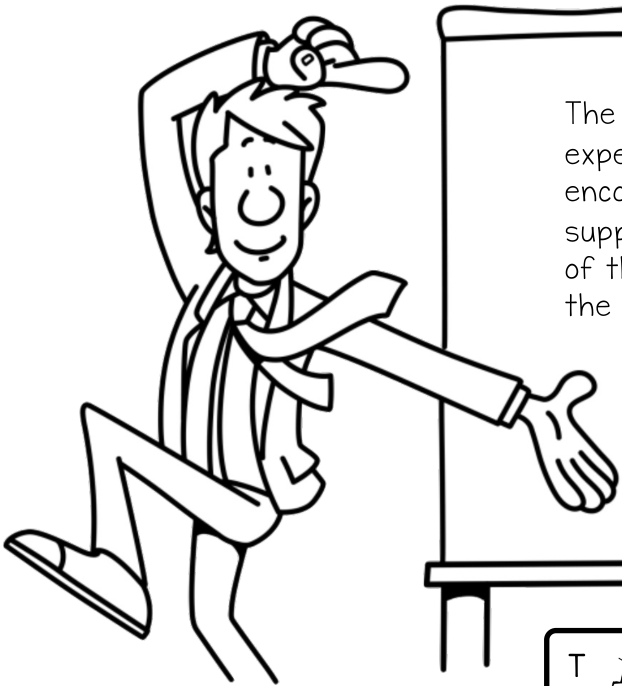
IB Physics

First Assessment 2025

TEACHING HOURS

A.0. TOOLS



The skills and techniques students must experience through the course are encompassed within the tools. These support the application and development of the inquiry process in the delivery of the physics course.

Tool 1: Experimental techniques
Tool 2: Technology
Tool 3: Mathematics

T
O
K

Can scientists ever be truly certain of their discoveries?

UNDERSTANDINGS

Tool 1: Experimental techniques

- Addressing safety of self, others and the environment
- Measuring variables

Tool 2: Technology

- Applying technology to collect data
- Applying technology to process data

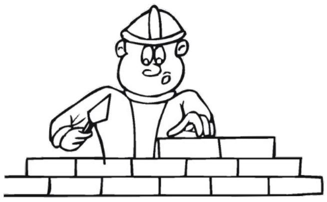
Tool 3: Mathematics

- Applying general mathematics
- Using units, symbols and numerical values
- Processing uncertainties
- Graphing

Name :

FUNDAMENTAL AND DERIVED UNITS

There are **7** fundamental base units. They are...



1. Metre (m) → Length
2. Kilogram (kg) → mass
3. second (s) → Time
4. ampere (A) → current
5. Kelvin (K) → temperature
6. mole (mol) → amount of substance
7. candela (cd) → light intensity

All other units are **DERIVED UNITS** such as....

e.g Newtons
Recall $F = ma$
$F = kg(ms^{-2})$

e.g Joule
Recall $KE = \frac{1}{2}mv^2$
$KE = kgm^2s^{-2}$

Units can also prove that equations are **INVALID**

e.g $v^2 = at$ INVALID
$m^2s^{-2} \neq ms^{-2} \times s = ms^{-1}$

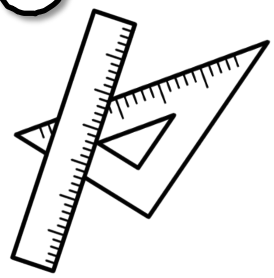
SCIENTIFIC NOTATION AND MULTIPLIERS

In Physics, we will deal with very large and very small numbers, e.g.
c, speed of light = $299{,}792{,}458\ ms^{-1} \rightarrow 3\times10^{8}\ ms^{-1}$
e, the charge of an electron = $0.000\ 000\ 000\ 000\ 000160\ C \rightarrow 1.6\times10^{-19}\ C$

10^{12}	10^{9}	10^{6}	10^{3}	10^{-3}	10^{-6}	10^{-9}	10^{-12}
tera	giga	mega	kilo	milli	micro	nano	pico
(T)	(G)	(M)	(k)	(m)	(μ)	(n)	(p)

SIGNIFICANT FIGURES

5 Rules:



5sf → 123.45 — All NON-ZERO digits are SIGNIFICANT

4sf → 2007 — Zeroes BETWEEN non-zero digits are SIGNIFICANT

4sf → 32.60 — TRAILING or FINAL zero in the decimal portion ONLY are SIGNIFICANT

ADDING / SUBTRACTING

When adding or subtracting, always keep to the least number of decimal places

1dp $250.3 + 112$ 0dp $= 362.3 = 362$ 0dp
3dp $0.245 - 0.1$ 1dp $= 0.145 = 0.1$ 1dp

DIVIDING/MULTIPLYING

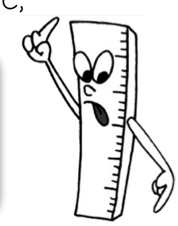
When multiplying or dividing, always keep to the least number of significant figures

3sf $91.4 / 3.1$ 2sf $= 29.4838 = 29$ 2sf
3sf 14.2×3 1sf $= 42.6 = 40$ 1sf

ORDERS OF MAGNITUDE

The IB expects you to know the orders of magnitude of certain quantities. For example,

Diameter of a nucleus	→ $10^{-15}m$	Size of the visible universe	→ $10^{25}m$
Diameter of an atom	→ $10^{-10}m$	Age of the universe	→ $10^{18}s$
Speed of light	→ $10^{8}ms^{-1}$	Mass of the universe	→ $10^{50}kg$



COMPARING ORDERS OF MAGNITUDE

Comparisons can now be easily made between two quantities because the working out of the ratio between two powers is just a matter of adding or subtracting whole numbers

Comparing $10^2/10^{-3} = 10^5$

AN ADULT HUMAN IS 5 ORDERS OF MAGNITUDE HEAVIER THAN A SHEET OF PAPER

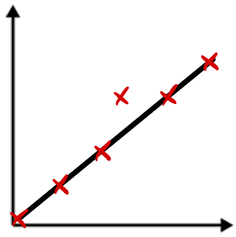
10^2 kg

10^{-3} kg

ERRORS AND UNCERTAINTIES

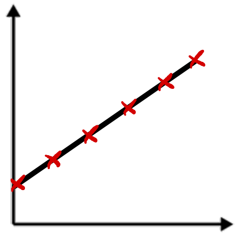
RANDOM ERROR

Due to the person. Repeat readings will minimise the issue



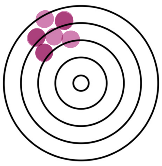
SYSTEMATIC ERROR

Due to the equipment, normally a ZERO ERROR



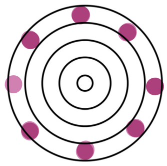
PRECISION

Data grouped together



ACCURACY

average matches the text value



UNCERTAINTIES IN CALCULATIONS

A thermometer measures the temperature of the room as 30°C. What is the absolute, fractional and percentage uncertainty in this reading?

