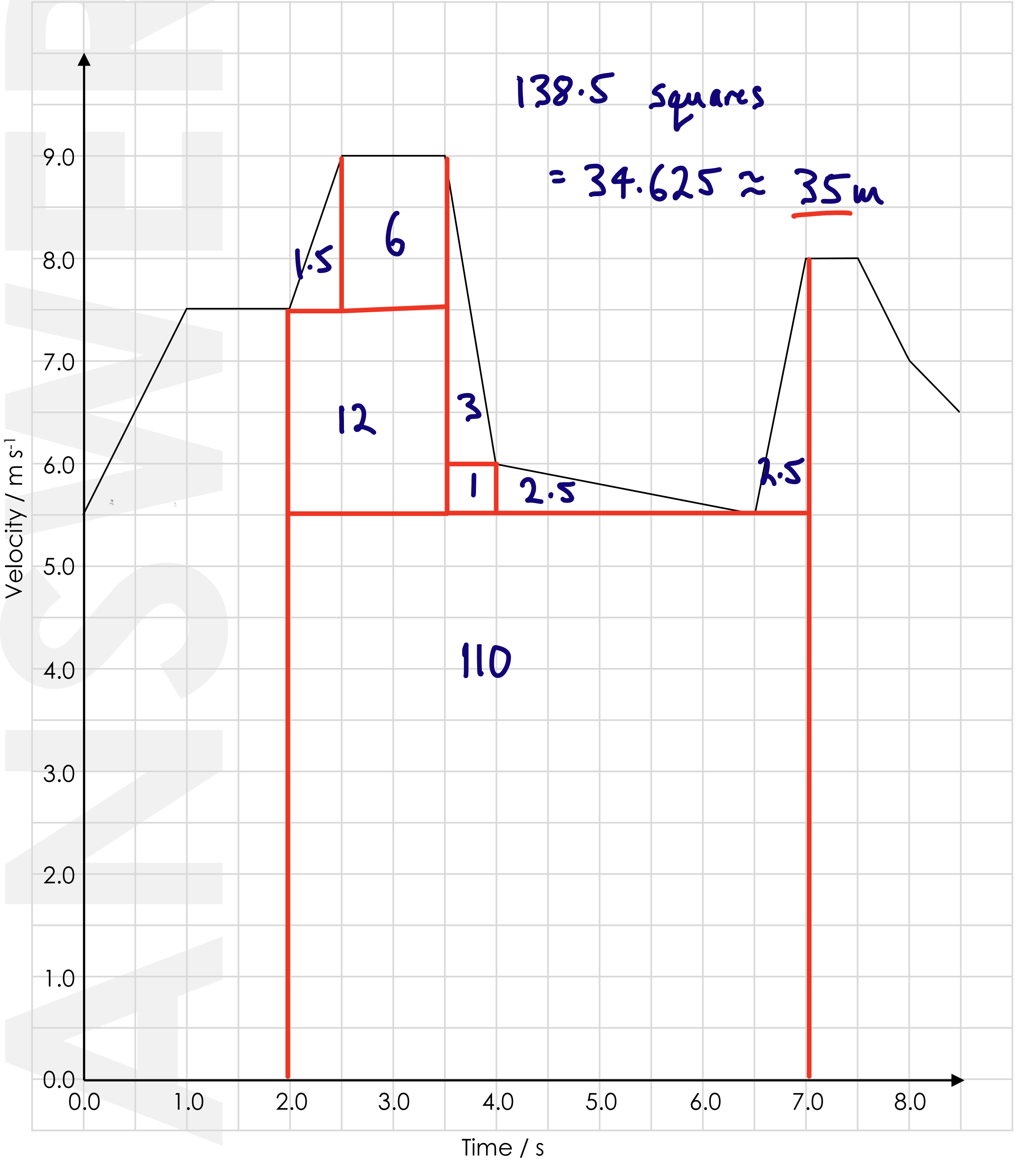
2nd November – Part 1

1. Calculate the **acceleration** at:
   a. t = 2.0 s $a = 1.6 \text{ m s}^{-2}$
   b. t = 6.5 s $a \approx -1.1 \text{ m s}^{-2}$



2nd November – Part 2

2. Calculate the **displacement** between t = 2.0 and t = 7.0 s.



3rd November

1 2

Percentage Uncertainty – Single Measurement

The percentage uncertainty for a single measurement can be calculated from the absolute uncertainty (which is often stated in exam questions) and the measured value.

$$\textit{percentage uncertainty} = \frac{\textit{absolute uncertainty}}{\textit{measured value}} \times 100\%$$

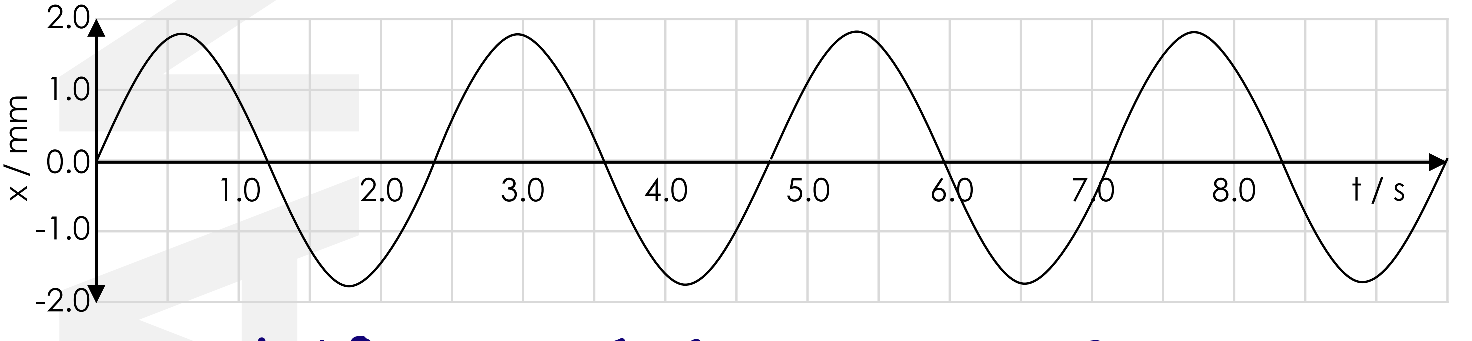
Example: Calculate the percentage uncertainty in the length of a pencil measured with a value of 12.2 ± 0.1 cm.

$$\textit{percentage uncertainty} = \frac{0.1}{12.2} \times 100\% = 0.820 \approx 0.82\ \%\ (2\ \text{s.f.})$$

1. Calculate the **percentage uncertainty** (to 2 s.f.) in the following data:

	Measured Value	Absolute Uncertainty	Percentage Uncertainty / %
a.	15 mm	± 1 mm	6.7
b.	272 mm	± 1 mm	0.37
c.	8.21 s	± 0.01 s	0.12
d.	8.21 s	± 0.2 s	2.4
e.	2.8 kg	± 0.1 kg	3.6
f.	2.802 kg	± 0.001 kg	0.036

2. Determine the **amplitude** and **time period** of the following wave.



A = 1.8mm $\quad T = \frac{9.5}{4} = 2.375 \approx 2.4s$

4^{th} November

1 2 3

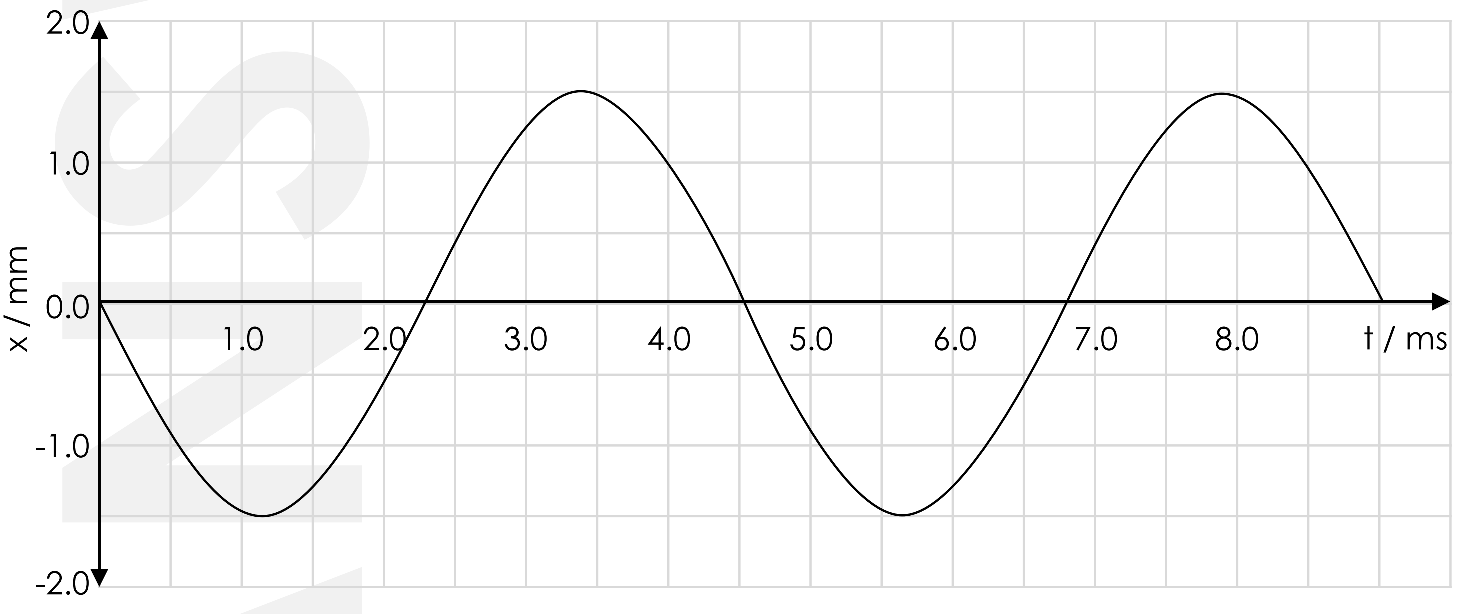
1. Calculate the **percentage uncertainty** (to 2 s.f.) in the following data:

	Measured Value	Absolute Uncertainty	Percentage Uncertainty / %
a.	10 mm	± 1 mm	10
b.	10.14 mm	± 0.01 mm	0.099
c.	8.2 cm	± 1 mm	1.2
d.	0.882 m	± 1 mm	0.11
e.	0.8 s	± 0.1 s	13
f.	8.2 s	± 0.1 s	1.2

2. **Define** Ohm's law.

The potential difference across a component is directly proportional to the current through it, at a constant temperature.

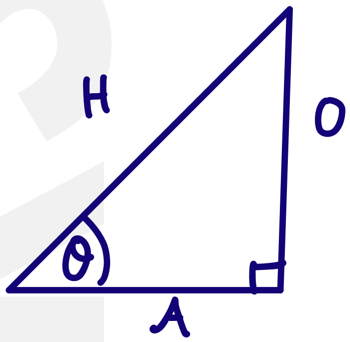
3. Determine the **amplitude**, **time period** and **frequency** of the following wave.



