Seconde International Composition Groupée

December 2016

Physics

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19/20

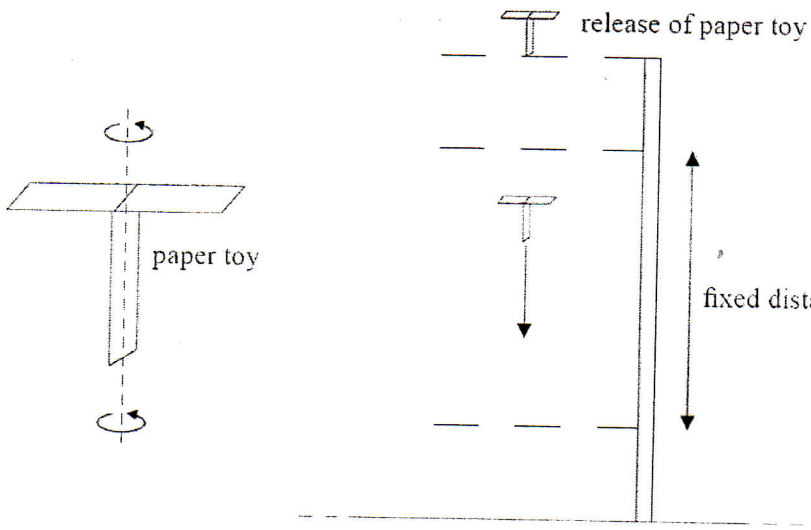
Mark : 7 /7

Duration: 1h 10 minutes

Teacher : M Rolland.

Question 1

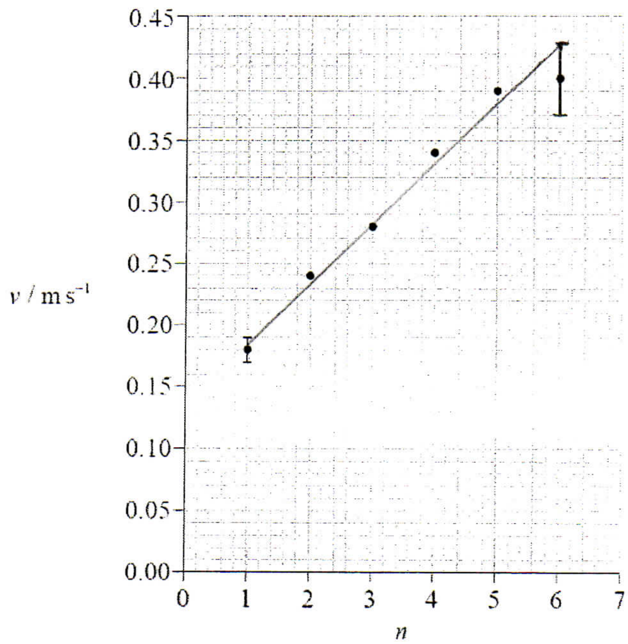
A student performs an experiment with a paper toy that rotates as it falls slowly through the air. After release, the paper toy quickly attains a constant vertical speed as measured over a fixed vertical distance.



The aim of the experiment was to find how the terminal speed of the paper toy varies with its weight. The weight of the paper toy was changed by using different numbers of paper sheets in its construction.

7.5 / 10

The graph shows a plot of the terminal speed v of the paper toy (calculated from the raw data) and the number of paper sheets n used to construct the toy. The uncertainty in v for $n=1$ is shown by the error bar.



(a) The fixed distance is 0.75 m and has an absolute uncertainty of 0.01 m. The percentage uncertainty in the time taken to fall through the fixed distance is 5 %.

(i) Calculate the absolute uncertainty in the terminal speed of the paper toy for $n=6$. [3]

3

$v = \frac{d}{t}$

$\frac{\Delta d}{d} = \frac{0.01}{0.75} = 0.013$

$\frac{\Delta t}{t} = 5\% = 0.050$

$\frac{\Delta v}{v} = \frac{\Delta d}{d} + \frac{\Delta t}{t} = 0.013 + 0.050 = 0.063$ ✓

$\therefore \Delta v = \left(\frac{\Delta d}{d} + \frac{\Delta t}{t}\right) \cdot v = 0.063 \times 0.40 = 0.03$ m

You use 2sf all the way so why not 2sf for your result?

1

(ii) On the graph, draw an error bar on the point corresponding to $n=6$. [1]

(b) On the graph, draw a line of best-fit for the data points. [1]

~~0.5~~ 1 ✗ Shouldn't it really be a straight line!

