Practical skills: 1

TOPIC- precision, accuracy, errors, uncertainty, force meters, calipers, screw gauge, pendulum, lever arm etc.

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(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]

2 A coin is made in the shape of a thin cylinder, as shown in Fig. 2.1.

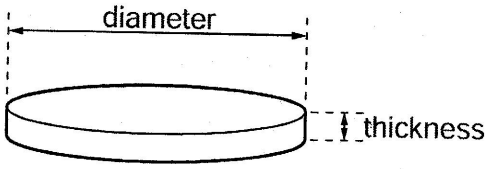


Fig. 2.1

Fig. 2.2 shows the measurements made in order to determine the density ρ of the material used to make the coin.

quantity	measurement	uncertainty
mass	9.6 g	± 0.5 g
thickness	2.00 mm	± 0.01 mm
diameter	22.1 mm	± 0.1 mm

Fig. 2.2

(a) Calculate the density ρ in $kg\,m^{-3}$.

ρ = ... $kg\,m^{-3}$ [3]

(b) (i) Calculate the percentage uncertainty in ρ.

percentage uncertainty = ... [3]

(ii) State the value of ρ with its actual uncertainty.

ρ = ... ± ..... $kg\,m^{-3}$ [1]

[Turn over

2 **(a)** Define *pressure*.

.....[1]

(b) A cylinder is placed on a horizontal surface, as shown in Fig. 2.1.

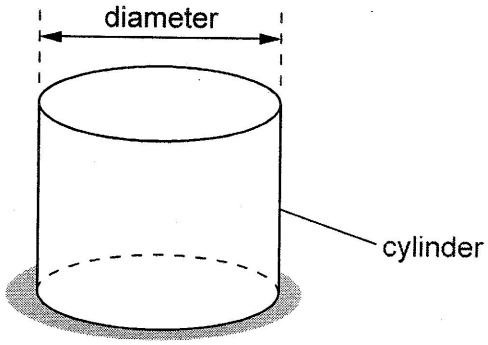


Fig. 2.1

The following measurements were made on the cylinder:

mass = 5.09 ± 0.01 kg
diameter = 9.4 ± 0.1 cm.

(i) Calculate the pressure produced by the cylinder on the surface.

pressure = ... Pa [3]

(ii) Calculate the actual uncertainty in the pressure.

actual uncertainty = ... Pa [3]

(iii) State the pressure, with its actual uncertainty.

pressure = ... ± ..... Pa [1]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Measurements made for a sample of metal wire are shown in Fig. 1.1.

quantity	measurement	uncertainty
length	1750 mm	± 3 mm
diameter	0.38 mm	± 0.01 mm
resistance	7.5 Ω	± 0.2 Ω

Fig. 1.1

(a) State the appropriate instruments used to make each of these measurements.

(i) length

..... [1]

(ii) diameter

..... [1]

(iii) resistance

..... [1]

(b) **(i)** Show that the resistivity of the metal is calculated to be $4.86 \times 10^{-7}\,\Omega\,m$.

[2]

(ii) Calculate the uncertainty in the resistivity.

uncertainty = ± ..... Ω m [4]

(c) Use the answers in **(b)** to express the resistivity with its uncertainty to the appropriate number of significant figures.

For Examiner's Use

resistivity = ... ± ..... Ω m [1]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 The volume V of liquid flowing in time t through a pipe of radius r is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8Cl}$$

where P is the pressure difference between the ends of the pipe of length l, and C depends on the frictional effects of the liquid.

An experiment is performed to determine C. The measurements made are shown in Fig. 1.1.

$\frac{V}{t}$ / 10^{-6} m^3 s^{-1}	P/10^3 N m^{-2}	r/mm	l/m
1.20 ± 0.01	2.50 ± 0.05	0.75 ± 0.01	0.250 ± 0.001

Fig. 1.1

(a) Calculate the value of C.

C = ... N s m^{-2} [2]

(b) Calculate the uncertainty in C.

uncertainty = ... N s m^{-2} [3]

(c) State the value of C and its uncertainty to the appropriate number of significant figures.

C = ... ± ..... N s m^{-2} [1]

[Turn over

Answer **all** the questions in the spaces provided.

1 The speed v of a transverse wave on a uniform string is given by the expression

$$v = \sqrt{\frac{Tl}{m}}$$

where T is the tension in the string, l is its length and m is its mass.

An experiment is performed to determine the speed v of the wave. The measurements are shown in Fig. 1.1.

quantity	measurement	uncertainty
T	1.8N	± 5%
l	126cm	± 1%
m	5.1g	± 2%

Fig. 1.1

(a) State an appropriate instrument to measure the length l.

..... [1]

(b) **(i)** Use the data in Fig. 1.1 to calculate the speed v.

v = ... $m\,s^{-1}$ [2]

(ii) Use your answer in **(b)(i)** and the data in Fig. 1.1 to determine the value of v, with its absolute uncertainty, to an appropriate number of significant figures.

v = ... ± .....$m\,s^{-1}$ [3]

[Total: 6]

[Turn over

Answer **all** the questions in the spaces provided.

