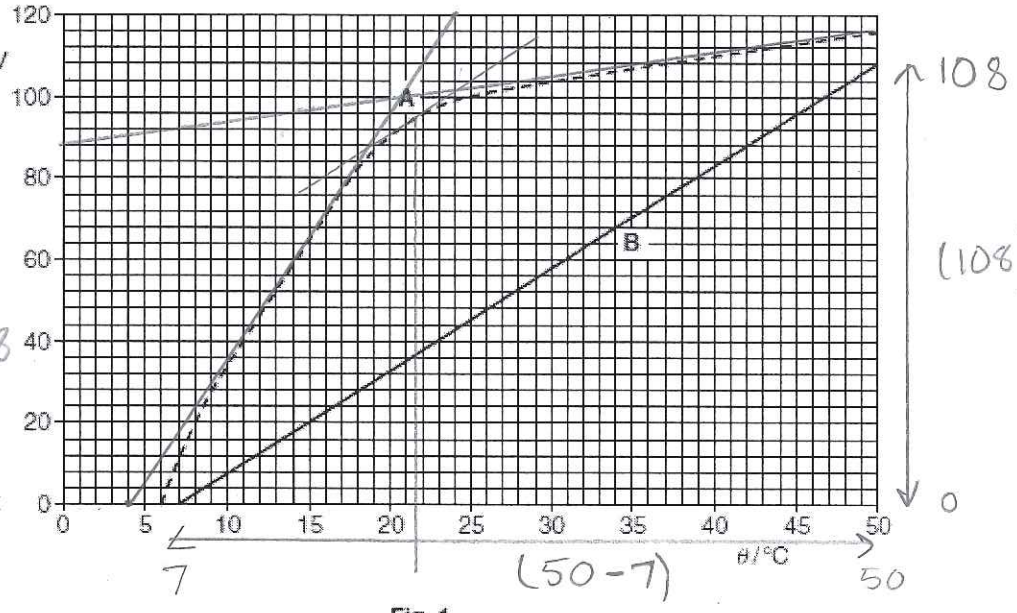
Simple measurements using a temperature sensor

The data displayed in Fig. 1 shows the variation of p.d. V with celsius temperature θ obtained using two different temperature sensors **A** and **B**.



(15) $\Delta V = 120V$
$\Delta\theta = 24-4$
$= 20°C$

(35) $\Delta V = 116-88$
$= 28V$
$\Delta\theta = 50°C$

Fig. 1

Q1 Define these terms which describe the performance of a sensor:

RANGE ...The difference between the largest and smallest values of a quantity that are measured.....

RESOLUTION ...The smallest measurable unit of change in a quantity (or measurement of a quantity).....

SENSITIVITY ...How much the OUTPUT changes for a given change in INPUT i.e. ...OUTPUT/INPUT ratio.....

Q2 Calculate the sensitivity of sensor B from the information on the graph [Fig 1]. Show your working below and annotate Fig. 1 to make your method clear

$\text{sensitivity} = \frac{\Delta V}{\Delta\theta} = \frac{108}{43} = 2.51\,\text{mV°C}^{-1}$

or $2.5\times10^{-3}\,\text{V°C}^{-1}$

Q3 Calculate the sensitivity of sensor A at temperatures of 15°C and 35°C from the information on the graph [Fig 1]. Show your working below and annotate Fig. 1 to make your method clear

$\text{sensitivity @ } 15°C = \frac{120}{20} = 6\,\text{mV°C}^{-1}$

$\text{sensitivity @ } 35°C = \frac{28}{50} = 0.56\,\text{mV°C}^{-1}$

Q4 Estimate the temperature at which the sensitivity of sensor A is equal to the sensitivity of sensor B.

temperature = ...21.5°C ± 1°C.

Explain how you arrived at your answer.

The gradients of the graphs are identical.

Q5 Calculate the temperature resolution of sensor B if the voltmeter used can only read 5mV increments. Use the value of sensitivity the you calculated in Q2. Show your working below.

$SENS = \frac{\Delta V}{\Delta \theta}$ so $\Delta \theta_m = \frac{\Delta V_m}{SENS} = \frac{5 \times 10^{-3}}{2.5 \times 10^{-3}} = 2°C$

Q6 Explain why a student might choose to use sensor A for measuring a temperature of around 15°C but would choose sensor B for measuring a temperature of 35°C.

at 15°C the sensitivity of A > B.
but at 35°C the sensitivity of B > A.
ie in both cases a more accurate
temperature reading could be obtained.

Trolley down a ramp

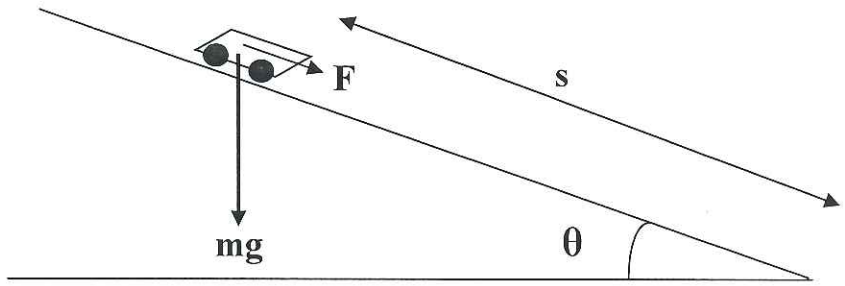


Fig.2

Q1 Explain why the force F accelerating the trolley down the ramp is less than the weight [mg].

The force F is the component of the weight which acts down the slope, ($F = mg\sin\theta$) and therefore F will always be less than mg

Q2 The force $F = mg\sin\theta$ Using Newton's second law $F = ma$ show that the acceleration down the slope is equal to $g \sin \theta$

$F = mg\sin\theta$ and $F = ma$ so $ma = mg\sin\theta$ or $a = g\sin\theta$.

Q3 If the trolley starts from rest then $V^2 = 2as$ Rearrange this formula to make **a** the subject. What measurements would need to be made to obtain a value of a?

$V^2 = 2as$ so $a = \frac{V^2}{2s}$

measurements: V (at the bottom of the slope) and s the travel distance of the trolley down the slope.

Q4 The value of a could be measured for a range of slope angles θ. Suggest a suitable graph that could be drawn to obtain a value of g and explain how the value of g could be calculated.

$a = g\sin\theta$ $v^2 = 2as$ $a = \frac{v^2}{2s}$

so $(v^2 = 2gs\sin\theta)$

(graph $a/\sin\theta$.)

g = slope of graph.

Q5 The table below contains experimental data. Use this to find a value of g using a suitable graph.

θ°	V/ms^{-1}	s/m	v^2	a	sinθ
10.0	1.35	0.800	1.82	1.14	0.174
15.0	2.01	0.800	4.04	2.53	0.259
20.0	2.32	0.800	5.38	3.36	0.342
25.0	2.58	0.800	6.66	4.16	0.422
30.0	2.92	0.800	8.53	5.33	0.500
35.0	3.00	0.800	9.00	5.63	0.574
40.0	3.18	0.800	10.01	6.32	0.643

The data is not perfect.

Show your working on the graph