1)

A student carries out a series of determinations of the acceleration of free fall *g*. The table shows the results.

g/m s^{-2}
4.91
4.89
4.88
4.90
4.93
4.92

What can be said about this experiment?

A It is accurate and precise.

B It is accurate but not precise.

C It is not accurate and not precise.

D It is not accurate but is precise.

2)

Which experimental technique reduces the systematic error of the quantity being investigated?

A adjusting an ammeter to remove its zero error before measuring a current

B measuring several internodal distances on a standing wave to find the mean internodal distance

C measuring the diameter of a wire repeatedly and calculating the average

D timing a large number of oscillations to find a period

3)

A student makes measurements from which she calculates the speed of sound as 327.66 m s^{-1}. She estimates that her result is accurate to ±3 %.

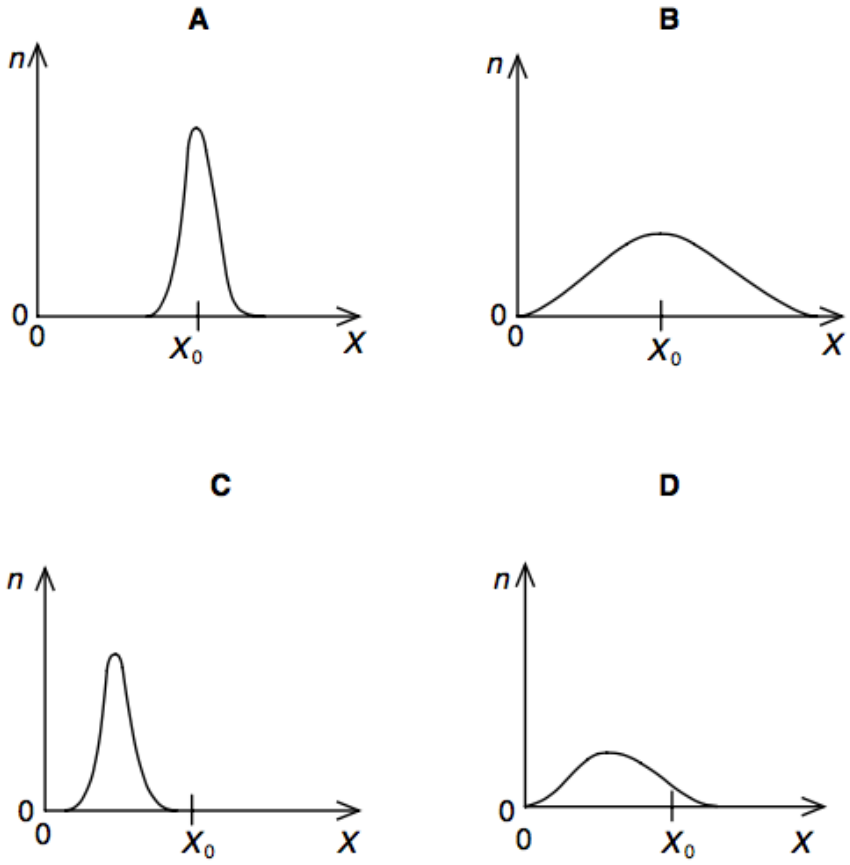
Which of the following gives her result expressed to the appropriate number of significant figures?

A 327.7 m s^{-1} **B** 328 m s^{-1} **C** 330 m s^{-1} **D** 300 m s^{-1}

4)

A quantity X is measured many times. A graph is plotted showing the number n of times a particular value of X is obtained. X has a true value X_0.

Which graph could be obtained if the measurement of X has a large systematic error but a small random error?



5)

A steel rule can be read to the nearest millimetre. It is used to measure the length of a bar whose true length is 895 mm. Repeated measurements give the following readings.

length / mm	892, 891, 892, 891, 891, 892

Are the readings accurate and precise to within 1 mm?

	results are accurate to within 1 mm	results are precise to within 1 mm
A	no	no
B	no	yes
C	yes	no
D	yes	yes

6)

The power loss P in a resistor is calculated using the formula $P = V^2/R$.