A: 1.5 mm   T = 4.5 ms $f = \frac{1}{4.5 \times 10^{-3}} = 2.2 \times 10^{2}$ Hz

5th November

1. Calculate the **angle**, θ, in a triangle with a hypotenuse of length 6.5 cm and an adjacent side length of 3.1 cm.



$\cos\theta = \frac{A}{H}$

$\theta = \cos^{-1}\left(\frac{3.1}{6.5}\right) = 62°$

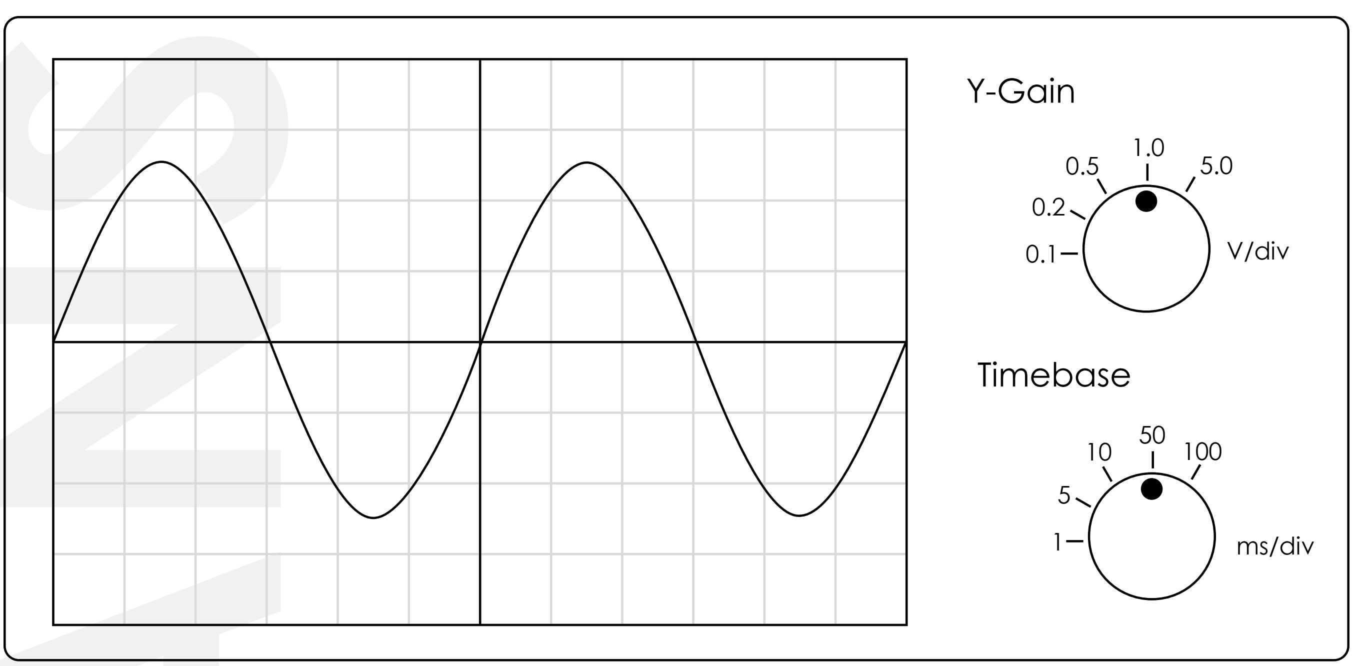
2. When investigating resistivity, a wire is used that has its diameter of 0.42 mm measured with a micrometer to ± 0.01 mm, and length of 40.0 cm measured with an uncertainty of ± 1 mm.

   Calculate the **percentage uncertainty** (to 2 s.f.) in:

   a. The **diameter** $\frac{0.01}{0.42} \times 100 = 2.4\%$

   b. The **length** $\frac{1}{400} \times 100 = 0.25\%$

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



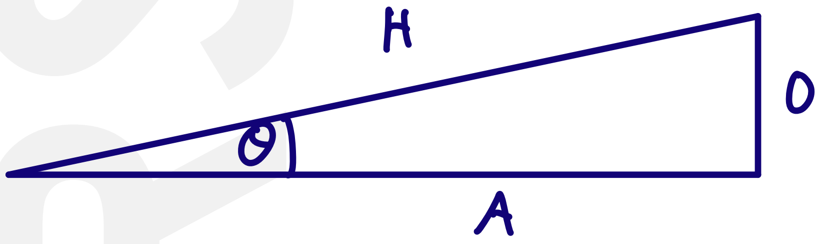
A: $2.5 \times 1.0 = 2.5\text{ V}$

T: $6.0 \times 50 \times 10^{-3} = 0.30\text{ s}$

6th November

1 2 3

1. Calculate the **length** of the adjacent side of a right angle triangle with an angle of 10˚ and an opposite side length of 9.3 cm.



$\tan\theta = \frac{O}{A}$

$A = \frac{9.3}{\tan 10} = 53\text{ cm}$

2. Laser light is incident on a double slit and projected onto a screen. The total distance across eleven fringes of light is measured with a ruler as 5.4 cm, with an uncertainty of ± 1 mm.

(not to scale)

a. Calculate the **percentage uncertainty** (to 2 s.f.) in the distance measured

$\frac{1}{54} \times 100 = 1.9\%$

b. Calculate the **spacing** between each fringe

$\frac{54}{10} = 5.4\text{ mm}$

c. State the **percentage uncertainty** in spacing between fringes

1.9%

3. Define:

a. **Wavelength** The distance between two adjacent points that are in phase.

b. **Monochromatic light**

Light that has a single wavelength.

c. **Coherent waves**

Waves that have a constant phase difference.

7th November

1 2 3

1. Calculate the **mean value**, and **range**, of the following numbers:

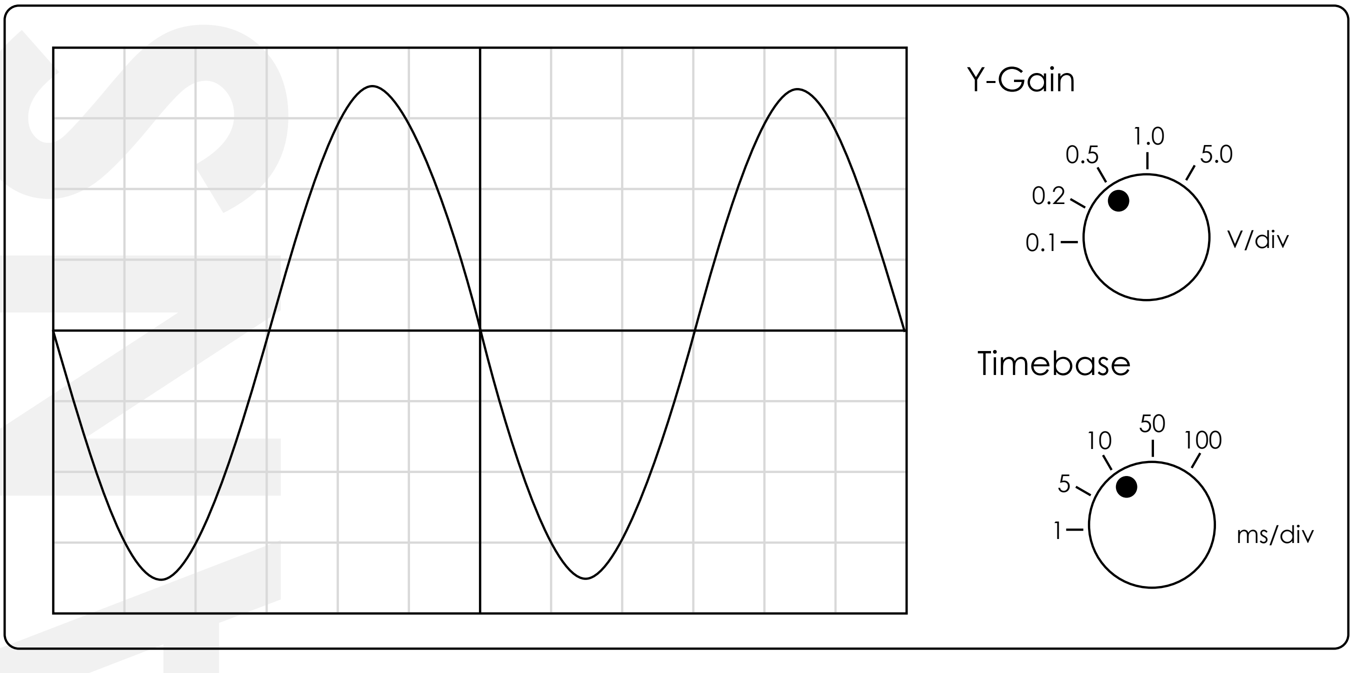
	Value 1	Value 2	Value 3	Value 4	Value 5	Mean	Range
a.	82.57	85.48	86.06	85.76	85.29	85.03	3.49
b.	17.94	16.82	16.23	16.28	16.57	16.77	1.71
c.	9.95	8.04	9.32	8.56	9.00	8.97	1.91
d.	3.50	3.57	3.62	3.41	3.43	3.51	0.21

2. The wavelength of light is investigated using a double slit. The slit separation is measured using a travelling microscope as 0.60 ± 0.01 mm.

Calculate the **percentage uncertainty** (to 2 s.f.) in this measurement.

$$\frac{0.01}{0.60} \times 100 = 1.7\%$$

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



$$A = 3.5 \times 0.5 = 1.75 \approx 1.8\,V$$

$$f = \frac{1}{T} = \frac{1}{6 \times 10 \times 10^{-3}} = 16.66 \approx 17\,Hz$$

8th November

1 2 3

1. Calculate the **mean value**, and **range**, of the following numbers:

	Value 1	Value 2	Value 3	Value 4	Value 5	Mean	Range
a.	83.53	84.85	86.06	82.66	85.29	84.48	3.4
b.	84.35	84.46	84.56	84.47	84.55	84.48	0.21
c.	1.85	1.04	1.32	1.56	1.23	1.40	0.81
d.	23.53	23.47	23.61	23.14	23.40	23.43	0.47

2. To investigate the Young modulus of a material like copper, a thin piece of wire can be loaded so it extends.

   The diameter of wire used in this experiment is measured with a micrometer screw gauge as 0.42 ± 0.01 mm.

   a. Calculate the **percentage uncertainty** (to 2 s.f.) in the diameter

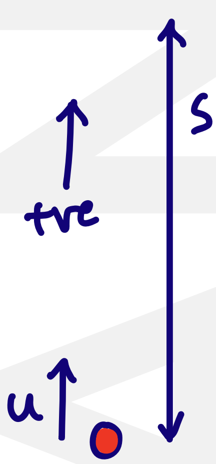
   $$\frac{0.01}{0.42} \times 100 = 2.4\%$$

   b. State the **percentage uncertainty** (to 2 s.f.) in the radius

   $$2.4\%$$

3. A ball is thrown vertically up into the air with an initial velocity of 5.0 m s^{-1}. Calculate how **long** the ball takes to return to the start position.