1 **(a)** Define *density*.

.....

.....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ	$8100\,\text{kg m}^{-3}$	± 5%
m	7.5 kg	± 4%

Fig. 1.1

(i) Calculate the diameter d.

d = ... m [1]

(ii) Use your answer in **(i)** and the data in Fig. 1.1 to determine the value of d, with its absolute uncertainty, to an appropriate number of significant figures.

d = ... ± ..... m [3]

[Total: 5]

Answer **all** the questions in the spaces provided.

1 **(a)** Define *density*.

.....

.....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ	$8100\,\text{kg m}^{-3}$	± 5%
m	7.5 kg	± 4%

Fig. 1.1

(i) Calculate the diameter d.

d = ... m [1]

(ii) Use your answer in **(i)** and the data in Fig. 1.1 to determine the value of d, with its absolute uncertainty, to an appropriate number of significant figures.

d = ... ± ..... m [3]

[Total: 5]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A simple pendulum may be used to determine a value for the acceleration of free fall g. Measurements are made of the length L of the pendulum and the period T of oscillation.

The values obtained, with their uncertainties, are as shown.

$T = (1.93 \pm 0.03)\,\text{s}$
$L = (92 \pm 1)\,\text{cm}$

(a) Calculate the percentage uncertainty in the measurement of

(i) the period T,

uncertainty = ... % [1]

(ii) the length L.

uncertainty = ... % [1]

(b) The relationship between T, L and g is given by

$$g = \frac{4\pi^2 L}{T^2}.$$

Using your answers in **(a)**, calculate the percentage uncertainty in the value of g.

For Examiner's Use

uncertainty = ... % [1]

(c) The values of L and T are used to calculate a value of g as $9.751\,\text{m s}^{-2}$.

(i) By reference to the measurements of L and T, suggest why it would not be correct to quote the value of g as $9.751\,\text{m s}^{-2}$.

.....

..... [1]

(ii) Use your answer in **(b)** to determine the absolute uncertainty in g.

Hence state the value of g, with its uncertainty, to an appropriate number of significant figures.

g = ... ± ..... m s^{-2} [2]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A metal wire has a cross-section of diameter approximately 0.8 mm.

(a) State what instrument should be used to measure the diameter of the wire.

.....[1]

(b) State how the instrument in **(a)** is

(i) checked so as to avoid a systematic error in the measurements,

.....

.....[1]

(ii) used so as to reduce random errors.

.....

.....

.....[2]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 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]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** The spacing between two atoms in a crystal is 3.8×10^{-10} m. State this distance in pm.

spacing = ... pm [1]

(b) Calculate the time of one day in Ms.

time = ... Ms [1]

(c) The distance from the Earth to the Sun is 0.15 Tm. Calculate the time in minutes for light to travel from the Sun to the Earth.

time = ... min [2]

(d) Underline all the vector quantities in the list below.

distance energy momentum weight work [1]

(e) The velocity vector diagram for an aircraft heading due north is shown to scale in Fig. 1.1. There is a wind blowing from the north-west.

For Examiner's Use

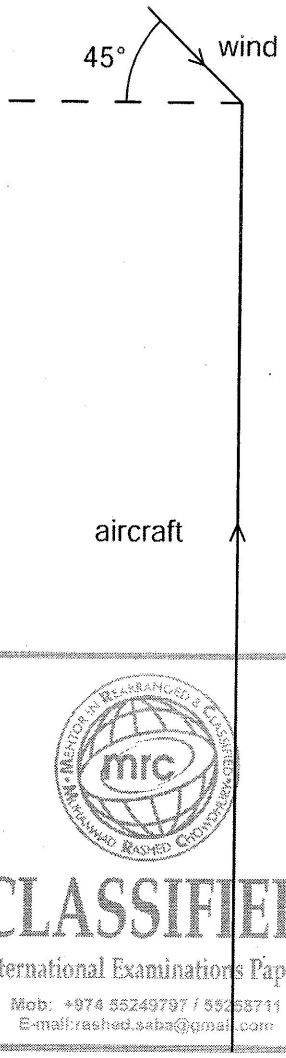


Fig. 1.1

The speed of the wind is $36\,m\,s^{-1}$ and the speed of the aircraft is $250\,m\,s^{-1}$.

(i) Draw an arrow on Fig. 1.1 to show the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

resultant velocity = ... $m\,s^{-1}$ [2]

1 **(a)** For each of the following, tick [✓] one box to indicate whether the experimental technique would reduce random error, systematic error or neither. The first row has been completed as an example.

For Examiner's Use

	random error	systematic error	neither
keeping your eye in line with the scale and the liquid level for a single reading of a thermometer		✓	
averaging many readings of the time taken for a ball to roll down a slope			
using a linear scale on an ammeter			
correcting for a non-zero reading when a micrometer screw gauge is closed			

[2]

(b) The measurement of a particular time interval is repeated many times. The readings are found to vary. The results are shown in Fig. 1.1.