30°C

ABSOLUTE

(30 ± 1)°C

FRACTIONAL

$\frac{1}{30}$

PERCENTAGE

$\frac{1}{30} \times 100 = 3.3\%$

PROPAGATING UNCERTAINTIES THROUGH CALCULATION

Addition and subtraction

If $y = a \pm b$, $(9 \pm 1) + (3 \pm 2) = 12 \pm 3$ (MAX $= 10 + 5 = 15$)

then $\Delta y = \Delta a + \Delta b$ (MIN $8 + 1 = 9$)

Multiplication and division

If $y = \frac{ab}{c}$,

then $\%y = \%a + \%b + \%c$

If a = 9.51 ± 0.15 and b = 12.56 ± 0.07

a) what is b + a?

$12.56 + 9.51 = 22.07$

$\Delta y = 0.15 + 0.07 = 0.22$

$\rightarrow 22.07 \pm 0.22$

b) what is b – a?

$12.56 - 9.51 = 3.05$

$\Delta y = 0.15 + 0.07 = 0.22$

$\rightarrow 3.05 \pm 0.22$

A car travels 64.7 ± 0.5 metres in 8.65 ± 0.05 seconds. What is its speed?

$\%s = \%d + \%t$ $= 64.7/8.65 = 7.48\,ms^{-1}$

$\%d = 0.5/64.7 \times 100 = 0.77\%$

$\%t = 0.05/8.65 \times 100 = 0.58\%$

$\%s = 0.77\% + 0.58\% = 1.35\%$

Speed $= 7.48 \pm 1.35\% = 7.48 \pm 0.10\,ms^{-1}$

ERROR BARS

You have been asked to investigate the relationship between the height of drop of a ball and the time it takes for the ball to hit the floor. It is assumed that $h = \frac{1}{2}at^2$.

Which data should we collect?

Heights

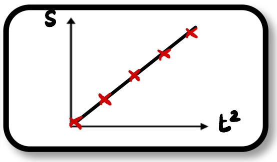
Multiple times

Calculate t^2

What should we plot?

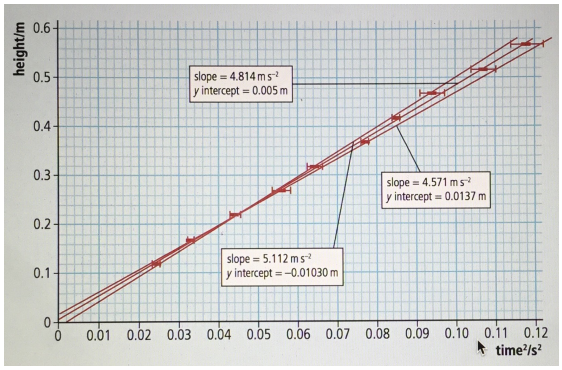
$s = \frac{1}{2}at^2$ ← x

y ↗ m ↗



gradient $= \frac{1}{2}a$

Height (m)	Time (s) ± 0.001s			Mean t (s)	% error in t	T^2 (s^2)	% error in t^2
0.118	0.155	0.153	0.156	0.155	0.970	0.024	1.940
0.168	0.183	0.182	0.183	0.183	0.274	0.033	0.547
0.218	0.208	0.205	0.210	0.208	1.204	0.043	2.408
0.268	0.236	0.235	0.237	0.236	0.424	0.056	0.847
0.318	0.250	0.254	0.255	0.253	0.988	0.064	1.976
0.368	0.276	0.277	0.276	0.276	0.181	0.076	0.362



SAMPLE CALCULATIONS

$$\% \text{ error} = \frac{\left(\frac{max - min}{2}\right)}{mean} \times 100 = \frac{\left(\frac{0.156 - 0.153}{2}\right)}{0.155} \times 100$$

GRADIENT MANIPULATION

$g_{best} = 2 \times 4.814 = 9.624 \, m/s^2$

$g_{max} = 2 \times 5.112 = 10.224 \, m/s^2$ $\quad g = 9.6 \pm 0.5$

$g_{min} = 2 \times 4.571 = 9.142 \, ms^{-2}$

$\Delta g = \frac{g_{max} - g_{min}}{2} = \frac{10.224 - 9.624}{2} = 0.541$

SCALARS AND VECTORS

DEFINITIONS AND EXAMPLES

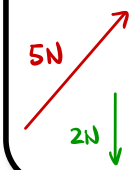
SCALAR quantities are those who have a MAGNITUDE only

Examples :- mass, distance, speed, time, temperature

VECTOR quantities are those who have a MAGNITUDE and DIRECTION

Examples :- displacement, velocity, acceleration, force, momentum

REPRESENTING VECTOR QUANTITIES

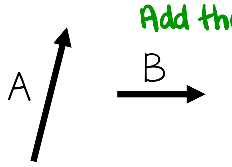


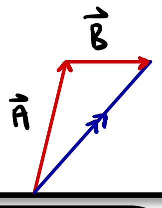
Direction of the arrow represents the direction of the vector

Length of the arrow represents the magnitude of the vector

ADDING / SUBTRACTING VECTORS

Add them TIP to TAIL in a SCALED DIAGRAM





What is $\vec{A} + \vec{B}$?

ADDING VECTORS AT RIGHT ANGLES

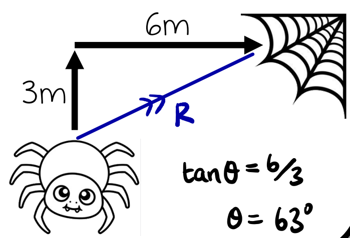
PYTHAGORAS

$x^2 + y^2 = z^2$

$3^2 + 6^2 = R^2$

$45 = R^2$

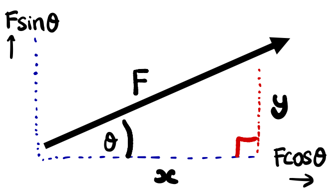
$R = 6.7m$



$\tan\theta = 6/3$

$\theta = 63°$

RESOLUTION OF VECTORS



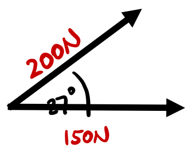
WHY?