   State any assumptions made in your answer.



s
u = 5.0 m s^{-1}
v = 0 m s^{-1}
a = −9.81 m s^{-2}
t = ?

$$t = \frac{v-u}{a} = \frac{0 - 5.0}{-9.81}$$

$$t = 0.5097$$

$$\therefore t_{total} = 2 \times 0.5097 = 1.0\ s$$

Assume no air resistance

9th November

1 2

Percentage Uncertainty – Repeat Measurements

The percentage uncertainty for repeated measurements can be calculated from the uncertainty, which is equal to half the range, and the mean value.

$$\textit{percentage uncertainty} = \frac{\textit{half the range}}{\textit{mean value}} \times 100\%$$

Example: Calculate the percentage uncertainty in the following set of data:

d / mm	23.4	22.9	23.1	23.3

half the range = (23.4 – 22.9) ÷ 2 = 0.25

mean value = (23.4 + 22.9 + 23.1 + 23.3) ÷ 4 = 23.175

$$\textit{percentage uncertainty} = \frac{0.25}{23.175} \times 100\% = 1.08 \approx 1.1\% \text{ (2 s.f.)}$$

1. Calculate the **percentage uncertainty** (to 2 s.f.) in the following data:

	Value 1 / mm	Value 2 / mm	Value 3 / mm	Value 4 / mm	Value 5 / mm	Mean / mm	½ Range / mm	Percentage Uncertainty / %
a.	83	84	87	81	86	84.2	3.0	3.6
b.	83	85	84	84	85	84.2	1.0	1.2
c.	1.35	1.24	1.32	1.36	1.23	1.30	0.065	5.0
d.	0.25	0.24	0.26	0.21	0.23	0.238	0.025	11

2. A cheetah accelerates from rest to a velocity of 22 m s^{-1} in a time of 3.5 seconds.

   Calculate how **far** it has travelled in this time.

s = ?
u = 0 ms^{-1}
v = 22 ms^{-1}
a =
t = 3.5 s

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

$s = 0.5 \times (0 + 22) \times 3.5 = 38.5$

≈ 39 m

10th November

1 2 3

1. Calculate the **percentage uncertainty** (to 2 s.f.) of the following data:

	Value 1 / mm	Value 2 / mm	Value 3 / mm	Value 4 / mm	Value 5 / mm	Mean / mm	½ Range / mm	Percentage Uncertainty / %
a.	127	130	132	128	128	129	2.5	1.9
b.	138	135	~~84~~	136	132	135.25	3.0	2.2
c.	2.65	2.68	2.68	2.66	2.64	2.662	0.02	0.75
d.	0.61	0.61	0.62	0.65	0.63	0.624	0.02	3.2

2. Define:

a. **Kirchhoff's first** law

$\Sigma I_{in} = \Sigma I_{out}$ (at a junction)

b. **Kirchhoff's second** law

$\Sigma E = \Sigma V$ (around any closed loop)

3. You are given the equation 'energy = momentum x the speed of light'. Work out whether this is **homogeneous** or not.

Note: An equation is homogenous if the units on both sides of the equals sign are the same.

$$E = pc$$

$$E = \frac{1}{2}mv^2 = [kg] \times [m s^{-1}]^2 = [kg\ m^2 s^{-2}]$$

$p = [kg\ m\ s^{-1}]$

$c = [m\ s^{-1}]$

$pc = [kg\ m\ s^{-1}] \times [m\ s^{-1}]$

$pc = [kg\ m^2 s^{-2}]$

Yes it is

11th November

1 2 3

1. Define a:

    a. **Progressive** wave

    Transfers energy.

    b. **Transverse** wave

    Oscillations at 90° to the direction of energy transfer.

2. While investigating standing waves on a string, the distance between adjacent nodes was measured as 22.0 cm with an uncertainty of ± 0.4 cm owing to the difficulty in identifying exactly where the position of each node was.

    a. Calculate the **percentage uncertainty** (to 2 s.f.) in this measurement.

    $$\frac{0.4}{22.0} \times 100 = 1.8\%$$

    b. State the **percentage uncertainty** in the calculated wavelength of the standing wave (the distance from a node to a node is equal to half the wavelength).

    1.8%

3. A van of mass 4500 kg undergoes a collision where it decelerates from an initial velocity of 12.0 m s^{-1} to a final velocity of 4.0 m s^{-1} in a time of 400 ms.

    Calculate the **average force** experienced during the collision.

    $$F = \frac{\Delta p}{\Delta t} = \frac{m(v-u)}{t} = \frac{4500(4.0-12.0)}{400 \times 10^{-3}}$$

    $$F = 90\,000 \text{ N}$$

12th November

1 2 3

1. Determine the **result** that should be recorded for X and calculate the **percentage uncertainty** in the data:

X / mm	0.38	0.42	0.41	0.41	0.42

$X = 0.41$ mm

$\frac{0.02}{0.408} \times 100 = 4.9\%$

2. In a further experiment to investigate standing waves on a string, the distance between five nodes was measured as 88.3 cm, again with an absolute uncertainty of ± 0.4 cm owing to the difficulty in identifying exactly where the position of each node was.

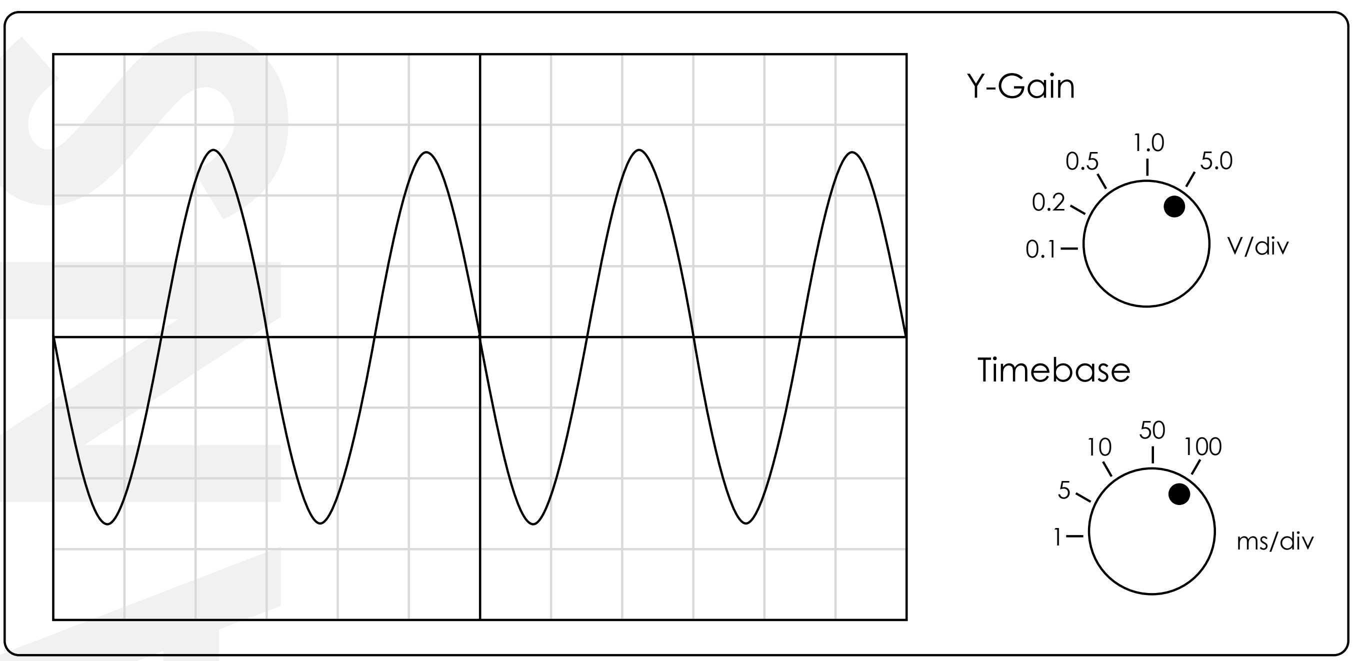
   a. Calculate the **percentage uncertainty** (to 2 s.f.) of this measurement

   $\frac{0.4}{88.3} = 0.45\%$

   b. State the **percentage uncertainty** in the calculated wavelength of the standing wave

   0.45%

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



$A = 2.6 \times 5.0 = 13V$

$f = \frac{1}{T} = \frac{1}{3 \times 100 \times 10^{-3}} = 3.3\ Hz$

13th November

1 2

1. Determine the **result** that should be recorded for the amplitude, A, and calculate the **percentage uncertainty** in the data:

A / cm	9.8	9.4	~~6.1~~	9.5	9.4

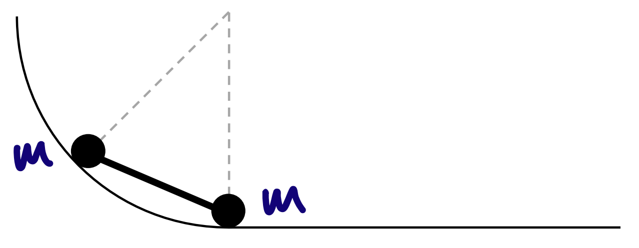
$A = 9.5\,cm$

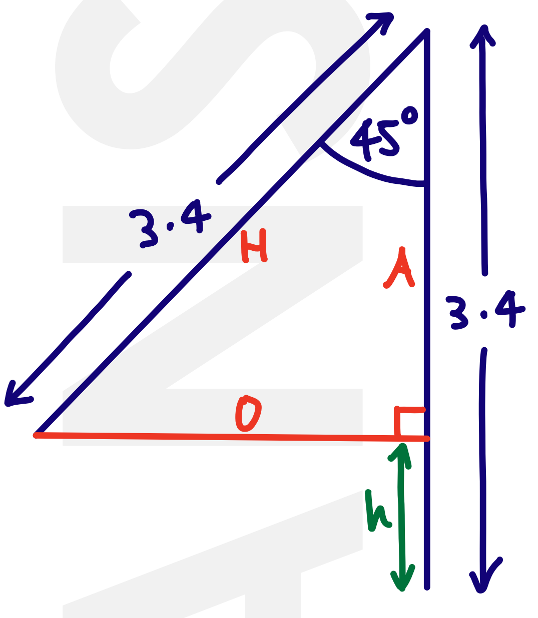
$\frac{0.2}{9.525} \times 100 = 2.1\%$

2. A smooth surface consists of a quarter circle sheet joined onto a smooth horizontal plane. A light, rigid rod with two small, equal masses, m, on each end lies in a vertical plane with the lower mass on the join of the flat and curved surfaces, as shown in the figure below. The separation of the masses is 1/8 of the circumference of the circle.

When released, the rod and masses will slide along the smooth horizontal plane. Calculate the **maximum speed** if the rod and masses remain in the same vertical plane.

The radius of the circle is 3.4 m.





$\cos\theta = \frac{A}{H}$

$A = H\cos\theta$

$A = 3.4\cos 45$

$A = 2.404\,m$

$h = 3.4 - 2.404$

$h = 0.9958$

$E_p \rightarrow E_k$

$\cancel{m}gh = \frac{1}{2}(2\cancel{m})v^2$

$gh = v^2$

$v = \sqrt{gh}$

$v = \sqrt{9.81 \times 0.9958}$

$v = 3.1\,ms^{-1}$

Adapted from a BPhO question from the 2019 Year 12 Challenge

14th November

1 2 3

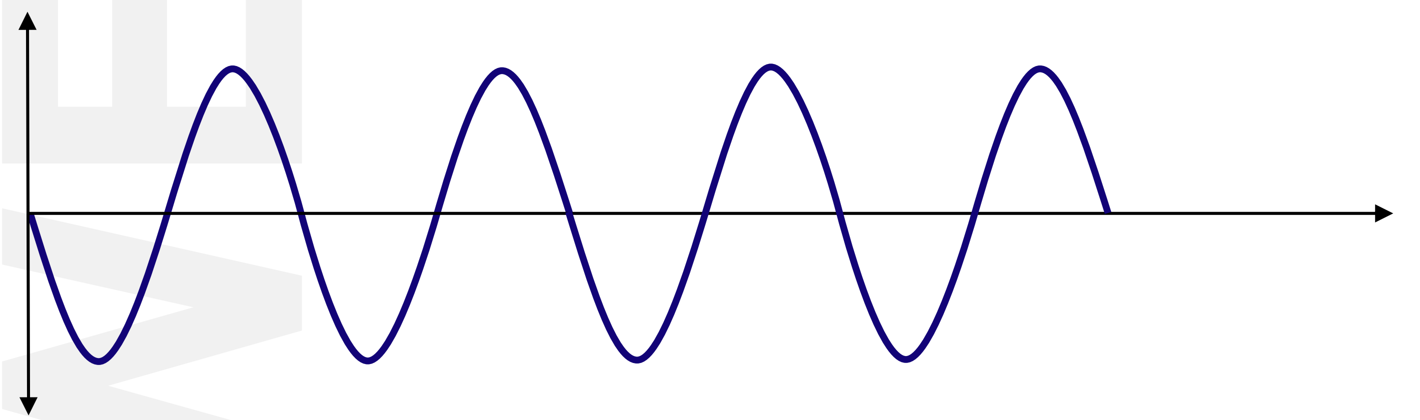
1. The diameter of a wire, used to measure the Young modulus of copper, was measured in three places with values of 0.42, 0.46 and 0.41 mm.