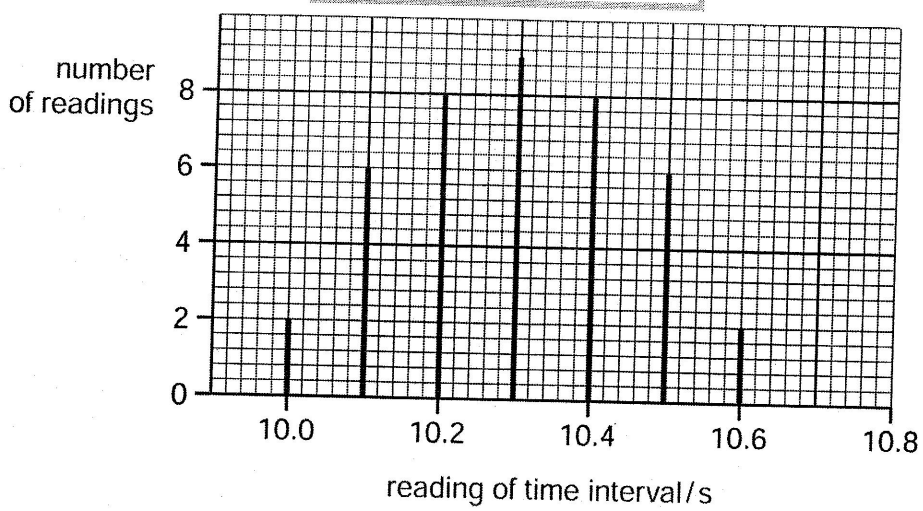


Fig. 1.1

The true value of the time interval is 10.1 s.

(i) State how the readings on Fig. 1.1 show the presence of

1. a systematic error,

.....

.....[1]

2. a random error.

.....

.....[1]

(ii) State the expected changes to Fig. 1.1 for experimental measurements that are

1. more accurate,

.....

.....[1]

2. more precise.

.....

.....[1]

For Examiner's Use

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Make estimates of the following quantities.

(a) the thickness of a sheet of paper

thickness = ... mm [1]

(b) the time for sound to travel 100 m in air

time = ... s [1]

(c) the weight of 1000 cm^3 of water

weight = ... N [1]

2 Briefly describe the structures of crystalline solids, polymers and amorphous materials.

crystalline solids .....

.....

.....

polymers .....

.....

.....

amorphous materials .....

.....

.....

[5]

For Examiner's Use

Answer **all** the questions in the spaces provided.

1 **(a)** **(i)** Define *density*.

.....

.....

(ii) State the base units in which density is measured.

.....

[2]

(b) The speed v of sound in a gas is given by the expression

$$v = \sqrt{\left(\frac{\gamma p}{\rho}\right)},$$

where p is the pressure of the gas of density ρ. γ is a constant.

Given that p has the base units of $\text{kg m}^{-1}\text{s}^{-2}$, show that the constant γ has no unit. [3]

2 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

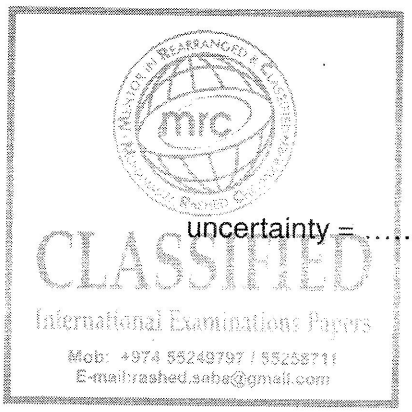
(a) the change in length $(L_S - L_0)$, quoting your answer with its uncertainty,

$(L_S - L_0)$ = ... 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]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** **(i)** State the SI base units of volume.

base units of volume ..... [1]

(ii) Show that the SI base units of pressure are $kg\,m^{-1}\,s^{-2}$.

[1]

(b) The volume V of liquid that flows through a pipe in time t is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8Cl}$$

where P is the pressure difference between the ends of the pipe of radius r and length l. The constant C depends on the frictional effects of the liquid.

Determine the base units of C.

base units of C ..... [3]

[Turn over

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** Determine the SI base units of power.

SI base units of power ..... [3]

(b) Fig. 1.1 shows a turbine that is used to generate electrical power from the wind.

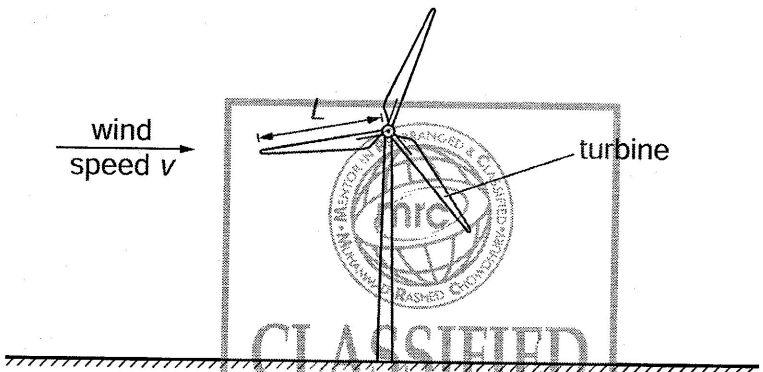


Fig. 1.1

The power P available from the wind is given by

$$P = CL^2\rho v^3$$

where L is the length of each blade of the turbine,
ρ is the density of air,
v is the wind speed,
C is a constant.