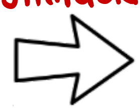
$\sin\theta = opp/hyp \qquad \sin\theta = \frac{y}{F} \qquad y = F\sin\theta$

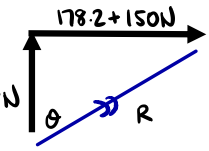
$\cos\theta = adj/hyp \qquad \cos\theta = \frac{x}{F} \qquad x = F\cos\theta$

ADDING VECTORS THAT ARE NOT AT RIGHT ANGLES

PYTHAGORAS







Vertical component of 200N

$= 200\sin 27 = 90.8N$

Horizontal component of 200N

$= 200\cos 27 = 178.2N$

$R^2 = (90.8)^2 + (178.2 + 150)^2$

$R = 340N$

$\tan\theta = opp/adj = 90.8/328.2$

$\theta = 15°$

PRACTICE QUESTIONS

FUNDAMENTAL AND DERIVED UNITS

1. Explain why it is important to have standard units in science.

SO THAT SCIENTISTS & ENGINEERS COMMUNICATE EFFICIENTLY

2. State the correct base SI units for the following base physics.

a) Distance m
b) Time s
c) Mass kg
d) Temperature K
e) Electric current A

3. What are 'derived units'? Give an example.

DESCRIBE A QUANTITY USING OTHER BASE UNITS. $1N = 1\,kgms^{-2}$

4. State the SI units for the following derived physical units.

a) Force NEWTON
b) Acceleration ms^{-2}
c) Weight NEWTON
d) Energy JOULE
e) Power WATT
f) Charge COULOMB

5. Convert the following to SI units.

a) 28 000 km h^{-1} $28000\times10^3/60\times60 = 7.78\times10^3\,ms^{-1}$
b) 45 cm^3 $0.45\times0.01\times0.01 = 4.5\times10^{-5}\,m^3$
c) 400 kPa $4\times10^5\,Pa$
d) 3000 GL $1L = 0.001m^3 \quad 3000\times10^9\times0.001 = 3\times10^9\,m^3$
e) 2.5 MJ $2.5\times10^6\,J$

6. Calculate the distance travelled by a car that is travelling at 30 km h^{-1} for 45 minutes. Express your answer in SI units.

$d = s\times t = 30{,}000/60\times60 \times (45\times60) = 22500m$

7. Kepler's law of periods for the motion of planets around the Sun, where R is the orbital radius of a planet, M the mass of the Sun, T the time it takes the planet to orbit the Sun and G is the universal gravitational constant, can be represented by the equation:

$$\frac{R^3}{T^2} = \frac{GM_{SUN}}{4\pi^2}$$

Determine the SI unit for G.

$G = \frac{R^3 4\pi^2}{T^2 M} = \frac{m^3}{s^2 kg} = m^3 s^{-2} kg^{-1}$

SCIENTIFIC NOTATION AND SIGNIFICANT FIGURES

8. Express the following numbers in scientific notation

a) 25000 2.5×10^4
b) 0.0000043 4.3×10^{-6}
c) 253456 (2sf) 2.5×10^5

9. Submultiples of units may be expressed using a prefix. Which one of the following lists the prefixes in decreasing order of magnitude?

milli– centi– micro
centi– micro– nano
milli– micro– nano
centi– milli– nano

10. Express each of the numbers in the table in scientific notation to two significant figures.

Measurement	Number of significant figures	In scientific notation to two s.f
0.0060	2	6.0×10^{-3}
1.0060	5	1.0
1 000 000 000	1	1.0×10^{9}
1 780 000 004	10	1.8×10^{9}
462.52	5	4.6×10^{2}
0.6200	4	6.2×10^{-1}
4086	4	4.1×10^{3}

11. Complete each of the following calculations using the appropriate number of significant figures.

a) The area of a square with sides 5.6cm $5.6\times5.6 = 31\text{cm}^2$

b) The volume of a cube with sides equal to 1.56cm $(1.56)^3 = 3.80\text{cm}^3$

12. The mass of a body is measured to be 0.400 kg and its acceleration to be 2 m s^{-2}. The net force on the body, expressed to the correct number of significant figures using F = ma is:

$F = ma = 0.400\times 2 = 0.8\text{N}$

(3) (1) (1)

13. What are the correct units for pressure if it equates to force/area?

$\frac{\text{kgms}^{-2}}{\text{m}^2} = \text{kgm}^{-1}\text{s}^{-2}$

14. Calculate the magnitude of F/A to the correct number of s.f for the value of F = 23.91 and A = 17.1

$23.91\,(4) / 17.1\,(3) = 1.40$

ORDERS OF MAGNITUDE

15. Define "order of magnitude".

THE ORDER OF MAGNITUDE OF A NUMBER IS THE POWER OF TEN CLOSEST TO THAT NUMBER

16. Complete the following to use the orders of magnitude of distances, masses and times in the Universe.

a) Mass of the Universe 10^{50} kg

b) Average mass of a car 10^{3} kg

c) Mass of a fly 10^{-3} kg

d) Mass of an electron 10^{-30} kg

e) Size of visible Universe 10^{25} m

f) Diameter of an atom 10^{-13} m

g) Age of the Universe 10^{18} s

h) Human life span 10^{9} s

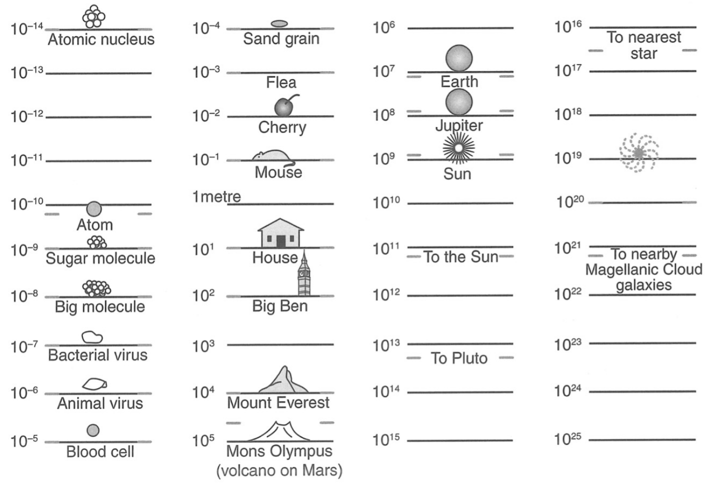
17. How much larger is an atom than an atomic nucleus? $10^{-10}/10^{-14} = 10^{4}$ BIGGER

18. How much larger is a blood cell than a bacterial virus? $10^{-5}/10^{-7} = 10^{2}$ BIGGER

19. How much larger is a house than a mouse? $10^{1}/10^{-1} = 10^{2}$ BIGGER

20. How much larger is the Earth than an atomic nucleus? $10^{7}/10^{-14} = 10^{21}$ LARGER

21. Compare the distance to the Sun with that to Pluto. $10^{9}/10^{13} = 10^{4}$ SMALLER



RANDOM AND SYSTEMATIC ERRORS

22. Identify two ways to reduce random errors.

TAKING MULTIPLE READINGS AND GET AN AVERAGE
CONTROLLING ALL OTHER VARIABLES

23. Identify two ways to reduce systematic errors.

USING THE MOST ACCURATE APPARATUS CHECKING FOR ZERO ERRORS

24. Define the "accuracy of a measurement".

HOW CLOSE THAT MEASUREMENT IS TO THE ACCEPTED VALUE

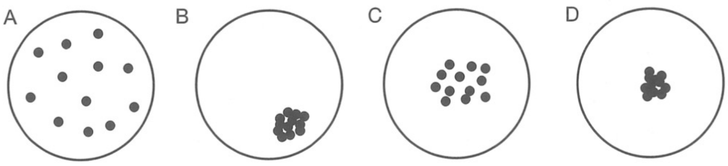
25. Define the "precision of a measurement".