   Calculate the **mean value** and **percentage uncertainty** (to 2 s.f.) of these measurements.

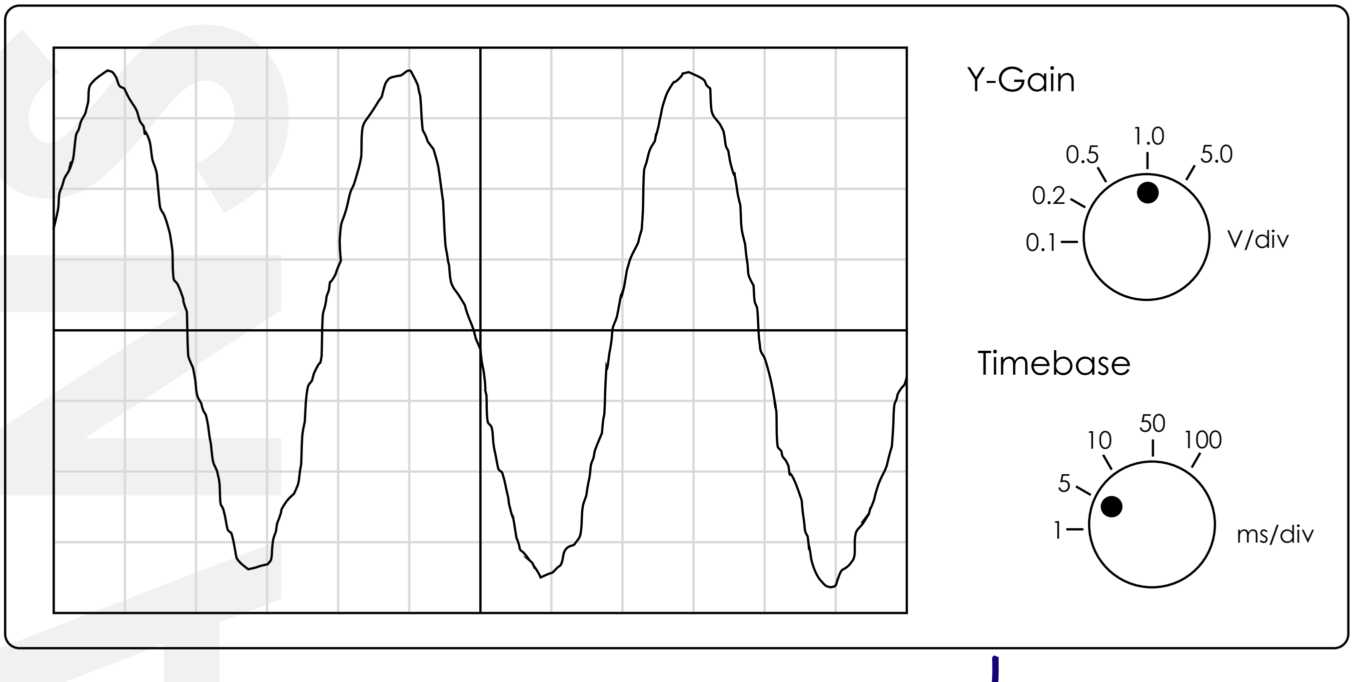
   $$\frac{0.42 + 0.46 + 0.41}{3} = 0.43\ \text{mm}$$

   $$\frac{0.025}{0.43} \times 100 = 5.8\%$$

2. Complete the following **sinusoidal** curve:



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



$$A = 3.8 \times 1.0 = 3.8\ \text{V}$$

$$f = \frac{1}{T} = \frac{1}{4.1 \times 5 \times 10^{-3}} = 49\ \text{Hz}$$

15th November

1 2

Adding Uncertainties

The total uncertainty in a final value can be estimated by adding the absolute uncertainties in the measured values.

$$A = B + C \qquad \Delta A = \Delta B + \Delta C$$

$$A = B - C \qquad \Delta A = \Delta B + \Delta C$$

Note: The uncertainty here has been represented here by 'ΔX'. There is no standard for this at A Level and exam mark schemes give credit for all reasonable methods of working out.

1. The original length of a spring was 5.2 cm. After a tensile load was applied its final length is 8.3 cm. A ruler was used with an uncertainty of ± 1 mm.

   a. State the **absolute uncertainty** in each measurement

   ± 1 mm

   b. Calculate the **extension** of the spring in mm

   $8.3 - 5.2 = 3.1$ cm or 31 mm

   c. State the **total uncertainty** in the extension

   ± 2 mm

   d. Calculate the **percentage uncertainty** (to 2 s.f.) in the extension of the spring

   $\frac{2}{31} \times 100 = 6.5\%$

2. Write down the definition of **Hooke's law**.

   $F \propto x$ (provided the elastic limit is not exceeded)

16th November

1 2 3

1. The original length of a wire was 94.2 cm. After a tensile load was applied its final length was 97.1 cm. A ruler was used with an uncertainty of ± 1 mm.

   a. State the **absolute uncertainty** in each measurement

   ± 1 mm

   b. Calculate the **extension** of the wire in mm

   $971 - 942 = 29$ mm

   c. State the **total uncertainty** in the extension

   ± 2 mm

   d. Calculate the **percentage uncertainty** (to 2 s.f.) in the extension of the wire

   $$\frac{2}{29} \times 100 = 6.9\%$$

2. Define:

   a. Tensile **stress**

   The force exerted per unit cross sectional area.

   b. Tensile **strain**

   The extension of an object divided by its original length.

   c. The **Young modulus** of a material

   The ratio of tensile stress to tensile strain.

17^{th} November

1. Convert the following quantities into **SI units**:

   a. 630 nm — 6.30×10^{-7} m

   b. 82.3 x 10^{-3} nm — 8.23×10^{-11} m

   c. 568 ml — 5.68×10^{-4} m^3

   d. 4.25 ly — 4.02×10^{16} m

   e. 30.0 mph — 13.4 ms^{-1}

2. The time taken for a pendulum to make one oscillation was recorded as 0.8 s with an uncertainty estimated to be ± 0.2 s due to human error.

   a. Calculate the **percentage uncertainty** (to 2 s.f.) in this measurement

   $$\frac{0.2}{0.8} \times 100 = 25\%$$

   To improve the experiment the time taken for ten oscillations was recorded. A value of 8.2 was recorded, with the same uncertainty of ± 0.2 s due to human error.

   b. Calculate the **percentage uncertainty** (to 2 s.f.) in this measurement

   $$\frac{0.2}{8.2} \times 100 = 2.4\%$$

   The experiment was carried out by a different group. They recorded the following times from a stopwatch.

t_{10} / s	8.19	8.17	8.07	8.02	8.11

   c. Calculate the **percentage uncertainty** (to 2 s.f.) in this set of data

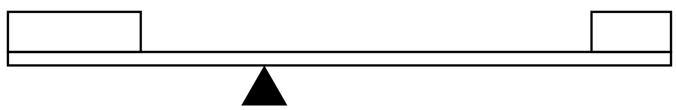
   $$\frac{0.085}{8.112} = 1.0\%$$

   d. Comment on your answer

   Percentage uncertainty reduces with repeated readings for multiple oscillations.

18th November

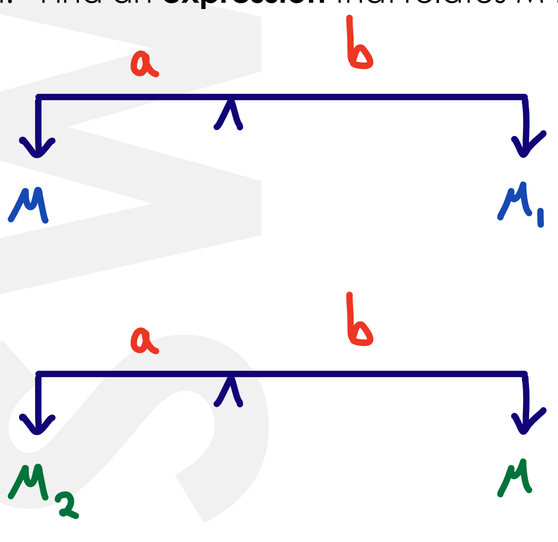
1. A lever balance, of the same type shown below, can be used to measure the mass of an object.



It consists of two small, unequal pans at the end of a beam balanced on a fulcrum. The arms of the balance are of unequal length, but the beam remains horizontal when the pans are not loaded.

An object of mass M is to be measured. When placed in one pan, the balance is levelled with a mass M_1 in the other pan. When M is placed into other pan, it is balanced by a mass M_2.

a. Find an **expression** that relates M to M_1 and M_2.



$Ma = M_1 b \rightarrow \frac{a}{b} = \frac{M_1}{M}$

$M_2 a = Mb \rightarrow \frac{a}{b} = \frac{M}{M_2}$

$\frac{M_1}{M} = \frac{M}{M_2}$ $M^2 = M_1 M_2$

$M = \sqrt{M_1 M_2}$

b. If M_1 = 1.22 kg and M_2 = 1.90 kg, calculate the **value** of the mass M.

$M = \sqrt{M_1 M_2} = \sqrt{1.22 \times 1.90} = 1.52\ kg$

Adapted from a BPhO question from the 2017 Year 12 Challenge

19th November – Part 1

Combining Uncertainties

The total percentage uncertainty in a calculated value can be estimated by combining the percentage uncertainties of the measured values.

$A = BC$ $\%A = \%B + \%C$

$A = BCD$ $\%A = \%B + \%C + \%D$

$A = B/C$ $\%A = \%B + \%C$

$A = B^2$ $\%A = 2 \times \%B$

$A = B^3$ $\%A = 3 \times \%B$

$A = \sqrt{B}$ $\%A = ½ \times \%B$

$A = B^2C/D^3E$ $\%A = (2 \times \%B) + \%C + (3 \times \%D) + \%E$

Note: The percentage uncertainty has been represented here by '%X', this can also be represented by '%U', '%uncertainty' or even 'ε'. There is no standard A Level symbol for this and exam mark schemes give credit for all reasonable methods of working out.

