IB Measurement Problems

1. Which **one** of the following lists a fundamental unit and a derived unit?

A.	ampere	second
B.	coulomb	kilogram
C.	coulomb	newton
D.	metre	kilogram

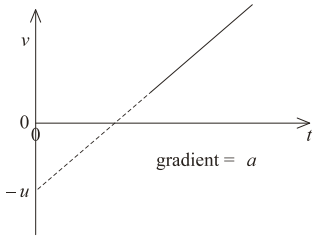
2. The variation with time t of the speed v of an object is given by the expression

$$v = u + at$$

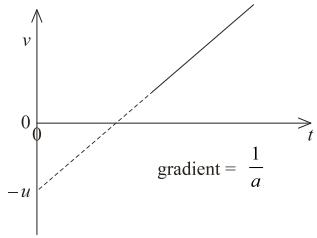
where u and a are constants.

A graph of the variation with time t of speed v is plotted. Which **one** of the following correctly shows how the constants may be determined from this graph?

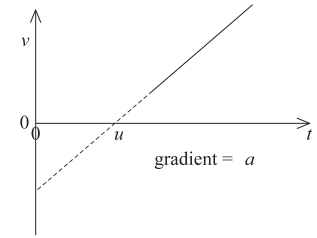
A.



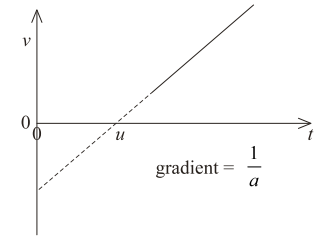
B.



C.



D.



3. The order of magnitude of the weight of an apple is

A. 10^{-4} N.

B. 10^{-2} N.

C. 1 N.

D. 10^{2} N.

(1)

4. The resistive force F acting on a sphere of radius r moving at speed v through a liquid is given by

$$F = cvr$$

where c is a constant. Which of the following is a correct unit for c?

A. N

B. N s^{-1}

C. N m^2 s^{-1}

D. N m^{-2} s

(1)

5. Which **one** of the following is a scalar quantity?

A. Pressure

B. Impulse

C. Magnetic field strength

D. Weight

6. Which **one** of the following quantities is a vector?

A. Work

B. Temperature

C. Electric field

D. Pressure

(1)

7. The kWh is equal to

A. 1.0×10^3 J.

B. 3.6×10^3 J.

C. 6.0×10^4 J.

D. 3.6×10^6 J.

(1)

8. Which **one** of the following includes three vector quantities?

A.	velocity	weight	field strength
B.	weight	mass	field strength
C.	velocity	energy	weight
D.	mass	energy	field strength

(1)

9. The volume of the Earth is approximately 10^{12} km^3 and the volume of a grain of sand is approximately 1 mm^3. The order of magnitude of the number of grains of sand that can fit in the volume of the Earth is

A. 10^{12}.

B. 10^{18}.

C. 10^{24}.

D. 10^{30}.

(1)

10. The time interval between human heartbeats is of the order of

A. 10^{-2} s.

B. 10^{-1} s.

C. 10^{0} s.

D. 10^{1} s.

(1)

11. The kilowatt-hour is equivalent to approximately

A. 60 J.

B. 3.6×10^3 J.

C. 8.6×10^4 J.

D. 3.6×10^6 J.

(1)

12. The speed of sound v in a gas is related to the pressure P of the gas by the expression

$$v = \sqrt{kP}$$

where k is a constant.

Which variables should be plotted in order to produce a straight-line graph with the slope equal to k?

A. v^2 against P^2

B. v^2 against P

C. v against P

D. v against $\sqrt{P}$

(1)

13. The length of a page of the examination paper is approximately 30 cm.

Which of the following gives the order of magnitude for the time taken for light to travel the length of the page?

A. 10^{-7} s

B. 10^{-8} s

C. 10^{-9} s

D. 10^{-10} s

(1)

14. The density of a metal cube is given by the expression $\rho = \frac{M}{V}$ where M is the mass and V is the volume of the cube. The percentage uncertainties in M and V are as shown below.