The uncertainty in the potential difference V is 3% and the uncertainty in the resistance R is 2%.

What is the uncertainty in P?

A 4% **B** 7% **C** 8% **D** 11%

7)

A thermometer can be read to an accuracy of ±0.5 °C. This thermometer is used to measure a temperature rise from 40 °C to 100 °C.

What is the percentage uncertainty in the measurement of the temperature rise?

A 0.5 % **B** 0.8 % **C** 1.3 % **D** 1.7 %

8)

In a simple electrical circuit, the current in a resistor is measured as (2.50 ± 0.05) mA. The resistor is marked as having a value of 4.7 Ω ± 2 %.

If these values were used to calculate the power dissipated in the resistor, what would be the percentage uncertainty in the value obtained?

A 2 % **B** 4 % **C** 6 % **D** 8 %

9)

In an experiment, a radio-controlled car takes 2.50 ± 0.05 s to travel 40.0 ± 0.1 m.

What is the car's average speed and the uncertainty in this value?

A $16 \pm 1\ \text{m s}^{-1}$

B $16.0 \pm 0.2\ \text{m s}^{-1}$

C $16.0 \pm 0.4\ \text{m s}^{-1}$

D $16.00 \pm 0.36\ \text{m s}^{-1}$

10)

A steel rule can be read to the nearest millimetre. It is used to measure the length of a bar whose true length is 895 mm. Repeated measurements give the following readings.

length / mm 892, 891, 892, 891, 891, 892

Are the readings accurate and precise to within 1 mm?

	results are accurate to within 1 mm	results are precise to within 1 mm
A	no	no
B	no	yes
C	yes	no
D	yes	yes

11)

The density of the material of a rectangular block is determined by measuring the mass and linear dimensions of the block. The table shows the results obtained, together with their uncertainties.

mass	=	(25.0 ± 0.1) g
length	=	(5.00 ± 0.01) cm
breadth	=	(2.00 ± 0.01) cm
height	=	(1.00 ± 0.01) cm

The density is calculated to be 2.50 g cm^{-3}.

What is the uncertainty in this result?

A ± 0.01 g cm^{-3} **B** ± 0.02 g cm^{-3} **C** ± 0.05 g cm^{-3} **D** ± 0.13 g cm^{-3}

12)

Make reasonable estimates of the following quantities.

(a) mass of an apple

mass = ... kg [1]

(b) number of joules of energy in 1 kilowatt-hour

number = ... [1]

(c) wavelength of red light in a vacuum

wavelength = ... m [1]

(d) pressure due to a depth of 10 m of water

pressure = ... Pa [1]

13)

A student uses a micrometer screw gauge to measure the diameter of a wire. He fails to notice that, with the gauge fully closed, the reading is not zero.

(a) State and explain whether the omission introduces a random error or a systematic error into the readings of the diameter.

.....

.....[2]

(b) Explain why the readings are precise but not accurate.

.....

.....

.....[2]

14)

A student uses a metre rule to measure the length of an elastic band before and after stretching it.

The lengths are recorded as

length of band before stretching, $L_0 = 50.0 \pm 0.1$ cm

length of band after stretching, $L_S = 51.6 \pm 0.1$ cm.

Determine

(a) the change in length $(L_S - L_0)$, quoting your answer with its uncertainty,

$(L_S - L_0)$ = ... cm [1]

(b) the fractional change in length, $\frac{(L_S - L_0)}{L_0}$,

fractional change = ... [1]

(c) the uncertainty in your answer in **(b)**.

uncertainty = ... [3]

15)

A student has been asked to determine the linear acceleration of a toy car as it moves down a slope. He sets up the apparatus as shown in Fig. 3.1.