HOW CLOSE REPEATED MEASUREMENTS ARE TO EACH OTHER

26. Two readings taken during an experiment were X = 5.00 ± 0.2 and Y = 5.0 ± 0.02. Which choice best describes the characteristics of these two measurements.

X has high accuracy while Y has high precision.
X has high accuracy while Y has low precision.
X has low accuracy while Y has high precision.
X has low accuracy while Y has low precision

Imagine four archers firing arrows at a target. The object of the exercise was to hit the target in the centre. The diagrams show were their arrows hit.



27. Which archer was the least accurate and the least precise? A

28. Which was archer was precise but not accurate? B

29. Which archer was accurate and precise? D

30. Compare the accuracy and the precision of the archer you have not yet chosen with the other three archers.

C → ACCURATE BUT NOT PRECISE

ABSOLUTE, FRACTIONAL AND PERCENTAGE UNCERTAINTIES

31. A student rolls a ball across a tabletop a distance of 1.00 m. This measurement has a 2% error associated with it. She measures the time the ball takes to roll this distance with a 5% error. She uses these measurements to calculate the average speed of the ball as it rolled. What is associated with the speed calculation?

SPEED = DISTANCE/TIME = 5%/2% = 7%

32. The kinetic energy of a moving object is calculated using the formula KE = ½ mv^2. The mass of an object was measured with a 4% uncertainty and its velocity with a 3% uncertainty. What will be the uncertainty in its calculated kinetic energy?

$\frac{1}{2}mv^2$ = 4% + (2 × 3%) = 10%

33. Three variables are related according to the equation $X = YZ^3$. In an experiment students measured X with an uncertainty of 4% and Y with an uncertainty of 5%. They then used these values to calculate a value for Z. What would be the uncertainty of Z?

$Z^3 = X/Y = 4\% / 5\% = 9\% \rightarrow Z = 3\%$

34. If X = 35 ± 0.5m and Y = 15 ± 0.7m, then what is 3X – 2Y and its uncertainty?

$3(35) - 2(15) = 75$ $\quad (0.5 \times 3) + (2 \times 0.7) = 2.9$ $\quad 75 \pm 2.9$

35. How should the volume of a cube with sides 4.5 ± 0.1cm be reported?

$4.5^3 = 91.1 cm^3$ $\quad (0.1/4.5 \times 100) \times 3 = 6.7\%$ $\quad \rightarrow 91.1 \pm 6.1$

$\rightarrow 91 \pm 6$

36. If X = 18 ± 0.5 and Y = 9.0 ± 0.4, find appropriate values, including errors, for:

a) X + Y $\quad 27 \pm 0.9$

b) X – Y $\quad 9 \pm 0.9$

c) X / 2Y $\quad 1 \pm 0.$ $\quad (0.5/18) \times 100 + (0.4/9 \times 100) = 7.2\%$

d) 2X – 3Y $\quad 9 \pm 2.2$

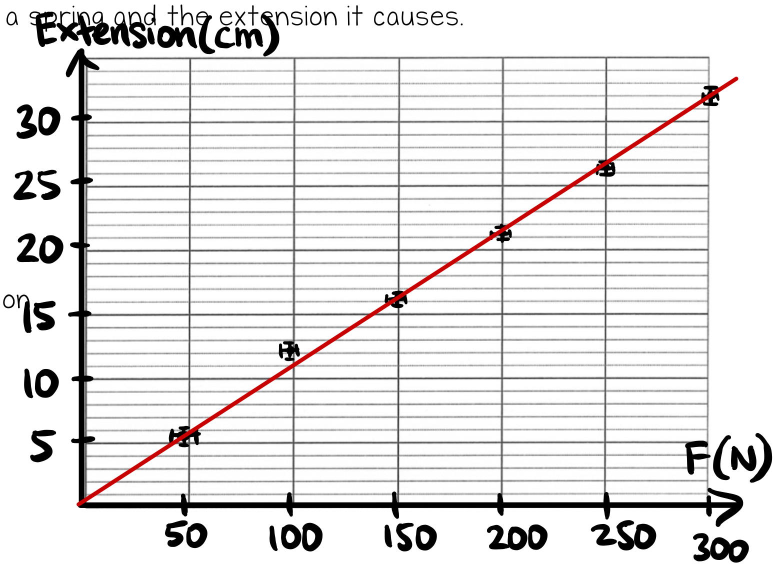
e) XY^3 $\quad 13122 \pm 2113$ $\quad (0.5/18 \times 100) + (0.4/9 \times 100 \times 3) = 16.1\%$

UNCERTAINTIES OF GRADIENTS AND INTERCEPTS

37. The table shows information about the force to a spring and the extension it causes.

Force ± 5 N	50	100	150	200	250	300
Extension ± 0.5 cm	5.5	12.0	16.0	21.0	26.0	31.5

Graph this information using appropriate error bars on the grid.



38. The table shows the average times it took an object to fall from rest through various distances.

Complete the third column and fourth column of the table to the appropriate number of significant figures.

Distance fallen (± 0.05 m)	Time to fall (± 0.05 s)	(Time to fall)^2	Absolute error in T^2
3.0	1.0	1.0	0.1
4.0	1.2	1.4	0.1
5.0	1.3	1.7	0.1
6.0	1.4	2.0	0.1
7.0	1.5	2.3	0.1
8.0	1.6	2.6	0.2

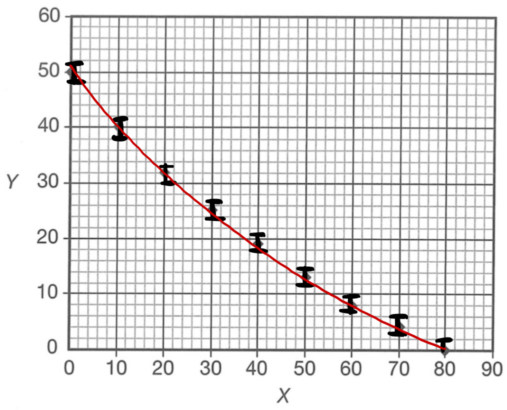
39. The experimental readings for an experiment are shown on the graph grid. The uncertainty in the measurement of variable Y is ± 2.0. The uncertainty in the measurement of variable X is negligible.

a) Draw in the error bars for the X measurements.

b) Draw in a line of best fit for the readings.

c) Estimate the value of Y when X = 15.