(c) The student hypothesizes that v is proportional to n. Use the data points for $n=2$ and $n=4$ from the graph opposite to show that this hypothesis is incorrect. [3]

1

The student hypothesizes a linear relationship between v and n. However, the graph above does not fully support the idea of linear best-fit, as the data points n=2 and n=4 are not on the best-fit line. On the other hand, the graph opposite demonstrates a more accurate line of best fit of v^2 against n, with data points n=2 and n=4 on the best-fit line.

∴ The hypothesis that v is proportional to n is incorrect.

would they be with error bars?

OK but what does this prove then?

$n=2$ $v = 0.24$ m/s

$n=4$ $v = 0.34$

For proportional relationship,

$\frac{n_2}{V_2} = \frac{n_4}{V_4} \Rightarrow \frac{n_2}{V_2} = \frac{2}{0.24}$

$\Rightarrow \frac{n_4}{V_4} = \frac{4}{0.34} = \frac{2}{0.17}$

$\therefore \frac{n_2}{V_2} \neq \frac{n_4}{V_4}$ and it isn't a proportional relationship.

$\frac{7.5}{10}$

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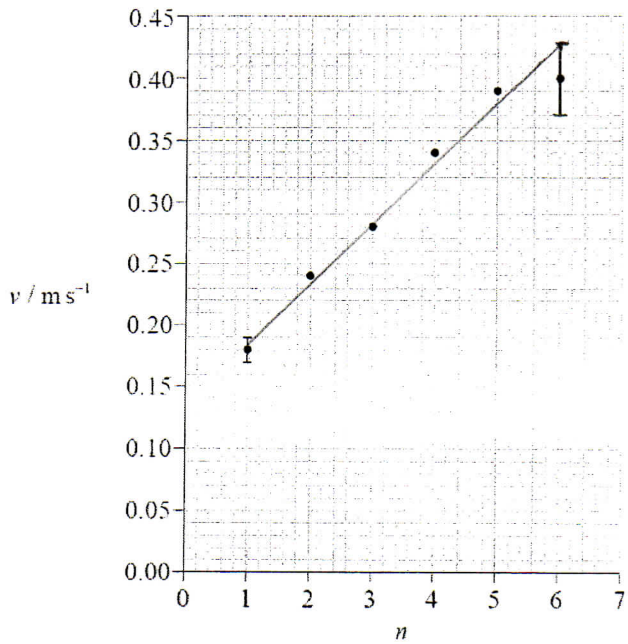

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$\frac{\Delta t}{t} = 5\% = 0.050$

$\frac{\Delta v}{V} = \frac{\Delta d}{d} + \frac{\Delta t}{t} = 0.013 + 0.050 = 0.063$ ✓

$\therefore \Delta V = (\frac{\Delta d}{d} + \frac{\Delta t}{t}) \cdot V = 0.063 \times 0.40 = 0.03$ m

You use 2sf all the way so why not 2sf for your result?

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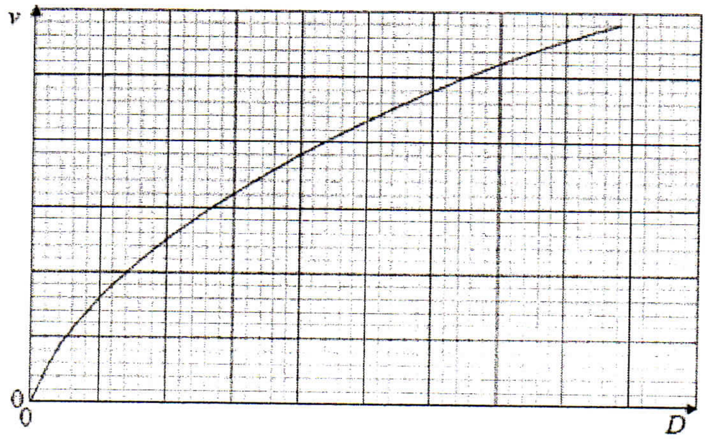
Question 2

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]

The expression $D = mV + C$ is a linear relationship.
However the graph does not support the idea of linear best fit.