(i) Show that C has no units.

[3]

(ii) The length L of each blade of the turbine is 25.0 m and the density ρ of air is 1.30 in SI units. The constant C is 0.931.
The efficiency of the turbine is 55% and the electric power output P is 3.50×10^5 W.

Calculate the wind speed.

For Examiner's Use

wind speed = ... $m\,s^{-1}$ [3]

(iii) Suggest two reasons why the electrical power output of the turbine is less than the power available from the wind.

1. .....

.....

2. .....

.....

[2]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Energy is stored in a metal wire that is extended elastically.

(a) Explain what is meant by *extended elastically*.

.....

..... [2]

(b) Show that the SI units of energy per unit volume are $kg\,m^{-1}\,s^{-2}$.

[2]

(c) For a wire extended elastically, the elastic energy per unit volume X is given by

$$X = C\varepsilon^2 E$$

where C is a constant,
ε is the strain of the wire,
and E is the Young modulus of the wire.

Show that C has no units.

[3]

[Turn over

Answer **all** the questions in the spaces provided.

1 **(a)** Underline **all** the base quantities in the following list.

ampere charge current mass second temperature weight [2]

(b) The potential energy E_P stored in a stretched wire is given by

$$E_P = \tfrac{1}{2}C\sigma^2V$$

where C is a constant,
σ is the strain,
V is the volume of the wire.

Determine the SI base units of C.

base units .....[3]

Answer **all** the questions in the spaces provided.

1 **(a)** Show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[3]

(b) The rate of flow of thermal energy $\frac{Q}{t}$ in a material is given by

$$\frac{Q}{t} = \frac{CAT}{x}$$

where A is the cross-sectional area of the material,
T is the temperature difference across the thickness of the material,
x is the thickness of the material,
C is a constant.

Determine the SI base units of C.

base units ..... [4]

Answer **all** the questions in the spaces provided.

1 **(a)** Use the definition of work done to show that the SI base units of energy are $kg\,m^2\,s^{-2}$.

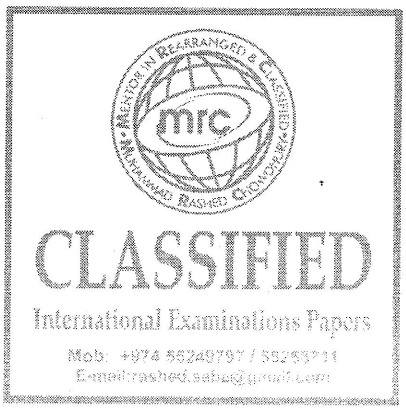
[2]

(b) Define potential difference.

.....

..... [1]

(c) Determine the SI base units of resistance. Show your working.



units ..... [3]

Answer **all** the questions in the spaces provided.

1 **(a)** Use the definition of power to show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[2]

(b) Use an expression for electrical power to determine the SI base units of potential difference.

units .....[2]

Answer **all** the questions in the spaces provided.

1 **(a)** A list of quantities that are either scalars or vectors is shown in Fig. 1.1.

quantity	scalar	vector
distance	✓	
energy		
momentum		
power		
time		
weight		

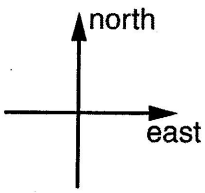
Fig. 1.1

Complete Fig. 1.1 to indicate whether each quantity is a scalar or a vector.

One line has been completed as an example. [2]

(b) A girl runs 120 m due north in 15 s. She then runs 80 m due east in 12 s.

(i) Sketch a vector diagram to show the path taken by the girl. Draw and label her resultant displacement R.



[1]

(ii) Calculate, for the girl,

1. the average speed,

average speed = ... $m\,s^{-1}$ [1]

2. the magnitude of the average velocity v and its angle with respect to the direction of the initial path.

magnitude of v = ... $m\,s^{-1}$

angle = ... °

[3]

[Total: 7]

2 **(a)** Describe the effects, one in each case, of systematic errors and random errors when using a micrometer screw gauge to take readings for the diameter of a wire.

systematic errors: .....

.....

random errors: .....

.....

[2]

(b) Distinguish between precision and accuracy when measuring the diameter of a wire.

precision: .....

.....

accuracy: .....

.....

[2]

[Total: 4]

Answer **all** the questions in the spaces provided.

1 **(a)** State two SI base units other than kilogram, metre and second.

1. .....

2. .....