1. Measurements were made to determine the current and potential difference in a circuit component.

Quantity	Percentage Uncertainty
Current	1.8 %
Potential Difference	3.1 %

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

a. **Resistance**

$R = V/I$ $\%R = \%V + \%I = 3.1 + 1.8 = 4.9\%$

b. **Power**

$P = VI$ $\%P = \%V + \%I = 3.1 + 1.8 = 4.9\%$

19th November – Part 2

2. Measurements were made to determine the current, potential difference and time in an electrical circuit with a heater.

Quantity	Percentage Uncertainty
Current	4.7 %
Potential Difference	1.7 %
Time	0.2 %

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

a. **Resistance**

$R = V/I$

$\%R = \%V + \%I = 1.7 + 4.7 = \underline{6.4\%}$

b. **Energy** transferred

$E = ItV$

$\%E = \%I + \%t + \%V = 4.7 + 0.2 + 1.7$

$= \underline{6.6\%}$

3. Measurements were made to determine the diameter, length and resistance of a wire.

Quantity	Percentage Uncertainty
Diameter	2.2 %
Length	0.6 %
Resistance	1.3 %

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

Calculate the **percentage uncertainty** in the calculated value of **resistivity**.

$\%\rho = \%R + \%A + \%L = 1.3 + (2 \times 2.2) + 0.6$

$= \underline{6.3\%}$

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

20th November

1 2 3

1. Determine the **result** that should be recorded for M and calculate the **percentage uncertainty** in the data:

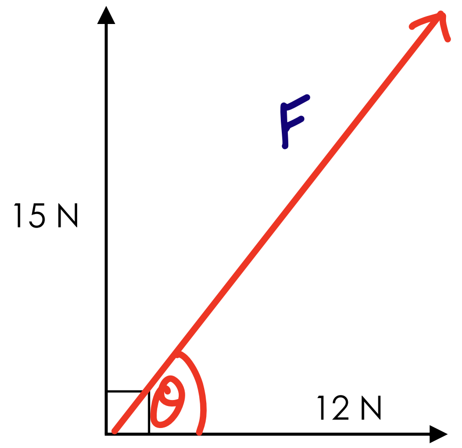
M / kg	0.098	0.101	0.100	0.104	0.098

$M = 0.100\ kg$ $\qquad \frac{0.003}{0.1002} \times 100 = 3.0\%$

2. Calculate the **size** and **direction** of the resultant force produced by these two perpendicular forces.

$F = \sqrt{12^2 + 15^2}$

$F = 19.2 \approx 19\ N$



$\theta = \tan^{-1}\left(\frac{15}{12}\right) = 51.3$

$\theta = 51°$

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

$A = 2.8 \times 0.1 = 0.28V$ $\qquad f = \frac{1}{T} = \frac{1}{9 \times 2 \times 5 \times 10^{-3}} = 11\ Hz$

21st November

1. Define:
   a. **Plastic** behaviour

      A material has a permanent change of shape when the load is removed.

   b. **Elastic** behaviour

      Material returns to its original dimensions when the load is removed.

2. The resistance of a wire is proportional to its length l, and inversely proportional to its cross-sectional area A. The constant of proportionality, ρ, is known as the resistivity of the material.

$$R = \frac{\rho l}{A}$$

For copper, the resistivity ρ_{Cu} = 1.68 x10^{-8} Ω m and for silicon, a semiconductor, with trace amounts of impurities, ρ_{Si} = 0.53 Ω m.

The resistance between two opposing faces of a copper cube of length 1.00 m and cross-sectional area 1.00 m^2 is 1.68 x 10^{-8} Ω.

Calculate the **length** of the side of a **cube** of silicon with if it had a resistance of 1.68 x10^{-8} Ω between opposite faces.

$$V = l^3 \quad A = l^2$$

$$R = \frac{\rho l}{A} = \frac{\rho l}{l^2} = \frac{\rho}{l}$$

$$l_{Si} = \frac{\rho_{Si}}{R_{Si}} = \frac{0.53}{1.68\times10^{-8}} = \underline{3.15\times10^{7}}\ \text{m}$$

Adapted from a BPhO question from the 2016 Year 12 Challenge

22nd November

1 2 3

1. Measurements were made to determine the force on a wire perpendicular to a magnetic field. Calculate the **percentage uncertainty** in the calculated value based on these measurements.

Quantity	Percentage Uncertainty
Magnetic field strength	5.0 %
Current	2.1 %
Length	0.3 %

$F = BIL$

$\%F = \%B + \%I + \%L$

$= 5.0 + 2.1 + 0.3$

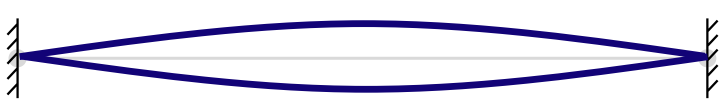
$= 7.4\%$

2. Rearrange the following equation to make '**k**' the subject: $T = 2\pi\sqrt{\frac{m}{k}}$

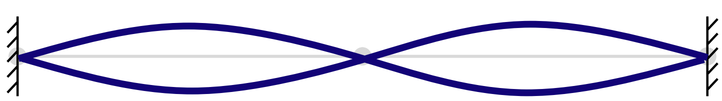
$T = 2\pi\sqrt{\frac{m}{k}}$ $\quad T^2 = 4\pi^2\frac{m}{k}$ $\quad k = 4\pi^2\frac{m}{T^2}$

3. Sketch the **standing/stationary** wave formed on a **string** fixed at both ends:

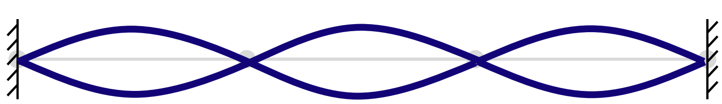
a. First harmonic



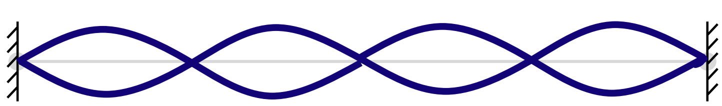
b. Second harmonic



c. Third harmonic



d. Fourth harmonic



23rd November

1 2 3

1. Measurements were made to determine the spring constant on an oscillating mass-spring system. Calculate the **percentage uncertainty** in the calculated value of ‘**k**’ based on these measurements.

Quantity	Percentage Uncertainty
Mass	0.2 %
Time period	1.3 %

$$T = 2\pi\sqrt{\frac{m}{k}}$$

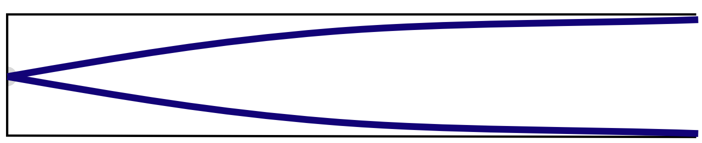
$$k = 4\pi^2 \frac{m}{T^2} \qquad \%k = \%m + (2 \times \%T) = 0.2 + (2 \times 1.3) = \underline{2.8}\%$$

2. Rearrange the following equation to make ‘**g**’ the subject: $T = 2\pi\sqrt{\frac{l}{g}}$

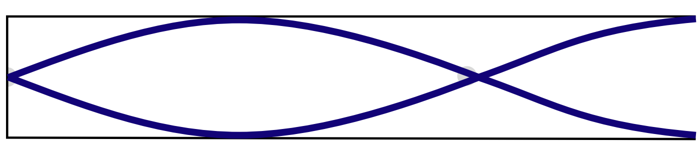
$$T = 2\pi\sqrt{\frac{L}{g}} \qquad T^2 = 4\pi^2\frac{L}{g} \qquad g = 4\pi^2\frac{L}{T^2}$$

3. Sketch the **standing/stationary** wave formed in the tube open at one end:

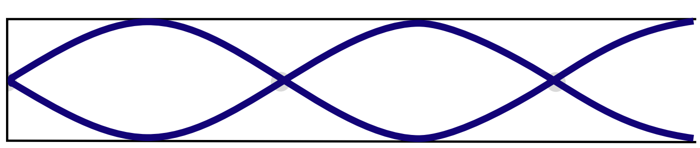
   a. First harmonic



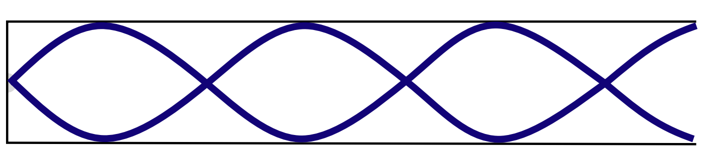
   b. Second harmonic



   c. Third harmonic



   d. Fourth harmonic



24th November

1 2 3

1. Measurements were made to determine the gravitational field strength using an oscillating pendulum. Calculate the **percentage uncertainty** in the calculated value of '**g**' based on these measurements.

Quantity	Percentage Uncertainty
Length	1.0 %
Time period	2.3 %

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$g = 4\pi^2 \frac{L}{T^2}$ $\quad$ $\%g = \%L + (2 \times \%T) = 1.0 + (2 \times 2.3) = \underline{5.6\%}$

2. Rearrange $F = 6\pi\eta r v$ to make:
   a. **r** the subject

   $r = F/6\pi\eta v$

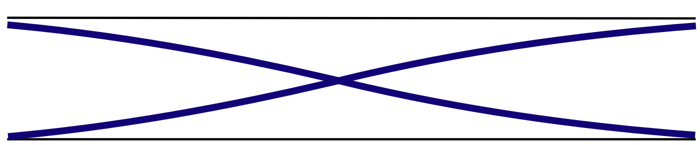
   b. **v** the subject

   $v = F/6\pi\eta r$

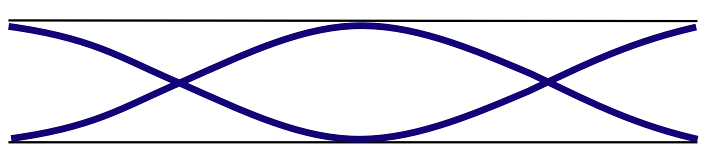
   c. **η** the subject

   $\eta = F/6\pi r v$

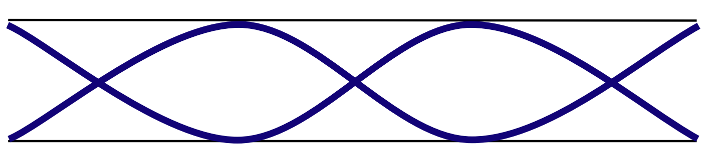
3. Sketch the **standing/stationary** wave formed in a tube open at both ends:
   a. First harmonic