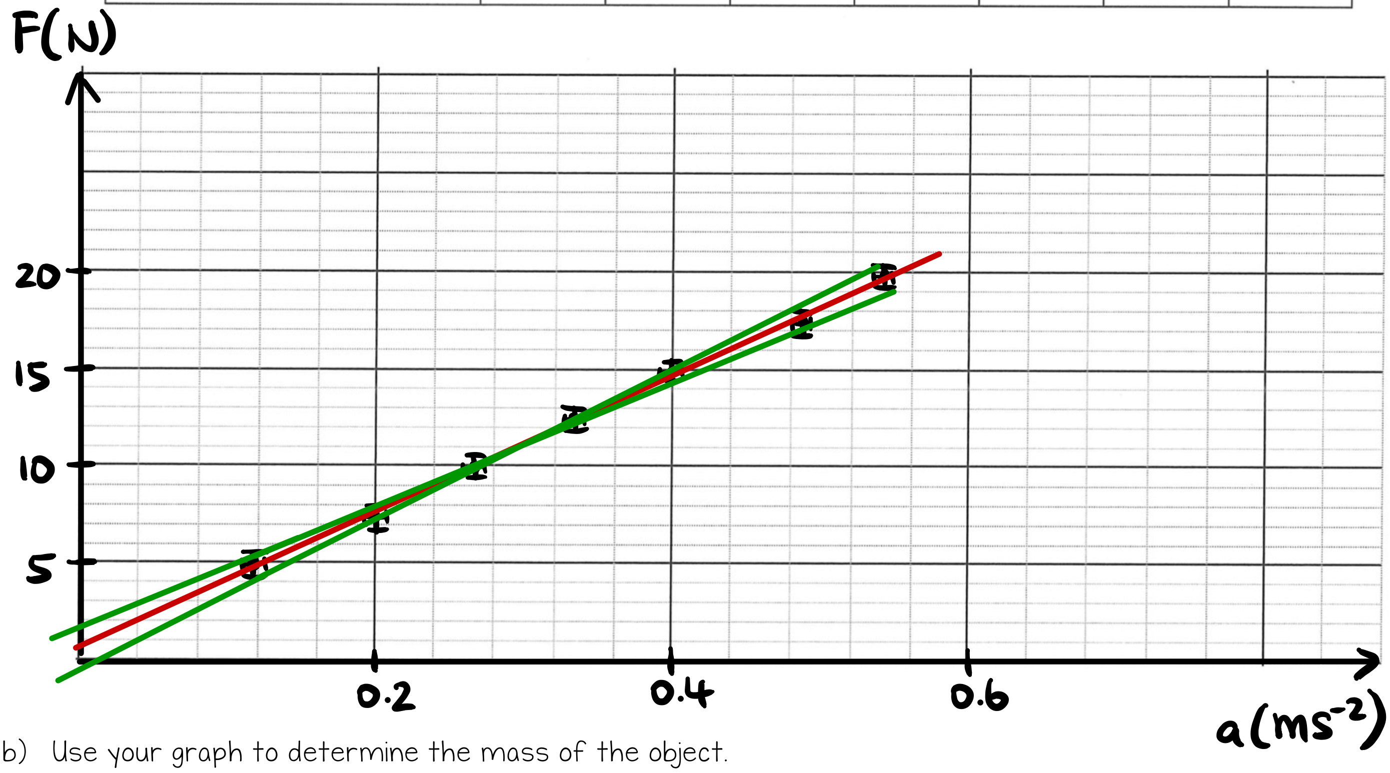
~36



40. The table shows the acceleration produced when a variable force acts on a body of constant mass. From Newton's laws of motion, we know that these two variables are connected by the equation F = ma + b, where b represents the frictional force acting.

a) Graph this information using appropriate error bars on the grid below.

Applied force (N)	5.0	7.5	10.0	12.5	15.0	17.5	20. 0
Acceleration produced (m s^{-2})	0.11	0.20	0.26	0.33	0.40	0.47	0.55



b) Use your graph to determine the mass of the object.

GRADIENT = m = (14/0.4) = 35Kg

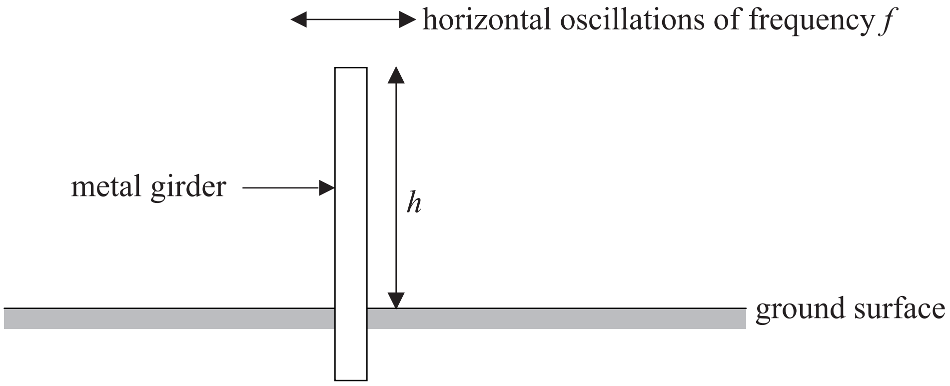
c) Add two additional lines to your graph to represent the error associated with the trend for this data. Again, using your graph, determine the frictional force acting on the object and its uncertainty.

F = INTERCEPT = (1 ± 1) N

A.0 Tools (Practice)

1. Data analysis question.

Metal girders are often used in buildings that have been constructed to withstand earthquakes. To aid the design of these buildings, experiments are undertaken to measure how the natural frequency f of horizontal oscillations of metal girders varies with their dimensions. In an experiment, f was measured for vertically supported girders of the same cross-sectional area but with different heights h.



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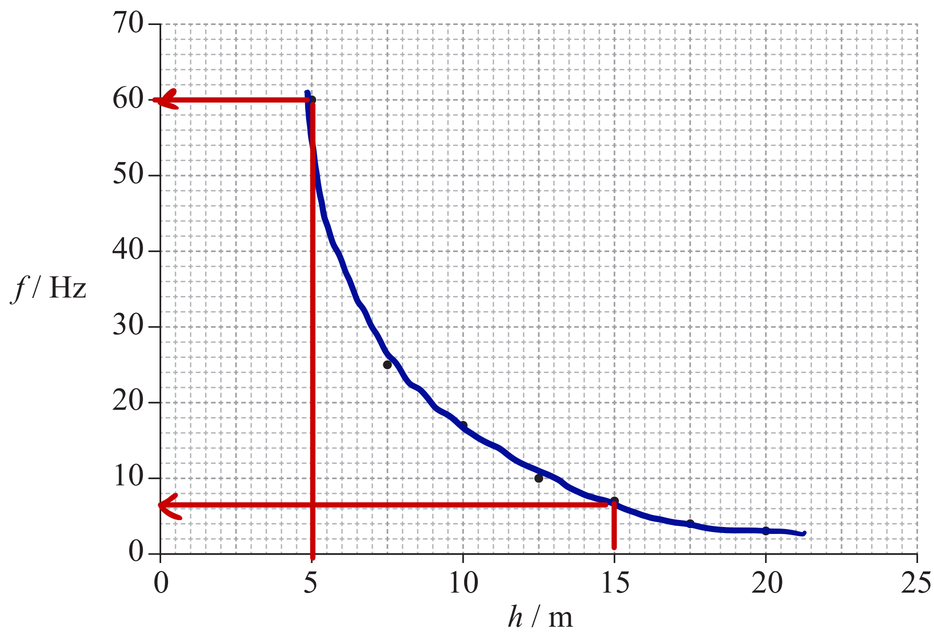
The graph shows the plotted data for this experiment. Uncertainties in the data are not shown.