M	12%
V	4.0%

The percentage uncertainty in the calculated value of the density is

A. 3.0%.

B. 8.0%.

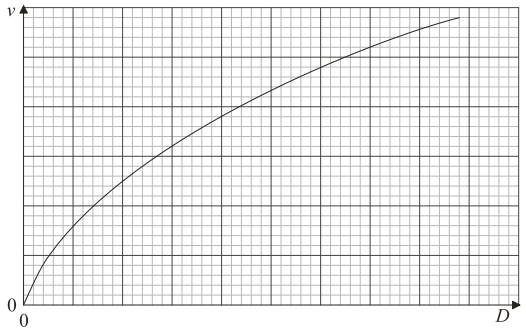
C. 16%.

D. 48%.

(1)

15. As part of a road-safety campaign, the braking distances of a car were measured.

A driver in a particular car was instructed to travel along a straight road at a constant speed *v*. A signal was given to the driver to stop and he applied the brakes to bring the car to rest in as short a distance as possible. The total distance *D* travelled by the car after the signal was given was measured for corresponding values of *v*. A sketch-graph of the results is shown below.



(a) State why the sketch graph suggests that *D* and *v* are **not** related by an expression of the form

$$D = mv + c,$$

where *m* and *c* are constants.

(1)

(b) It is suggested that *D* and *v* may be related by an expression of the form

$$D = av + bv^2,$$

where *a* and *b* are constants.

In order to test this suggestion, the data shown below are used. The uncertainties in the measurements of *D* and *v* are not shown.

v / m s^{-1}	D / m	$\frac{D}{v}$ / .....
10.0	14.0	1.40
13.5	22.7	1.68
18.0	36.9	2.05
22.5	52.9	
27.0	74.0	2.74
31.5	97.7	3.10

(i) In the table above, state the unit of $\frac{D}{v}$.

(1)

(ii) Calculate the magnitude of $\frac{D}{v}$, to an appropriate number of significant digits, for $v = 22.5$ m s^{-1}.

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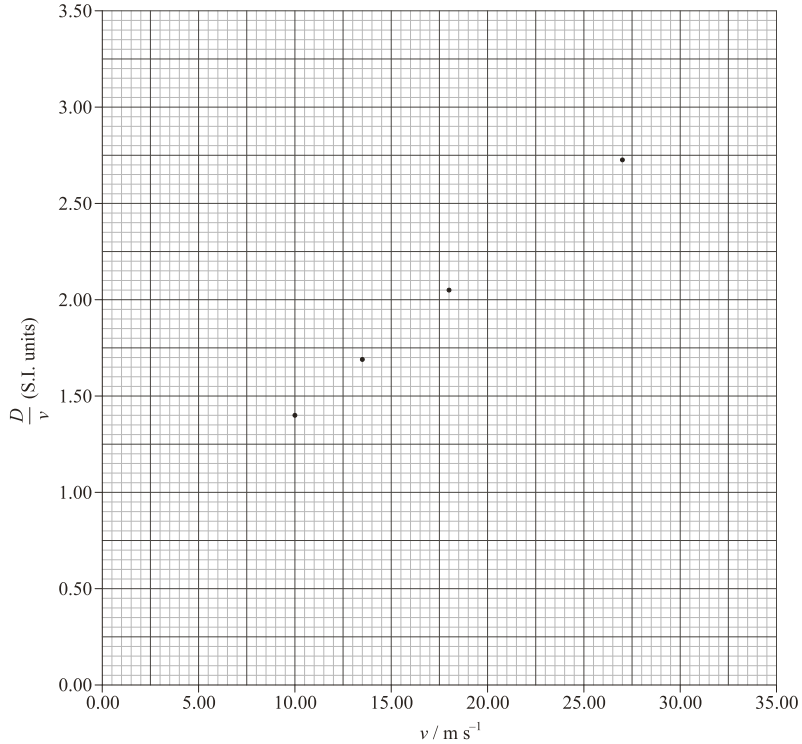
(1)

(c) Data from the table are used to plot a graph of $\frac{D}{v}$ (y-axis) against v (x-axis). Some of the data points are shown plotted below.



(i) plot the data points for speeds corresponding to 22.5 m s^{-1} and to 31.5 m s^{-1}.

(2)

(ii) draw the best-fit line for all the data points.

(d) Use your graph in (c) to determine

(i) the total stopping distance D for a speed of 35 m s^{-1}.