[1]

(b) Determine the SI base units of resistivity.

base units .....[3]

(c) **(i)** A wire of cross-sectional area 1.5 mm^2 and length 2.5 m has a resistance of 0.030 Ω. Calculate the resistivity of the material of the wire in nΩ m.

resistivity = ...nΩ m [3]

(ii) **1.** State what is meant by *precision*.

.....

.....

2. Explain why the precision in the value of the resistivity is improved by using a micrometer screw gauge rather than a metre rule to measure the diameter of the wire.

.....

.....

.....

[2]

[Total: 9]

Answer **all** the questions in the spaces provided.

1 **(a)** State two SI base quantities other than mass, length and time.

1. .....

2. .....

[2]

(b) A beam is clamped at one end and an object X is attached to the other end of the beam, as shown in Fig. 1.1.

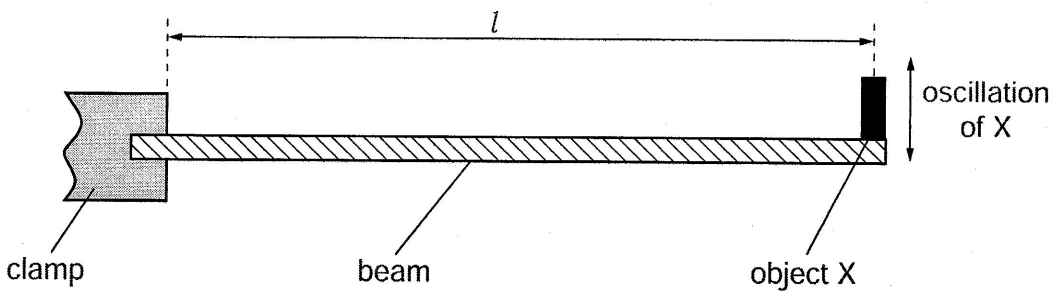


Fig. 1.1

The object X is made to oscillate vertically.

The time period T of the oscillations is given by

$$T = K\sqrt{\frac{Ml^3}{E}}$$

where M is the mass of X,
l is the length between the clamp and X,
E is the Young modulus of the material of the beam
and K is a constant.

(i) **1.** Show that the SI base units of the Young modulus are $kg\,m^{-1}\,s^{-2}$.

[1]

Answer **all** the questions in the spaces provided.

1 **(a)** Mass, length and time are SI base quantities.
State two other base quantities.

1. .....

2. .....

[2]

(b) A mass m is placed on the end of a spring that is hanging vertically, as shown in Fig. 1.1.

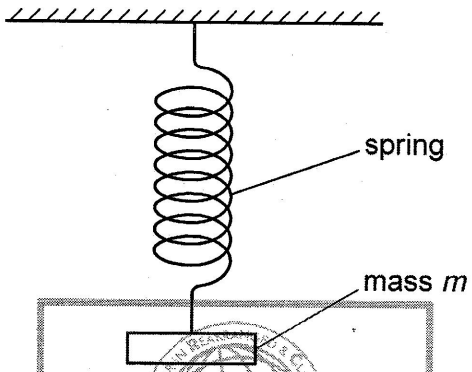


Fig. 1.1

The mass is made to oscillate vertically. The time period of the oscillations of the mass is T.

The period T is given by

$$T = C\sqrt{\frac{m}{k}}$$

where C is a constant and k is the spring constant.

Show that C has no units.

[3]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** State two SI base units other than the kilogram, metre and second.

1. .....

2. .....

[2]

(b) A metal wire has original length l_0. It is then suspended and hangs vertically as shown in Fig. 1.1.

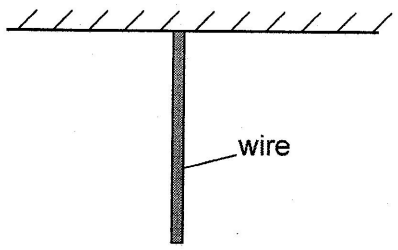


Fig. 1.1

The weight of the wire causes it to stretch. The elastic potential energy stored in the wire is E.

(i) Show that the SI base units of E are $kg\,m^2\,s^{-2}$.

[2]

(ii) The elastic potential energy E is given by

$$E = C\rho^2 g^2 A l_0^3$$

where ρ is the density of the metal,
g is the acceleration of free fall,
A is the cross-sectional area of the wire
and C is a constant.

Determine the SI base units of C.

SI base units of C ..... [3]

For Examiner's Use

For Examiner's Use

Answer **all** the questions in the spaces provided.

1 **(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.

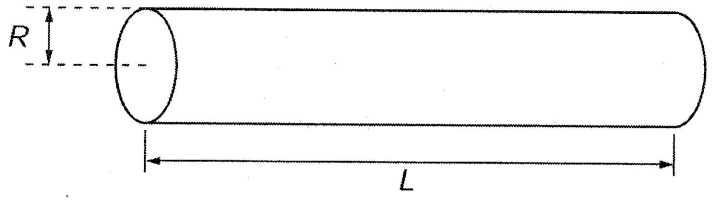


Fig. 1.1

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

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

Calculate the radius of the cylinder, with its uncertainty.

radius = ... □ ..... cm [5]

Answer **all** the questions in the spaces provided.