(a) Draw a best-fit line for the data. *[1]*

(b) It is hypothesized that the frequency *f* is inversely proportional to the height *h*.

By choosing **two** well separated points on the best-fit line that you have drawn in (a), show that this hypothesis is incorrect. *[4]*

$f \propto \frac{1}{h}$ $f = k/h$ $k = fh$

$k_1 = 6 \times 15 = 90$

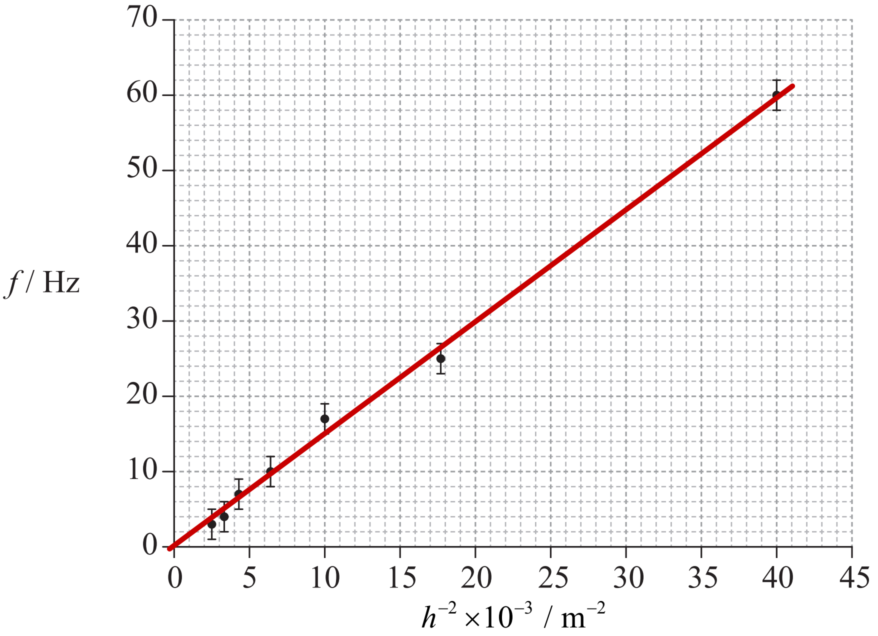
K IS NOT CONSTANT

$k_2 = 60 \times 5 = 300$

(c) Another suggestion is that the relationship between f and h is of the form shown below, where k is a constant.

$$f = \frac{k}{h^2}$$

The graph shows a plot of f against h^{-2}.



The uncertainties in h^{-2} are too small to be shown.

(i) Draw a best-fit line for the data that supports the relationship $f = \dfrac{k}{h^2}$. *[2]*

(ii) Determine, using the graph, the constant k. *[3]*

y

$f = \frac{k}{h^2}$ x

k = GRADIENT

$= \frac{\Delta y}{\Delta x} = 60/40\times10^{-3}$

$= \frac{1.5\times10^{-3}\ \text{Hz}}{\text{m}^{-2}} = 1.5\times10^{-3}\ \text{Hz m}^2$

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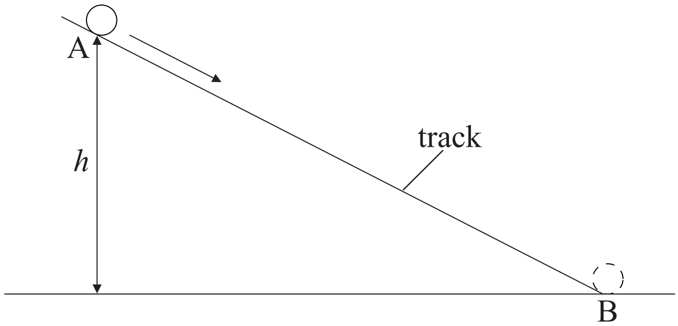
2. Data analysis question.

A small sphere rolls down a track of constant length AB. The sphere is released from rest at A. The time t that the sphere takes to roll from A to B is measured for different values of height h.



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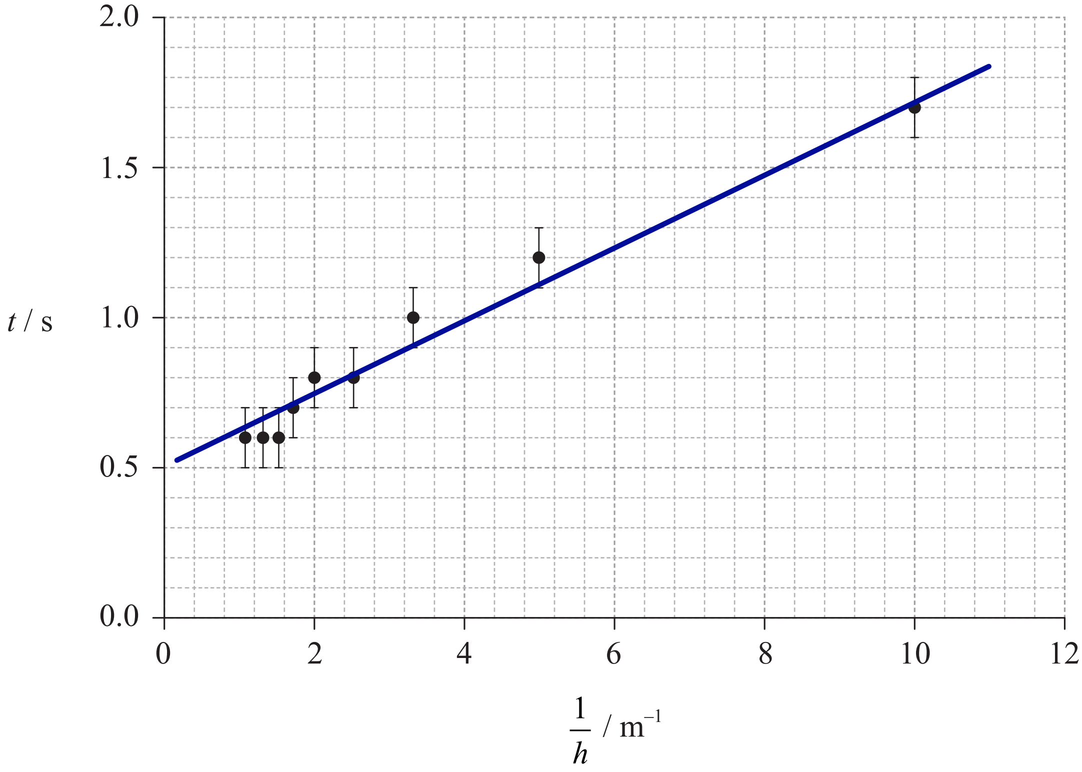
A student suggests that t is proportional to $\frac{1}{h}$. To test this hypothesis a graph of t against $\frac{1}{h}$ is plotted as shown on the axes below. The uncertainty in t is shown and the uncertainty in $\frac{1}{h}$ is negligible.