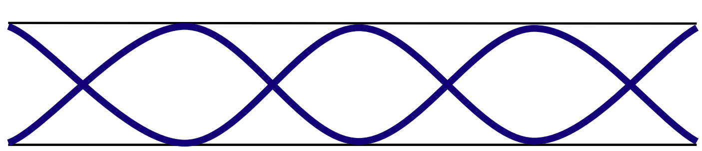
   b. Second harmonic



   c. Third harmonic



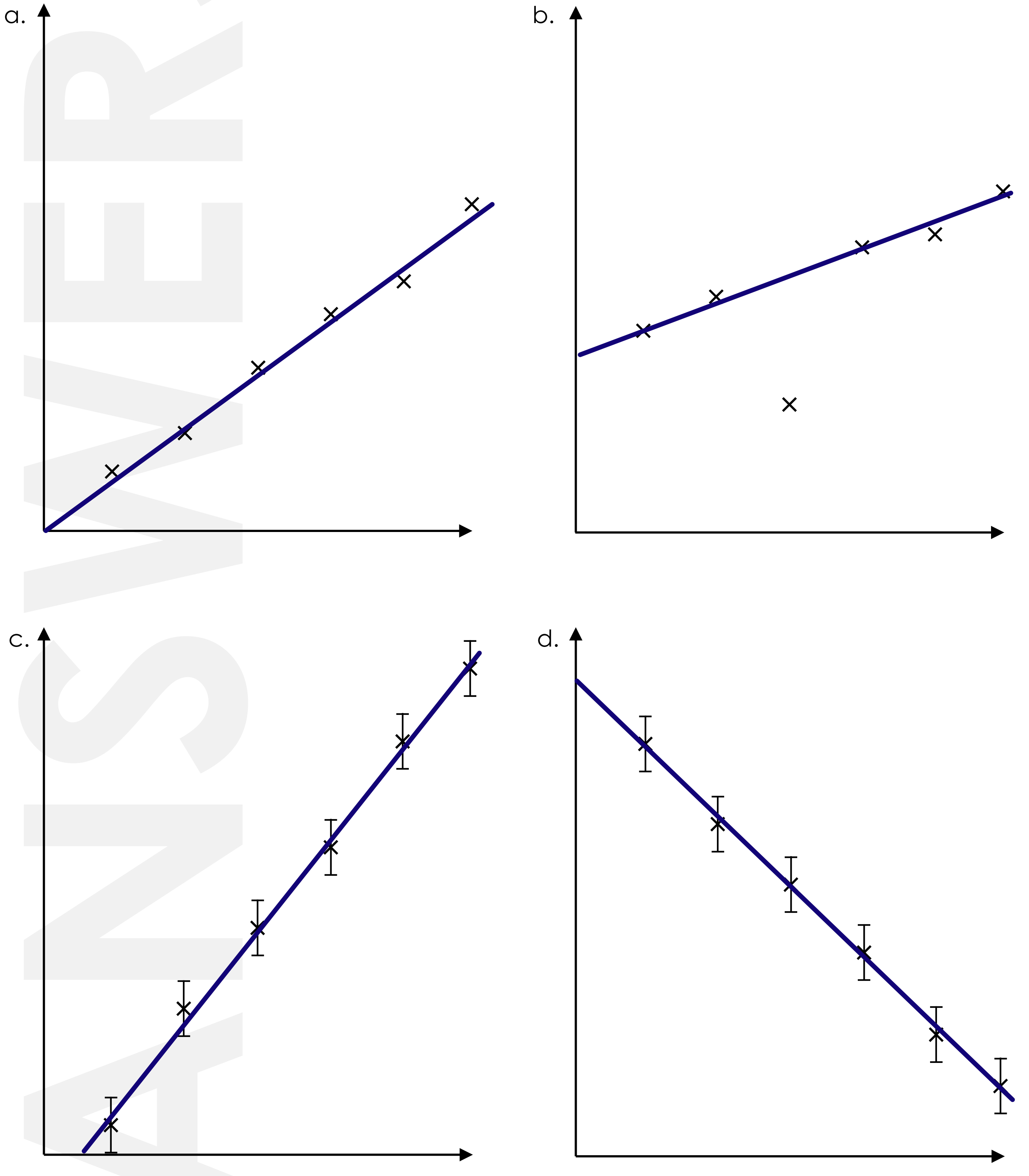
   d. Fourth harmonic



25th November – Part 1

1

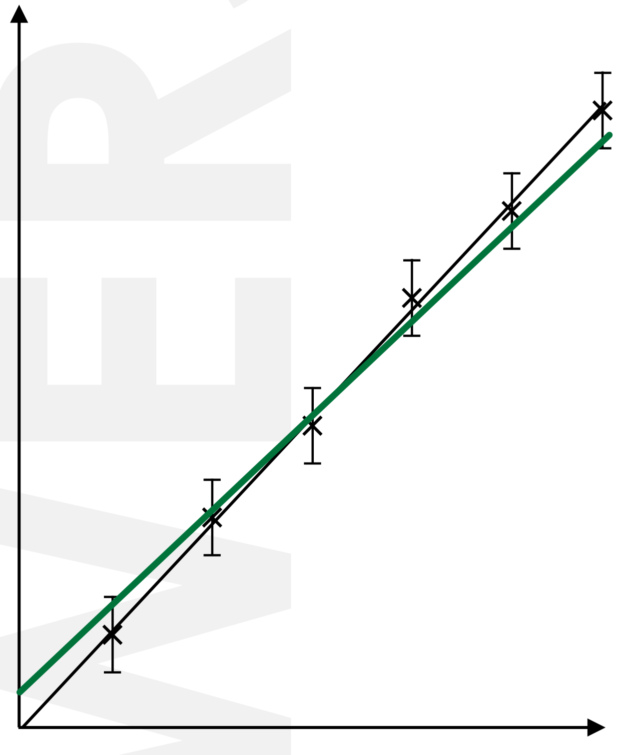
1. Draw in a straight **line of best fit** for the following data:



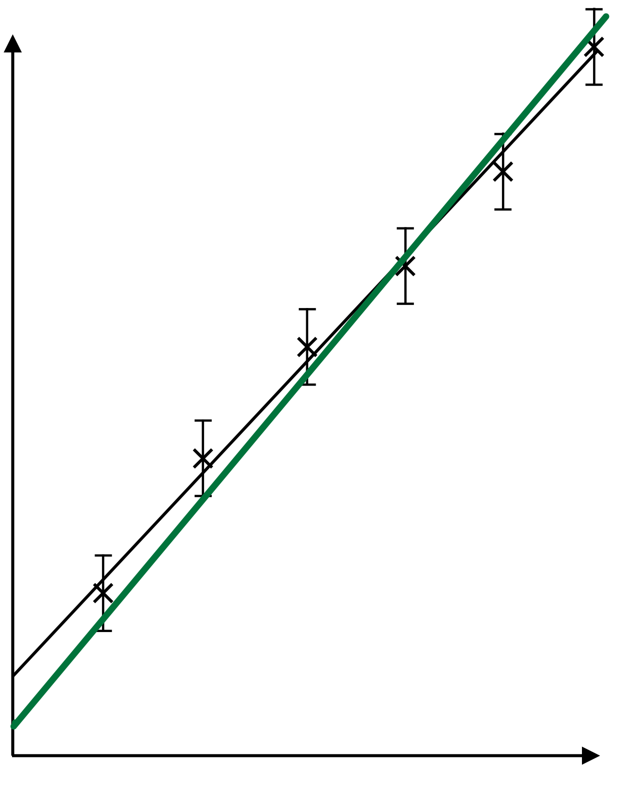
25th November – Part 2

2. The 'line of best fit' has been added to these graphs. Draw in a '**worst acceptable**' line. This must pass through all the error bars for the following data.

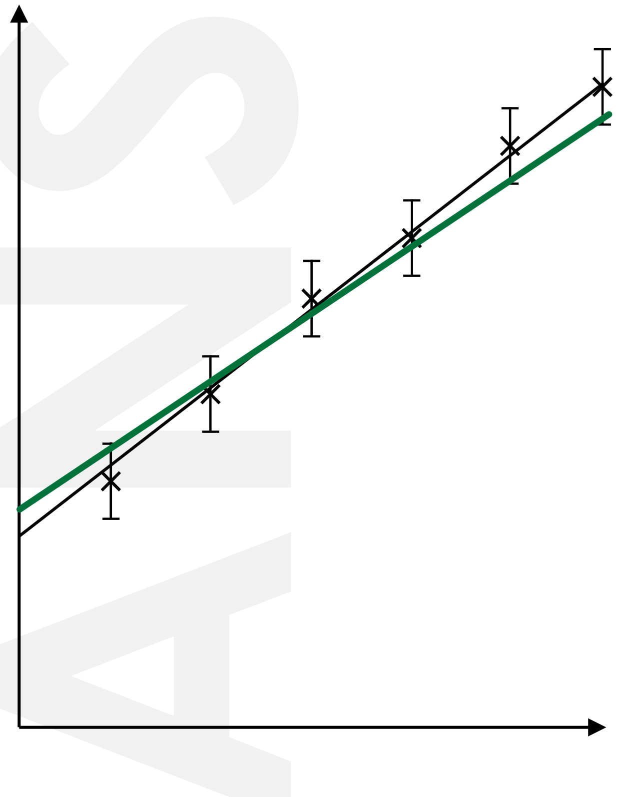
a.



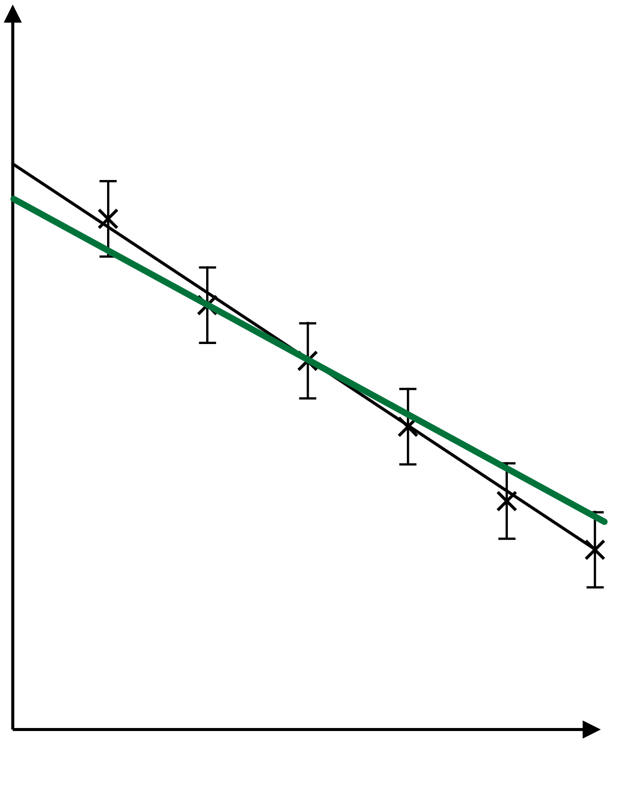
b.



c.



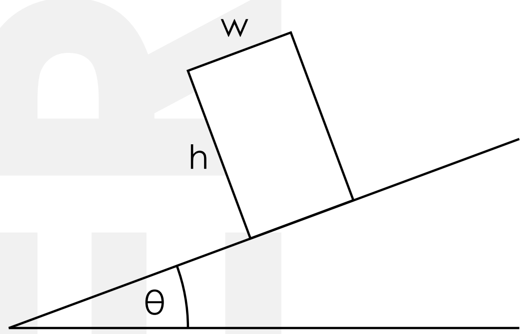
d.

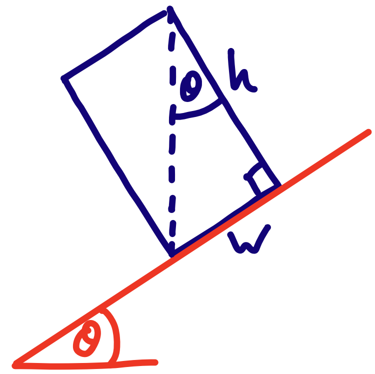


26th November

1. A solid rectangular block of height 'h' and width 'w' is placed on a plane inclined at an angle θ. Friction prevents the block from sliding down the slope.

   Write down an expression for the **maximum angle** of the slope 'θ_{max}' such that the block will remain upright.