1 **(a)** Make estimates of

(i) the mass, in kg, of a wooden metre rule,

mass = ... kg [1]

(ii) the volume, in cm^3, of a cricket ball or a tennis ball.

volume = ... cm^3 [1]

(b) A metal wire of length L has a circular cross-section of diameter d, as shown in Fig. 1.1.

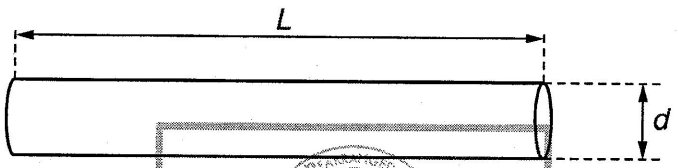


Fig. 1.1

The volume V of the wire is given by the expression

$$V = \frac{\pi d^2 L}{4}.$$

The diameter, length and mass M are measured to determine the density of the metal of the wire. The measured values are:

$d = 0.38 \pm 0.01$ mm,
$L = 25.0 \pm 0.1$ cm,
$M = 0.225 \pm 0.001$ g.

Calculate the density of the metal, with its absolute uncertainty. Give your answer to an appropriate number of significant figures.

density = ... ± ..... $kg\,m^{-3}$ [5]

[Total: 7]

For Examiner's Use

Answer **all** the questions in the spaces provided.

1 The uncalibrated scale and the pointer of a meter are shown in Fig. 1.1.

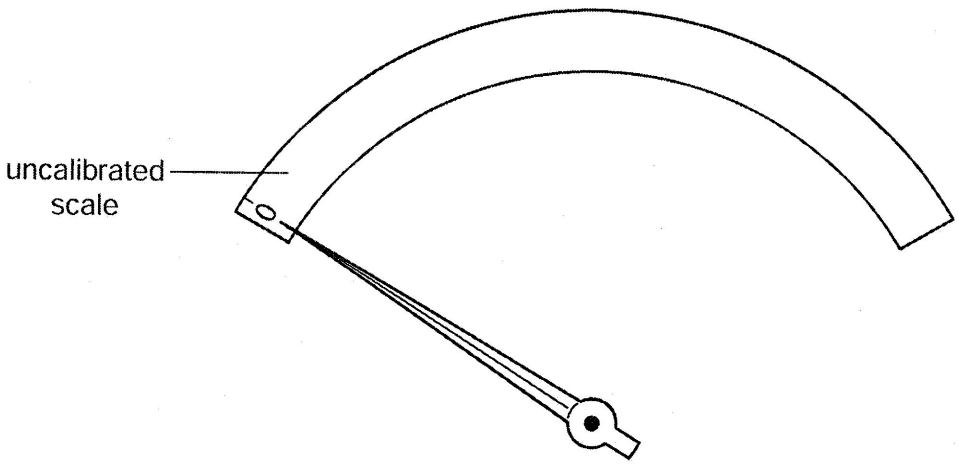


Fig. 1.1

The pointer is shown in the zero position.
The meter is to be used to indicate the volume of fuel in the tank of a car.
A known volume V of fuel is poured into the tank and the deflection θ of the pointer is noted.
Fig. 1.2 shows the variation with θ of V.