(a) (i) Draw the straight line that best fits the data. *[1]*

(ii) State why the data do not support the hypothesis. *[1]*

LINE DOES NOT GO THROUGH (0,0)

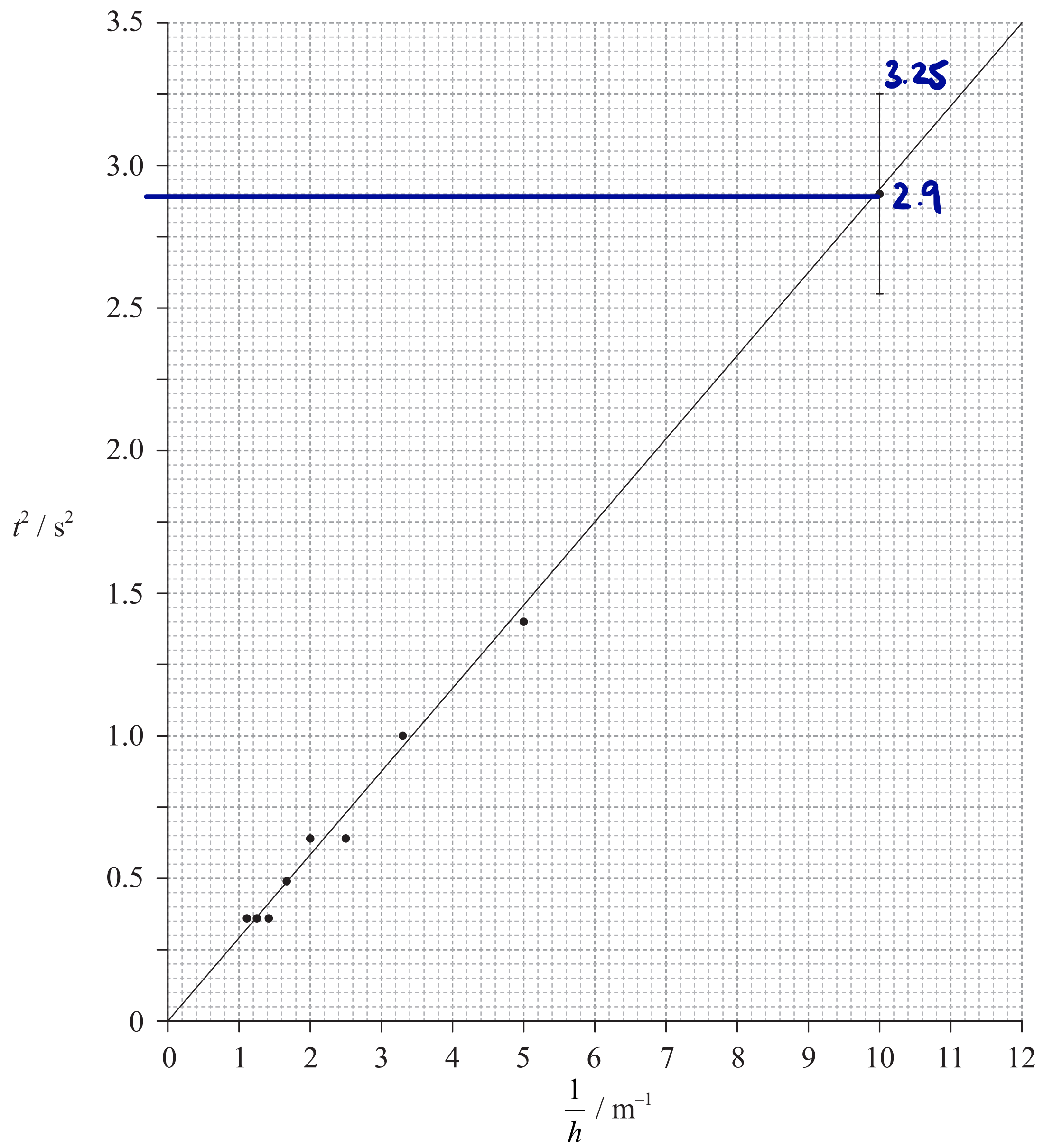
(b) Another student suggests that the relationship between t and h is of the form

$$t = k\sqrt{\frac{1}{h}}$$

where k is a constant.

To test whether or not the data support this relationship, a graph of t^2 against $\frac{1}{h}$ is plotted as shown below.

The best-fit line takes into account the uncertainties for all data points.



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The uncertainty in t^2 for the data point where $\frac{1}{h} = 10.0\,\text{m}^{-1}$ is shown as an error bar on the graph.

(i) State the value of the uncertainty in t^2 for $\frac{1}{h} = 10.0\,\text{m}^{-1}$. [1]

$\pm 0.35\,s^2$

(ii) Calculate the uncertainty in t^2 when $t = 0.8 \pm 0.1\,\text{s}$. Give your answer to an appropriate number of significant digits. [4]

$\%t = {}^{0.1}/_{0.8} \times 100 = 12.5\%$

$\%t^2 = 25\%$

$t^2 = 0.8^2 = 0.64 \pm 25\%$ $= 0.64 \pm 0.16$

(MUST BE 1SIG FIG)
$\pm 0.2 s^2$

(iii) Use the graph to determine the value of k. Do not calculate its uncertainty. [3]

$t = k\sqrt{1/h}$ BUT GRAPH IS t^2 VS $1/h$

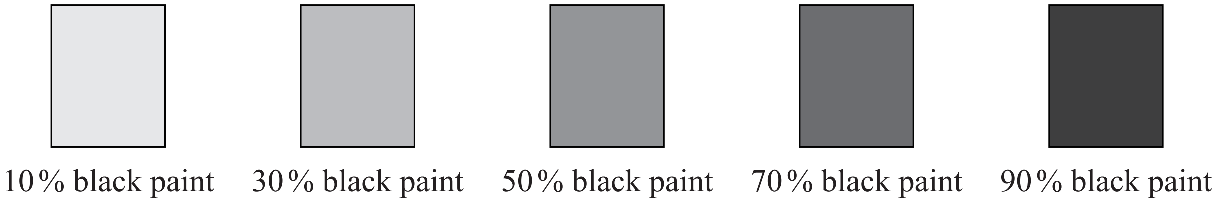
GRADIENT $= k^2$

GRADIENT $= {}^{2.9}/_{10} = 0.29$ $k = \sqrt{0.29} = 0.54$

(iv) State the unit of k. [1]