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	$\frac{D}{v}$ / ....s.....
10.0	14.0	1.40
13.5	22.7	1.68
18.0	36.9	2.05
22.5	52.9	2.35
27.0	74.0	2.74
31.5	97.7	3.10

1

(i) In the table above, state the unit of $\frac{D}{v}$. [1]

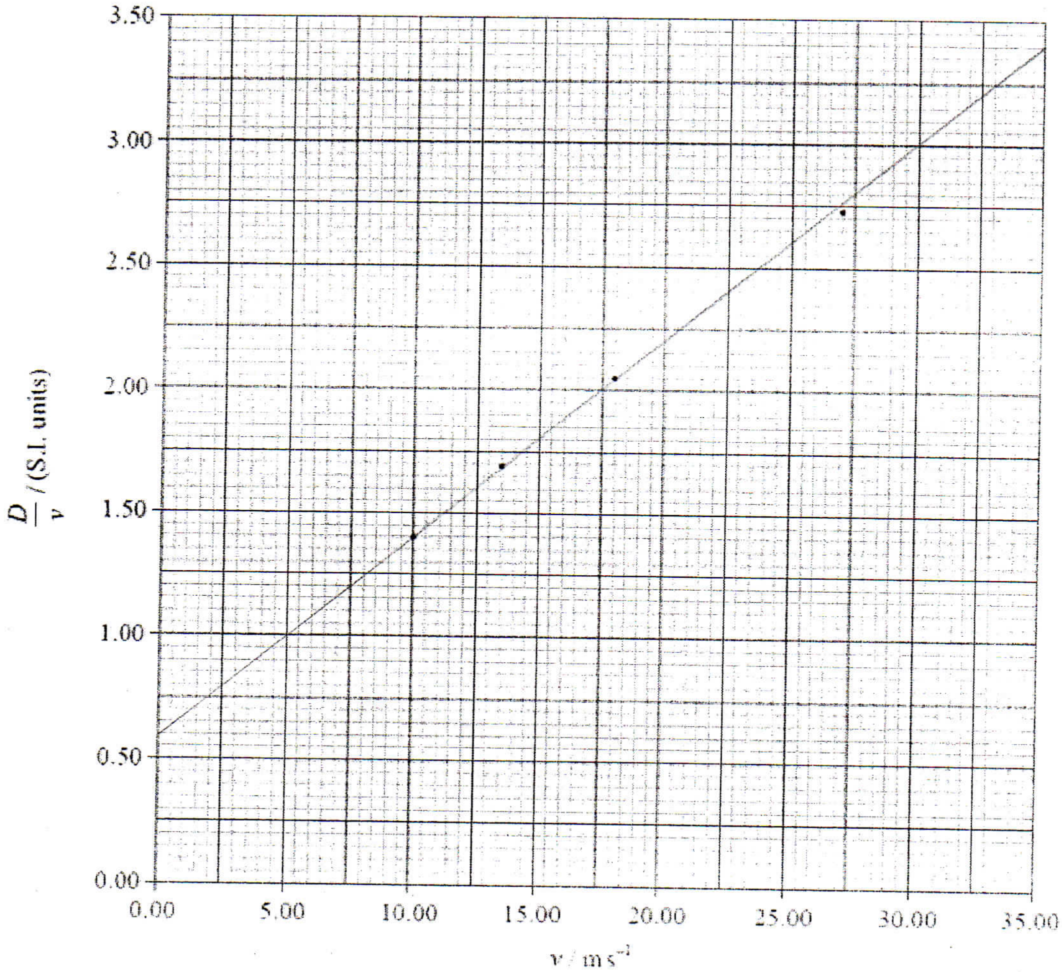
second

1

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

$\frac{D}{v} = \frac{52.9}{22.5} = 2.35$ s

(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.



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

(i) the total stopping distance D for a speed of $35\,m\,s^{-1}$. [2]

The graph supports the idea of linear best fit.
The best fit line meets $v = 35\,ms^{-1}$ at $\frac{D}{v} = 3.4\,s$.
$\therefore D = \frac{D}{v} \times v = 3.4 \times 35 = 119.0\,m$

2

(ii) the intercept on the $\frac{D}{v}$ axis. [1]

0.60

1

(iii) the gradient of the best-fit line. [2]

We take two points from the line: $P_1\,(10, 1.40)$ and $P_2\,(18, 2.05)$
The gradient is equal to $\frac{y_2 - y_1}{x_2 - x_1} = \frac{2.05 - 1.40}{18 - 10} = 0.0813$
$\therefore$ The gradient of the best-fit line is 0.0813

2

(e) Using your answers to (d)(ii) and (d)(iii), deduce the equation for D in terms of v. [1]

$D =$ $0.0813\,v^2 + 0.60\,v$

1

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

$D = 0.0813\,v^2 + 0.60\,v = 0.0813 \times 35^2 + 0.60 \times 35 = 120.6\,m$

1

(ii) Briefly discuss your answers to (d)(i) and (f)(i). [1]

My answers to (d)(i) and (f)(i) are respectively 119.0m and 120.6m.
The offset of 1.6m can be caused by 1) the inaccuracy of my best fit line to obtain the results from (d)(i); 2) the inaccuracy of my best fit line modelled in (e) due to the insufficiency of data points; 3) the measurement error in the data itself.

1