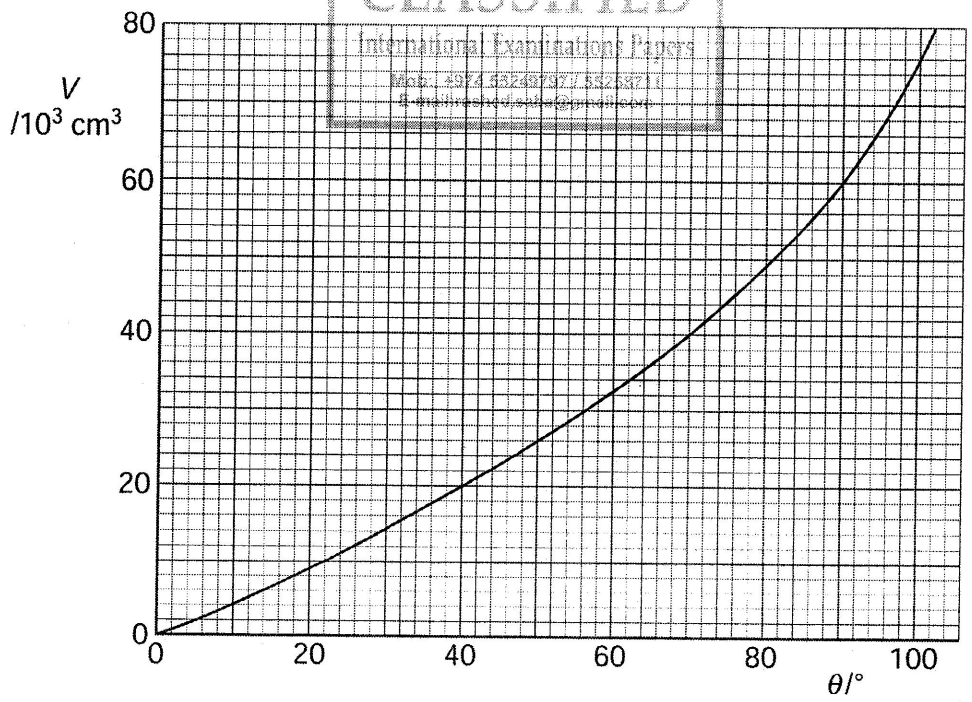


Fig. 1.2

For Examiner's Use

(a) On Fig. 1.1,

(i) calibrate the scale at 20×10^3 cm^3 intervals, [2]

(ii) mark a possible position for a volume of 1.0×10^5 cm^3. [1]

(b) Suggest one advantage of this scale, as compared with a uniform scale, for measuring fuel volumes in the tank of the car.

.....

.....[1]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A digital voltmeter with a three-digit display is used to measure the potential difference across a resistor. The manufacturers of the meter state that its accuracy is ±1% and ±1 digit. The reading on the voltmeter is 2.05 V.

(a) For this reading, calculate, to the nearest digit,

(i) a change of 1% in the voltmeter reading,

change = ...V [1]

(ii) the maximum possible value of the potential difference across the resistor.

maximum value = ...V [1]

(b) The reading on the voltmeter has high precision. State and explain why the reading may not be accurate.

.....

.....

.....[2]

2 **(a)** The distance s moved by an object in time t may be given by the expression

$$s = \frac{1}{2}at^2$$

where a is the acceleration of the object.

State two conditions for this expression to apply to the motion of the object.

1. .....

.....

2. .....

.....

[2]

For Examiner's Use

(b) A student takes a photograph of a steel ball of radius 5.0 cm as it falls from rest. The image of the ball is blurred, as illustrated in Fig. 2.1.
The image is blurred because the ball is moving while the photograph is being taken.

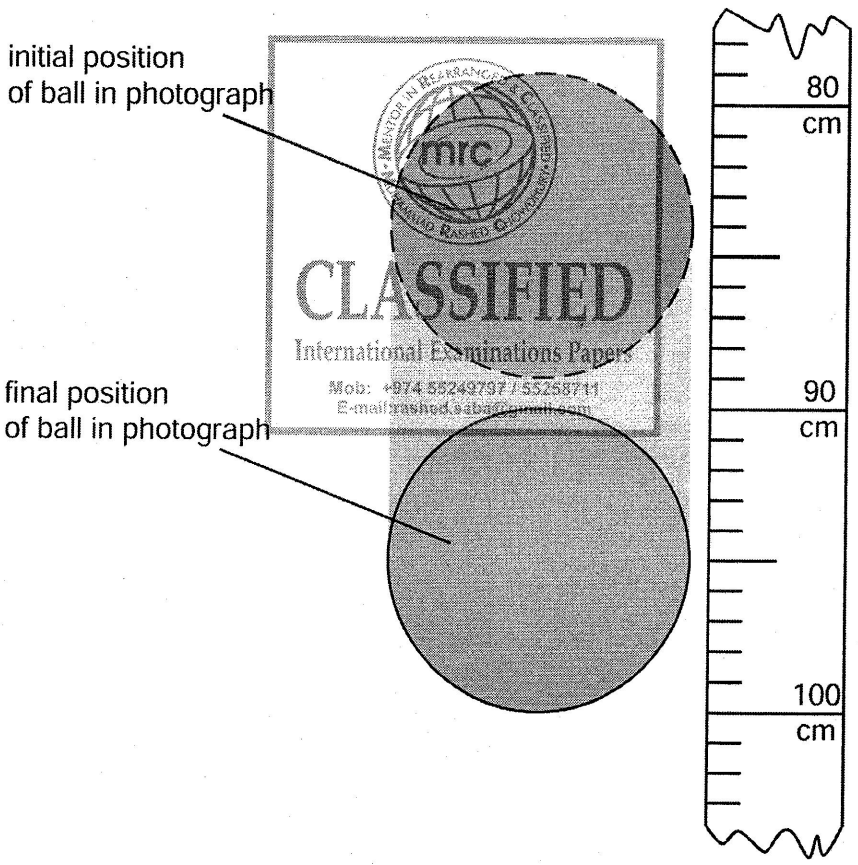


Fig. 2.1

The scale shows the distance fallen from rest by the ball. At time $t = 0$, the top of the ball is level with the zero mark on the scale. Air resistance is negligible.

Calculate, to an appropriate number of significant figures,

For Examiner's Use

(i) the time the ball falls before the photograph is taken,

time = ... s [3]

(ii) the time interval during which the photograph is taken.

time interval = ... s [3]

(c) The student in **(b)** takes a second photograph starting at the same position on the scale. The ball has the same radius but is less dense, so that air resistance is not negligible.