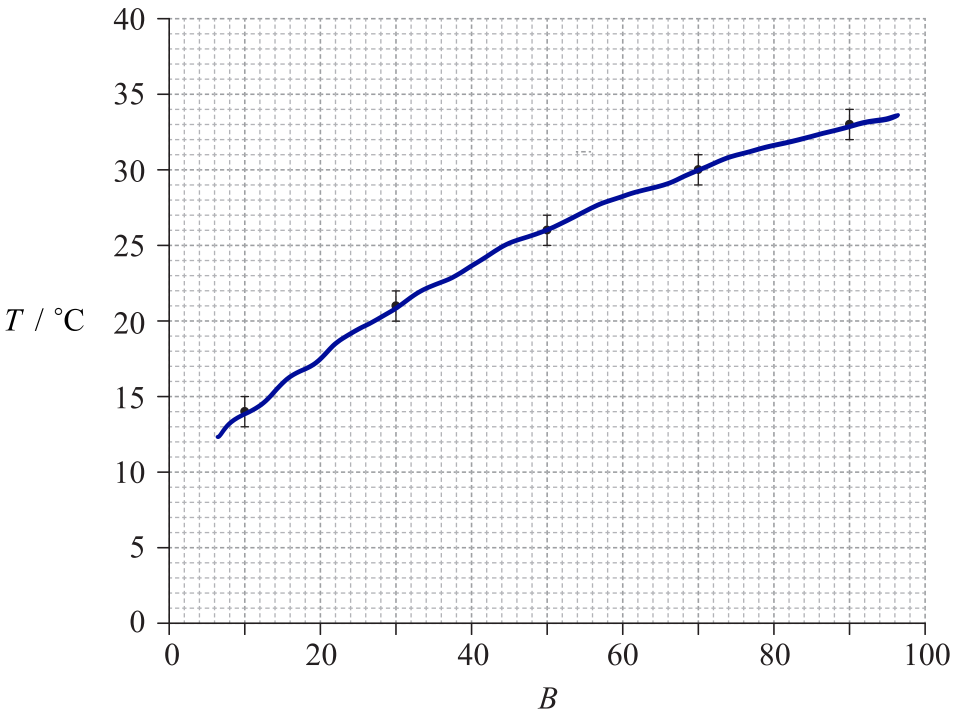
$\sqrt{\frac{s^2}{m^{-1}}}$ $\frac{s}{m^{-1/2}}$ $m^{1/2} s$

3. Connie and Sophie investigate the effect of colour on heat absorption. They make grey paint by mixing black and white paint in different ratios. Five identical tin cans are painted in five different shades of grey.



Connie and Sophie put an equal amount of water at the same initial temperature into each can. They leave the cans under a heat lamp at equal distances from the lamp. They measure the temperature increase of the water, T, in each can after one hour.

(a) Connie suggests that T is proportional to B, where B is the percentage of black in the paint. To test this hypothesis, she plots a graph of T against B, as shown on the axes below. The uncertainty in T is shown and the uncertainty in B is negligible.



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(i) State the value of the absolute uncertainty in T. [1]

$\pm 1^{\circ}C$

(ii) Comment on the fractional uncertainty for the measurement of T for $B = 10$ and the measurement of T for $B = 90$. [2]

$B = 10$, $T = 14 \pm 1$ FRACTIONAL UNCERTAINTY = $1/14$

$B = 90$, $T = 33 \pm 1$ FRACTIONAL UNCERTAINTY = $1/33$

(iii) On the graph opposite, draw a best-fit line for the data. [1]

(iv) Outline why the data do not support the hypothesis that T is proportional to B. [2]

NOT A STRAIGHT LINE

DOES NOT PASS (0,0)

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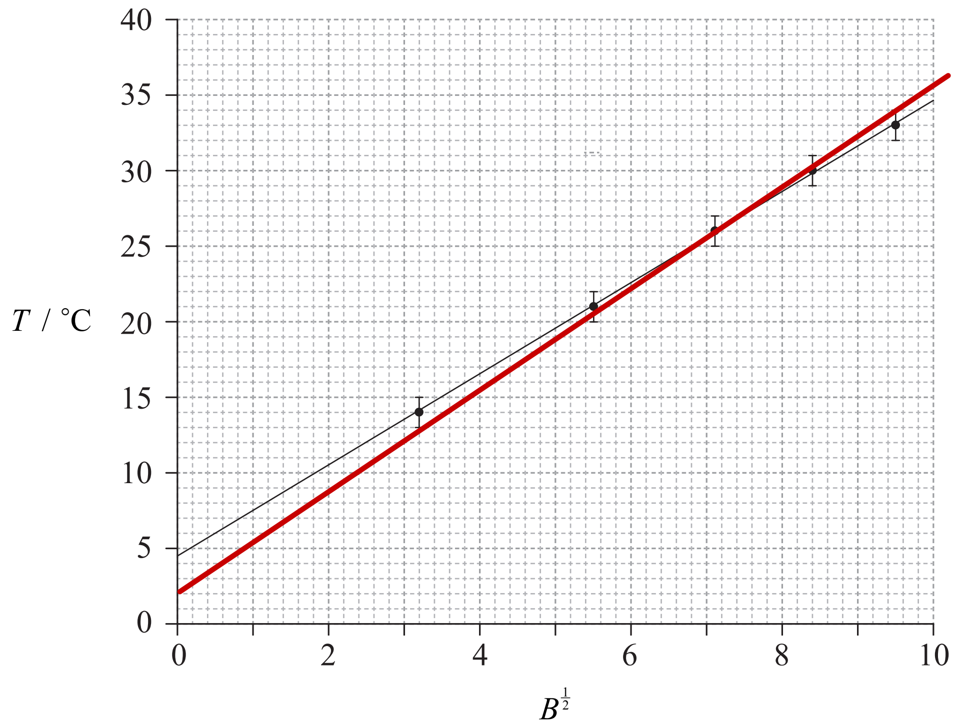
(b) Sophie suggests that the relationship between T and B is of the form

$$T = kB^{\frac{1}{2}} + c$$

y x

where k and c are constants.

To test whether or not the data support this relationship, a graph of T against $B^{\frac{1}{2}}$ is plotted as shown below. The uncertainty in T is shown and the uncertainty in $B^{\frac{1}{2}}$ is negligible.



(i) Use the graph to determine the value of c with its uncertainty. *[4]*

C = INTERCEPT $\quad$ C BEST = 4.5 °C

C WORST = 2 °C

c = 4.5 ± 2 $\quad$ (5 ± 2)

(ii) State the unit of k. *[1]*

°C