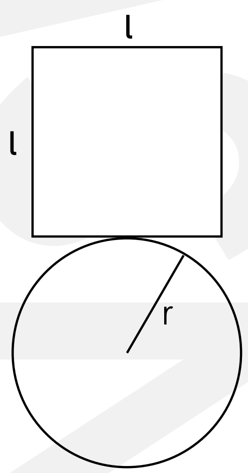


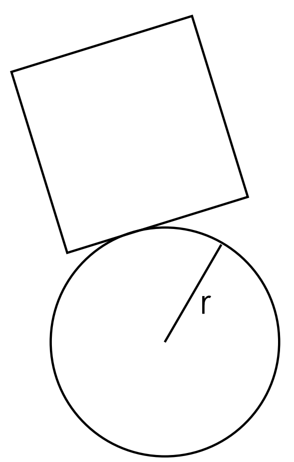
$\tan\theta = \frac{w}{h}$

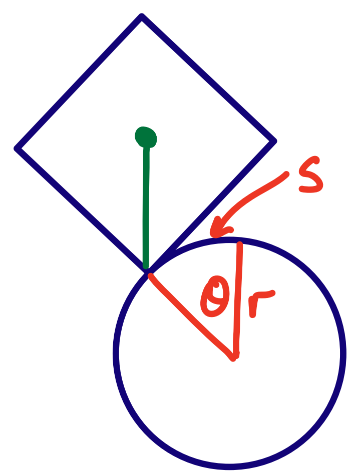
$\theta_{max} = \tan^{-1}\left(\frac{w}{h}\right)$

From a BPhO question from the 2015 Year 12 Challenge

2. A massive solid cube of side $l = r\pi/2$, and of uniform density, is placed on the highest point of a cylinder of radius r, as shown below. If the cylinder is rough so that no sliding occurs, calculate the full **range** of the **angle** through which the block can swing (or wobble) without tipping off (you can assume that this range of equilibrium positions is stable).







$l = \frac{r\pi}{2}$

$s = \frac{l}{2} = \frac{r\pi}{4}$

$\theta = \frac{s}{r} = \frac{r\pi/4}{r} = \frac{\pi}{4}\text{ rad} = 45°$

Full angle $= \frac{\pi}{2}$ rad or 90°

From a BPhO question from the 2015 Year 12 Challenge

27th November

1 2

1. Write the following derived units in terms of their SI Base Units:

a. **Coulomb**

$Q = It$

$C = [A] \times [s] = [As]$

b. **Newton**

$F = ma$

$N = [kg] \times [ms^{-2}] = [kgms^{-2}]$

c. **Joule**

$W = Fs$

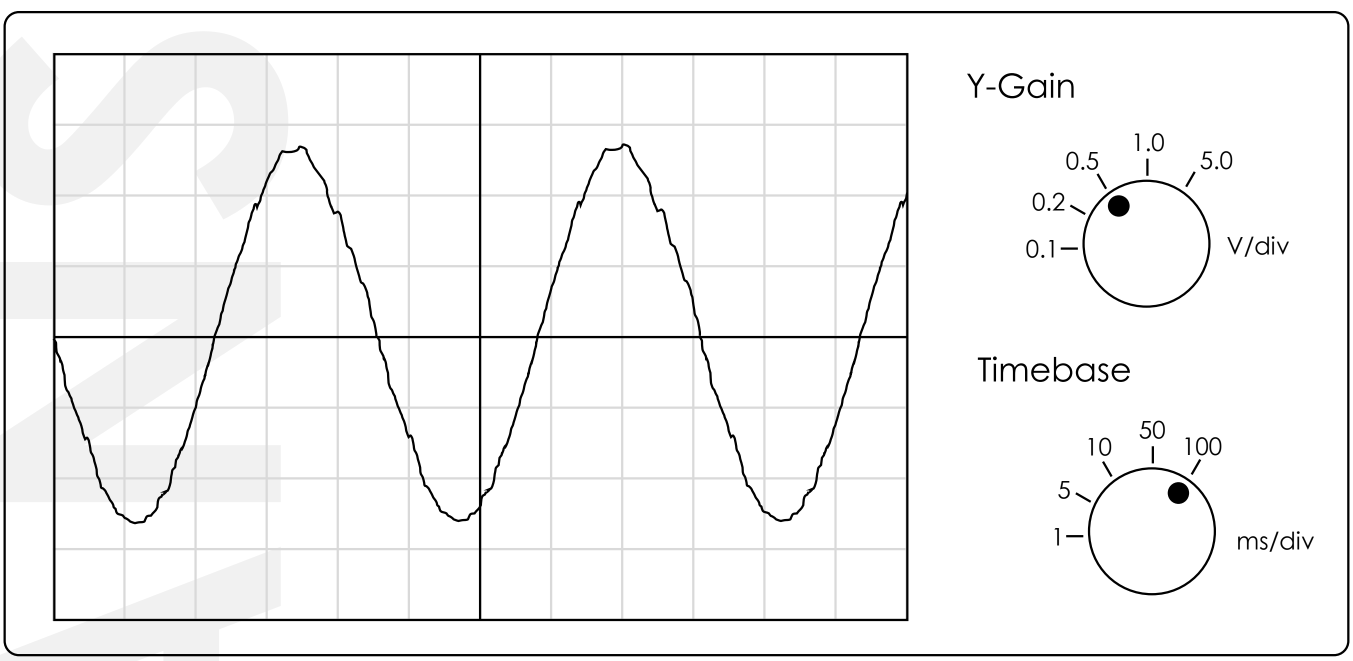
$J = [kgms^{-2}] \times [m] = [kgm^2s^{-2}]$

d. **Volt**

$V = W/Q$

$V = \frac{[kgm^2s^{-2}]}{[As]} = [kgm^2s^{-3}A^{-1}]$

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



$A = 2.8 \times 0.5 = 1.4\ V$

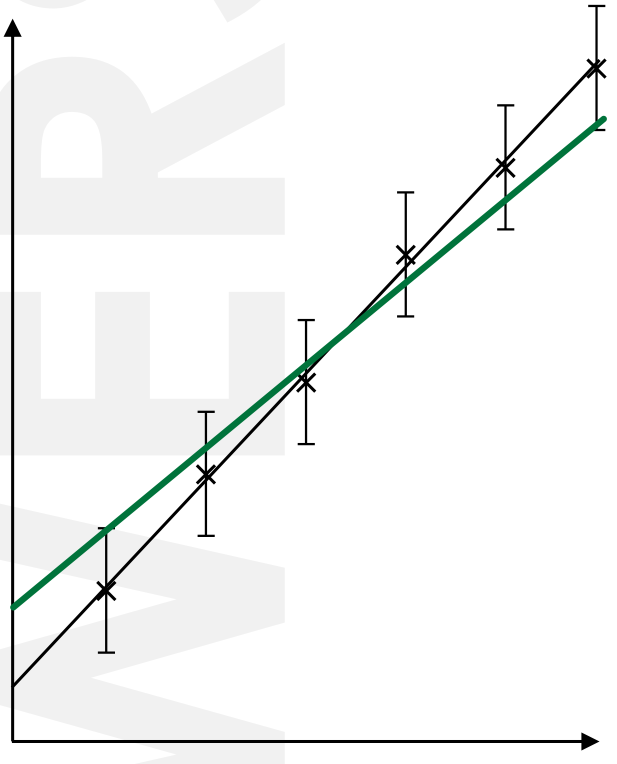
$f = \frac{1}{T} = \frac{1}{4.5 \times 100 \times 10^{-3}} = 2.2\ Hz$

28th November – Part 1

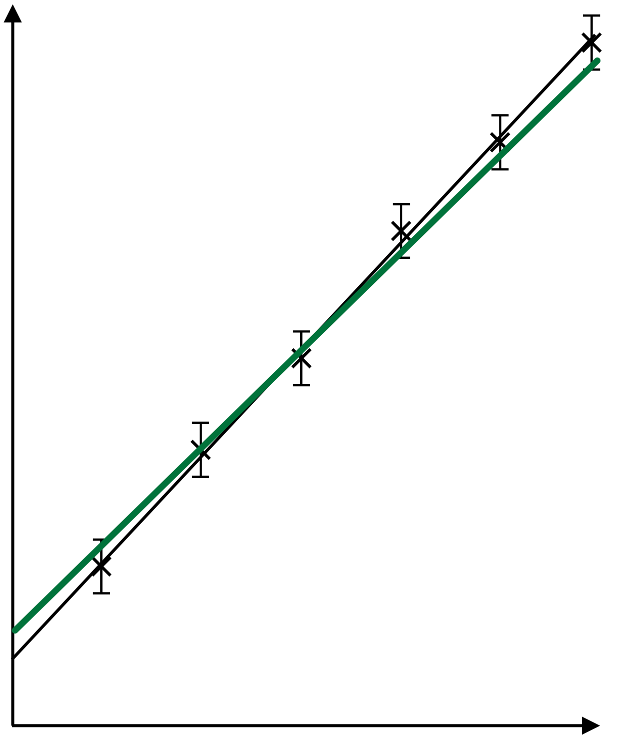
1

1. Draw in a '**worst acceptable**' line. This must pass through the error bars for the following data:

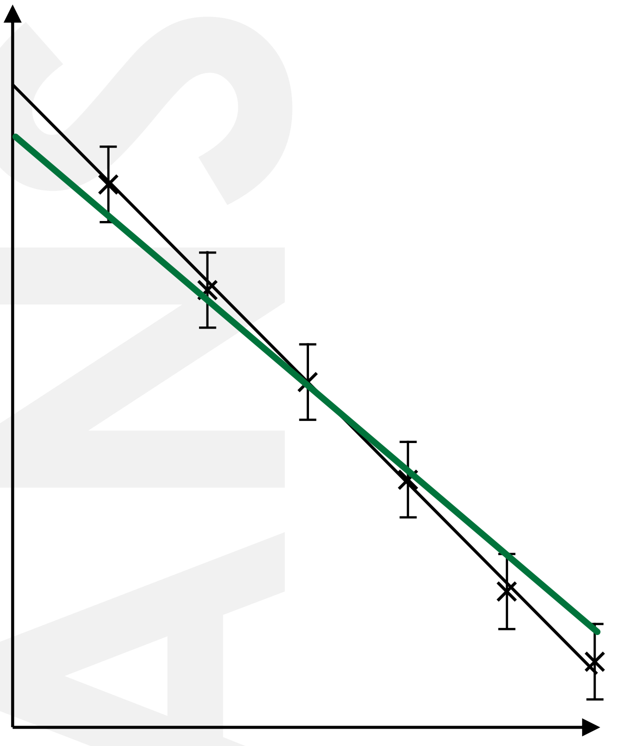
a.



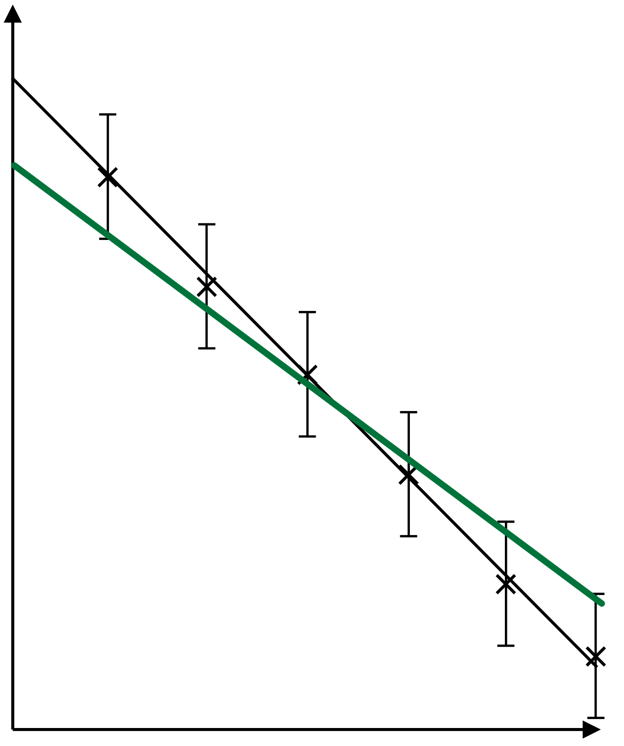
b.



c.