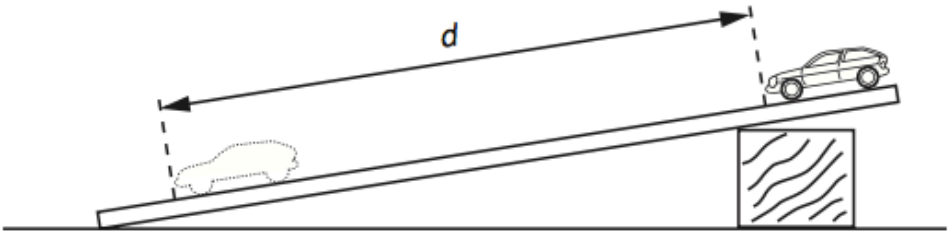


Fig. 3.1

The time *t* to move from rest through a distance *d* is found for different values of *d*. A graph of *d* (*y*-axis) is plotted against t^2 (*x*-axis) as shown in Fig. 3.2.

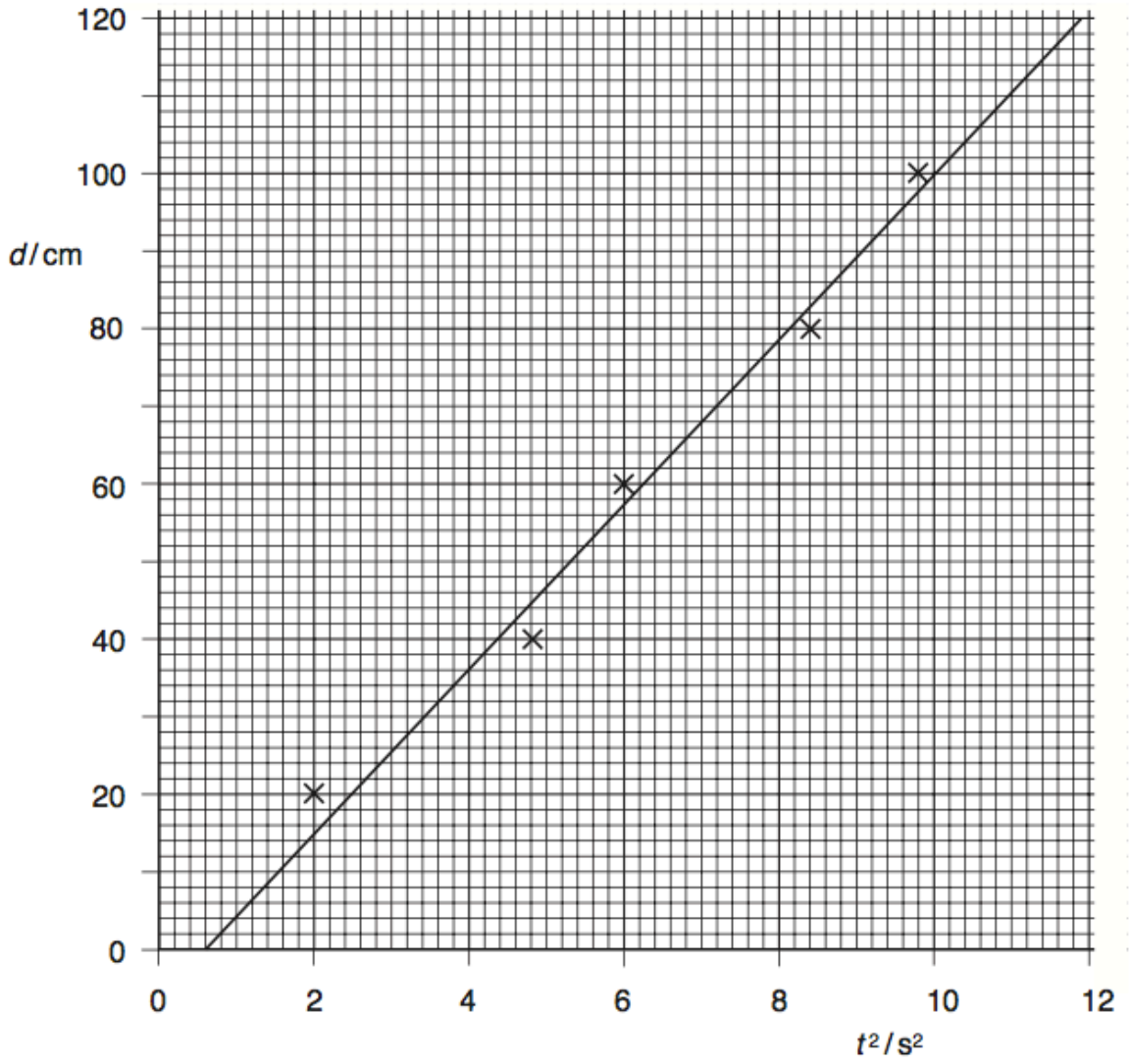


Fig. 3.2

(a) Theory suggests that the graph is a straight line through the origin.
Name the feature on Fig. 3.2 that indicates the presence of

(i) random error,

.....