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(2)

(ii) the intercept on the $\frac{D}{v}$ axis.

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(1)

(iii) the gradient of the best-fit line.

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(2)

(e) Using your answers to (d)(ii) and (d)(iii), deduce the equation for D in terms of v.

D = ...

(1)

(f) (i) Use your answer to (e) to calculate the distance D for a speed v of 35.0 m s^{-1}.

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(1)

(ii) Briefly discuss your answers to (d)(i) and (f)(i).

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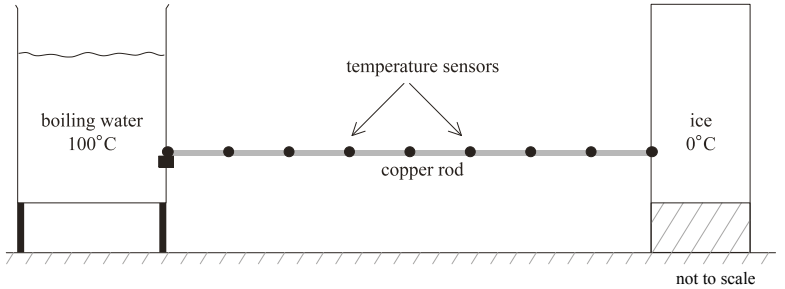
(1)

(Total 14 marks)

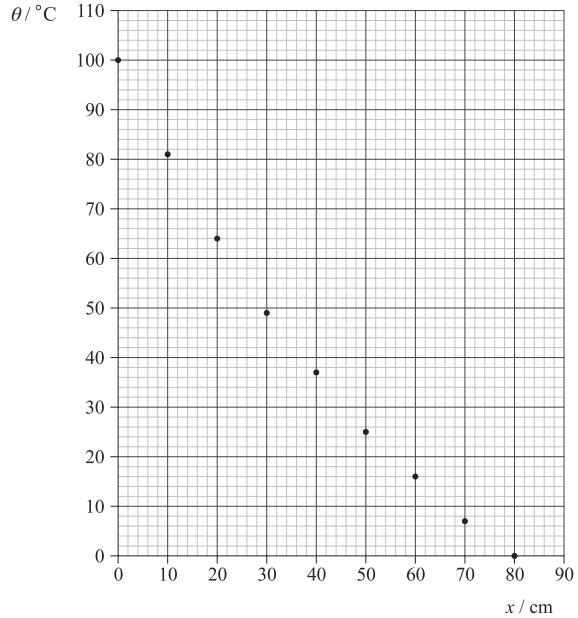
16. This question is about thermal energy transfer through a rod.

A student designed an experiment to investigate the variation of temperature along a copper rod when each end is kept at a different temperature. In the experiment, one end of the rod is placed in a container of boiling water at 100°C and the other end is placed in contact with a block of ice at 0.0°C as shown in the diagram.



Temperature sensors are placed at 10 cm intervals along the rod. The final steady state temperature θ of each sensor is recorded, together with the corresponding distance x of each sensor from the hot end of the rod.

The data points are shown plotted on the axes below.



The uncertainty in the measurement of θ is ±2°C. The uncertainty in the measurement of x is negligible.

(a) On the graph above, draw the uncertainty in the data points for x = 10 cm, x = 40 cm and x = 70 cm.

(2)

(b) On the graph above, draw the line of best-fit for the data.

(1)

(c) Explain, by reference to the uncertainties you have indicated, the shape of the line you have drawn.

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(2)

(d) (i) Use your graph to estimate the temperature of the rod at x = 55 cm.

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(1)

(ii) Determine the magnitude of the gradient of the line (the temperature gradient) at x = 50 cm.

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(3)

(e) The rate of transfer of thermal energy R through the cross-sectional area of the rod is proportional to the temperture gradient $\boxed{\frac{\Delta\theta}{\Delta x}}$ along the rod. At x = 10 cm, R = 43W and the magnitude of the temperature gradient is $\frac{\Delta\theta}{\Delta x} = 1.81\,°\text{C cm}^{-1}$. At x = 50 cm the value of R is 25 W.

Use these data and your answer to d(ii) to suggest whether the rate R of thermal energy transfer is in fact proportional to the temperature gradient.

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