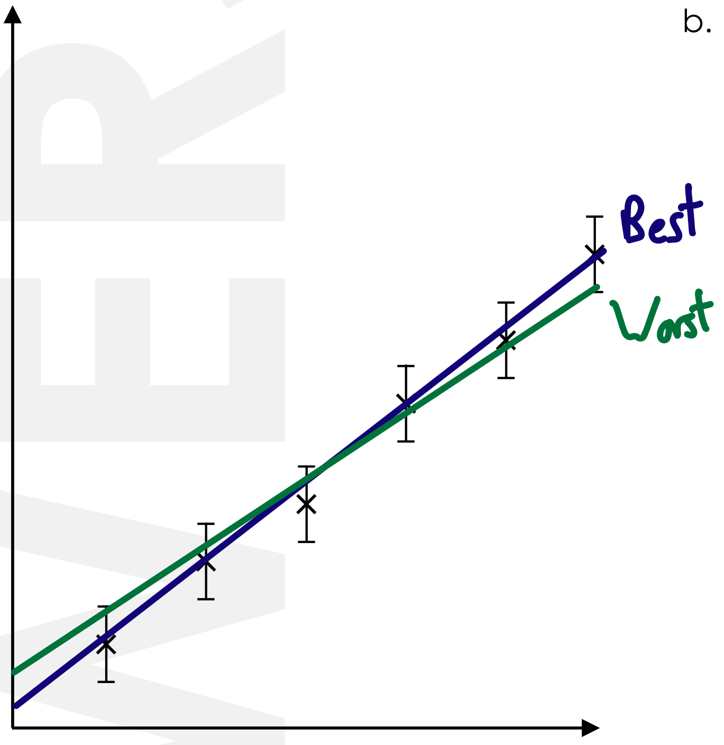
d.



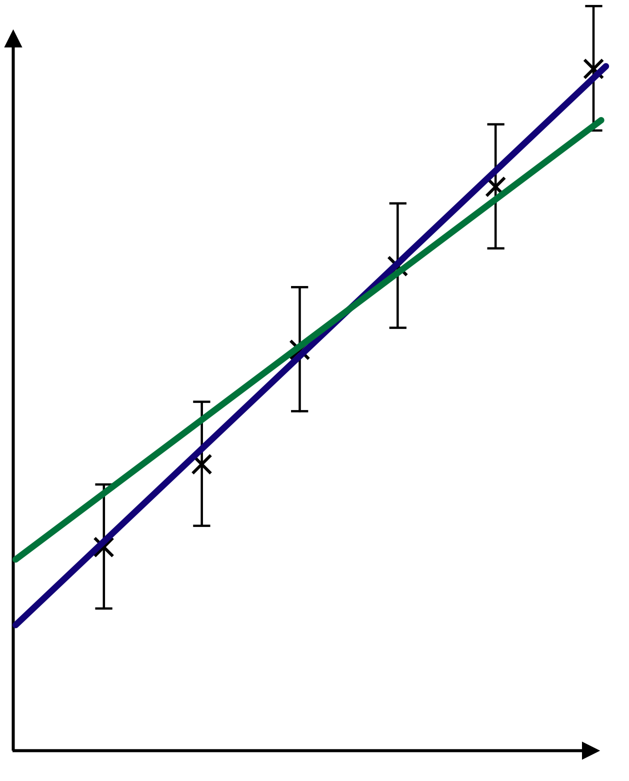
28th November – Part 2

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

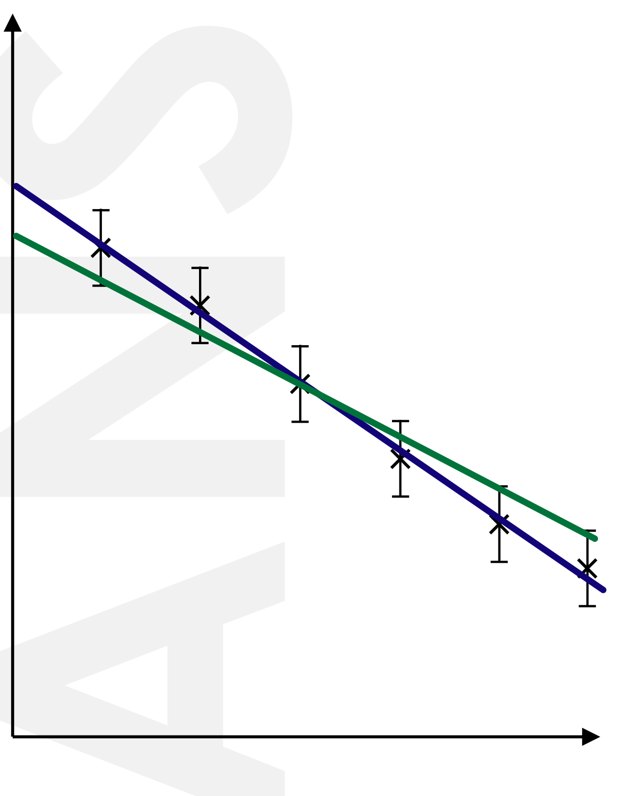
a.



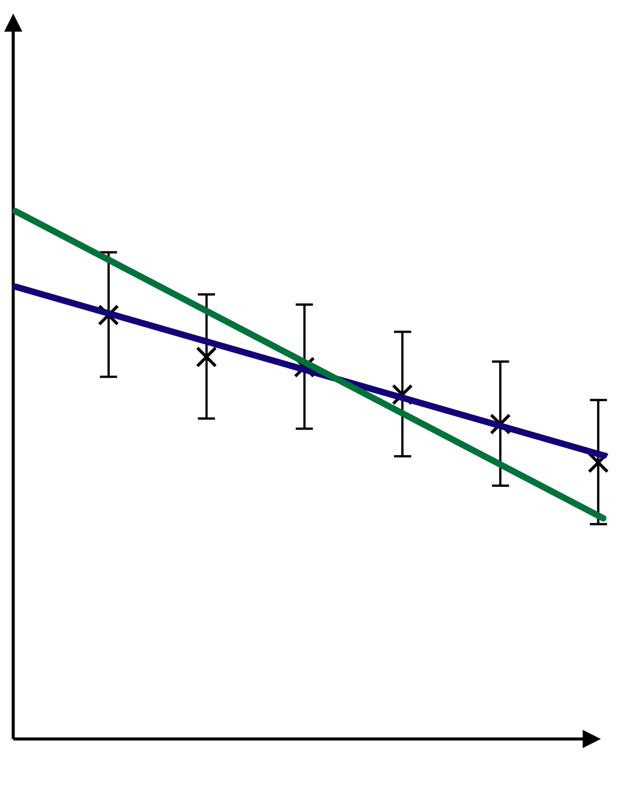
b.



c.



d.



29th November

1. A simple experiment is carried out to find the acceleration due to gravity 'g' by a freefall method. A ball is released from rest through a height measured as 80.0 cm with an uncertainty of ± 1 mm.

The following times are recorded with a digital stopwatch.

t / s	0.41	0.44	0.40	0.47	0.43

a. Calculate the **mean value** of 't'

$0.43\ s$

b. If air resistance is assumed to be negligible, calculate the **value** of 'g' that this data suggests

$s = 0.800\ m$
$u = 0$
v
$a = g$
$t = 0.43$

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

$g = \frac{2s}{t^2} = \frac{1.600}{0.43^2} = 8.653 = 8.7\ ms^{-2}$

c. Calculate the **percentage uncertainty** in the recorded data for height and time

$s: \frac{1}{800} \times 100 = 0.13\%$

$t: \frac{0.035}{0.43} \times 100 = 8.1\%$

d. Calculate the **percentage uncertainty** in your final calculated value of 'g'

$\%g = \%s + (2 \times \%t) = 0.125 + (2 \times 8.14) = 16.4$
$\approx 16\%$

e. Calculate the **uncertainty** (in m s^{-2}) in your value for 'g'

$8.653 \times 0.164 = 1.42$

$\therefore \pm 1.4\ ms^{-2}$

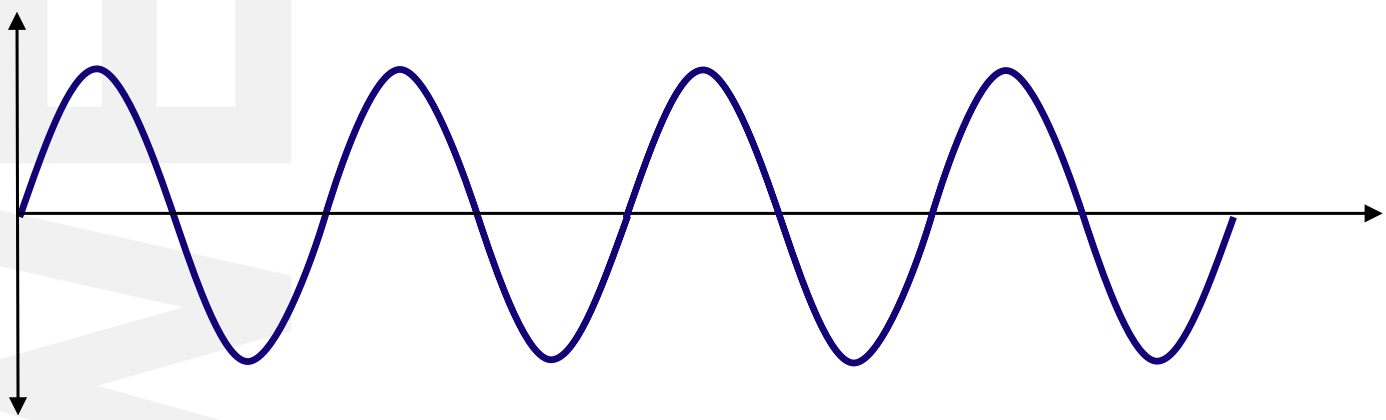
30th November

1 2 3

1. Define **equilibrium**.

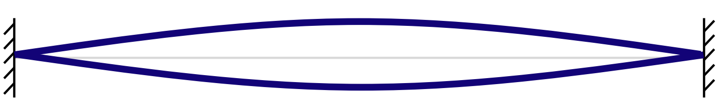
When the resultant force and moment on an object is zero.

2. Complete the following **sinusoidal** curve:

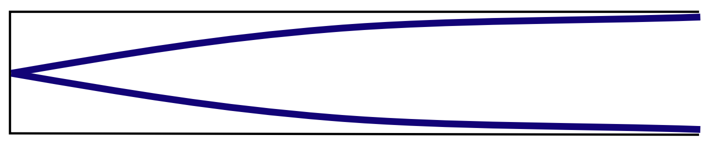


3. Sketch the fundamental frequency of **standing** wave formed below:

a. **String** fixed at both ends



b. Tube open at **one** end



c. Tube open at **both** ends