(ii) systematic error.

.....
[2]

16)

Make estimates of the following quantities.

(a) the speed of sound in air

speed = ... [1]

(b) the density of air at room temperature and pressure

density = ... [1]

(c) the mass of a protractor

mass = ... [1]

(d) the volume, in cm^3, of the head of an adult person

volume = ... cm^3 [1]

17)

A student takes readings to measure the mean diameter of a wire using a micrometer screw gauge.

(a) Make suggestions, one in each case, that the student may adopt in order to

(i) reduce a systematic error in the readings,

.....

.....

(ii) allow for a wire of varying diameter along its length,

.....

.....

(iii) allow for a non-circular cross-section of the wire.

.....

.....

[3]

(b) The mean diameter of the wire is found to be 0.50 ± 0.02 mm. Calculate the percentage uncertainty in

(i) the diameter,

uncertainty = ... %

(ii) the area of cross-section of the wire.

uncertainty = ... %

[2]

18)

(a) Distinguish between systematic errors and random errors.

systematic errors .....

.....

random errors .....

..... [2]

(b) A cylinder of length L has a circular cross-section of radius R, as shown in Fig. 1.1.

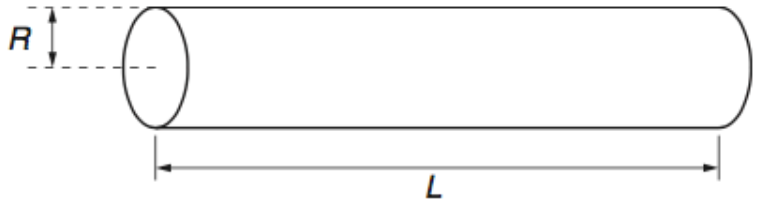


Fig. 1.1

The volume V of the cylinder is given by the expression

$$V = \pi R^2 L.$$

The volume and length of the cylinder are measured as

$V = 15.0 \pm 0.5\,\text{cm}^3$
$L = 20.0 \pm 0.1\,\text{cm}.$

Calculate the radius of the cylinder, with its uncertainty.

radius = ... ± ..... cm [5]

19)

Make reasonable estimates of the following quantities.

(a) the frequency of an audible sound wave

frequency = ... Hz [1]

(b) the wavelength, in nm, of ultraviolet radiation

wavelength = ... nm [1]

(c) the mass of a plastic 30 cm ruler

mass = ... g [1]

(d) the density of air at atmospheric pressure

density = ... kg m^{-3} [1]

20)

(a) State the most appropriate instrument, or instruments, for the measurement of the following.

(i) the diameter of a wire of diameter about 1 mm

..... [1]

(ii) the resistance of a filament lamp

..... [1]

(iii) the peak value of an alternating voltage

..... [1]

(b) The mass of a cube of aluminium is found to be 580 g with an uncertainty in the measurement of 10 g. Each side of the cube has a length of (6.0 ± 0.1) cm.

Calculate the density of aluminium with its uncertainty. Express your answer to an appropriate number of significant figures.

density = ... ± ..... g cm^{-3} [5]

21)

A particle is following a circular path and is observed to have an angular displacement of 10.3°.

(a) Express this angle in radians (rad). Show your working and give your answer to three significant figures.

angle = ...rad [2]

(b) **(i)** Determine tan10.3° to three significant figures.

tan10.3° = ...

(ii) Hence calculate the percentage error that is made when the angle 10.3°, as measured in radians, is assumed to be equal to tan10.3°.

percentage error = ...
[3]