State and explain the changes that will occur in the photograph.

.....

.....

.....

.....[2]

Answer **all** the questions in the spaces provided.

1 **(a)** One of the equations of motion may be written as

$$v^2 = u^2 + 2as.$$

(i) Name the quantity represented by the symbol a.

.....

(ii) The quantity represented by the symbol a may be either positive or negative. State the significance of a negative value.

.....

[2]

For Examiner's Use

(b) A student investigates the motion of a small polystyrene sphere as it falls from rest alongside a vertical scale marked in centimetres. To do this, a number of flash photographs of the sphere are taken at 0.1 s intervals, as shown in Fig. 1.1.

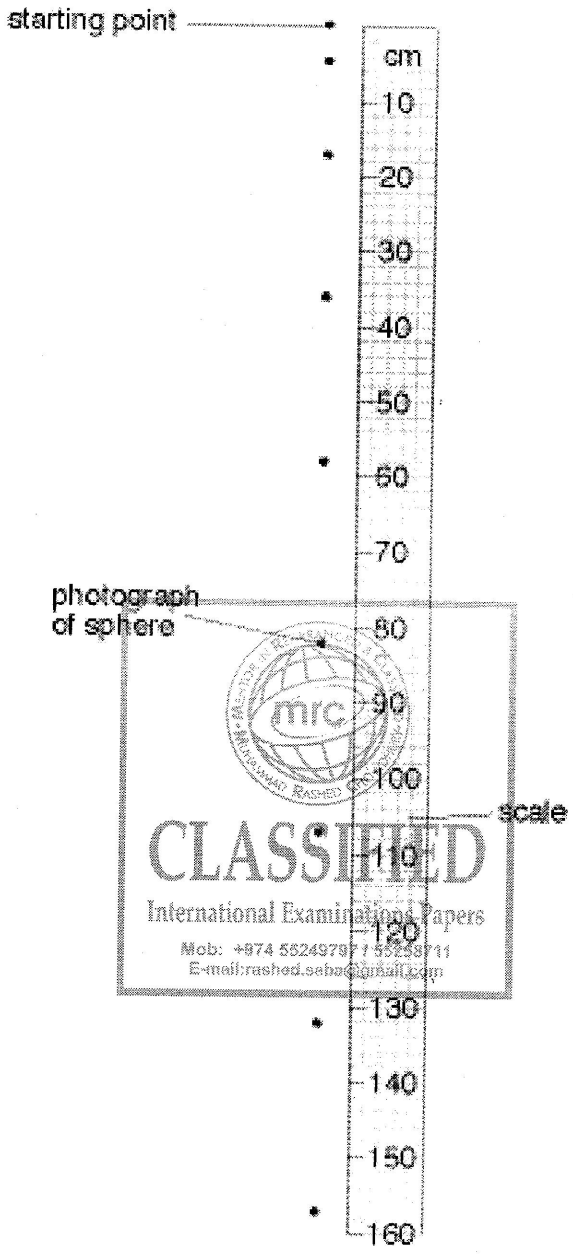


Fig. 1.1

The first photograph is taken at time $t = 0$.

By reference to Fig. 1.1,

(i) briefly explain how it can be deduced that the sphere reaches a constant speed,

.....

.....

(ii) determine the distance that the sphere has fallen from rest during a time of

1. 0.7 s,

distance = ... cm

2. 1.1 s.

distance = ... cm
[4]

(c) The student repeats the experiment with a lead sphere that falls with constant acceleration and does not reach a constant speed.

Determine the number of flash photographs that will be observed against the 160 cm scale.

Include in your answer the photograph obtained at time $t = 0$.

number = ... [3]

2 A student investigates the speed of a trolley as it rolls down a slope, as illustrated in Fig. 2.1.

For Examiner's Use

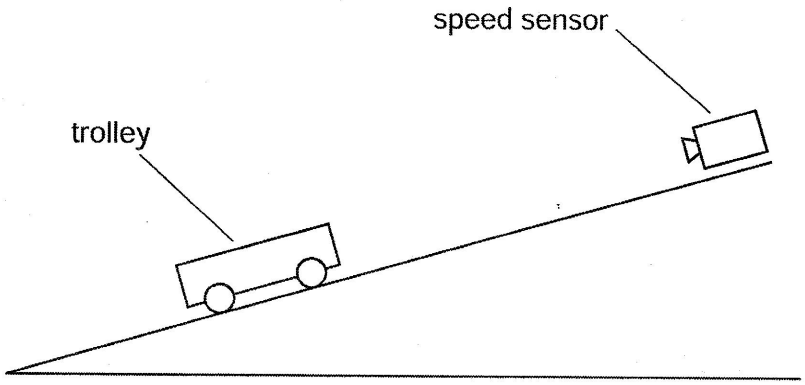


Fig. 2.1

The speed v of the trolley is measured using a speed sensor for different values of the time t that the trolley has moved from rest down the slope.

Fig. 2.2 shows the variation with t of v.

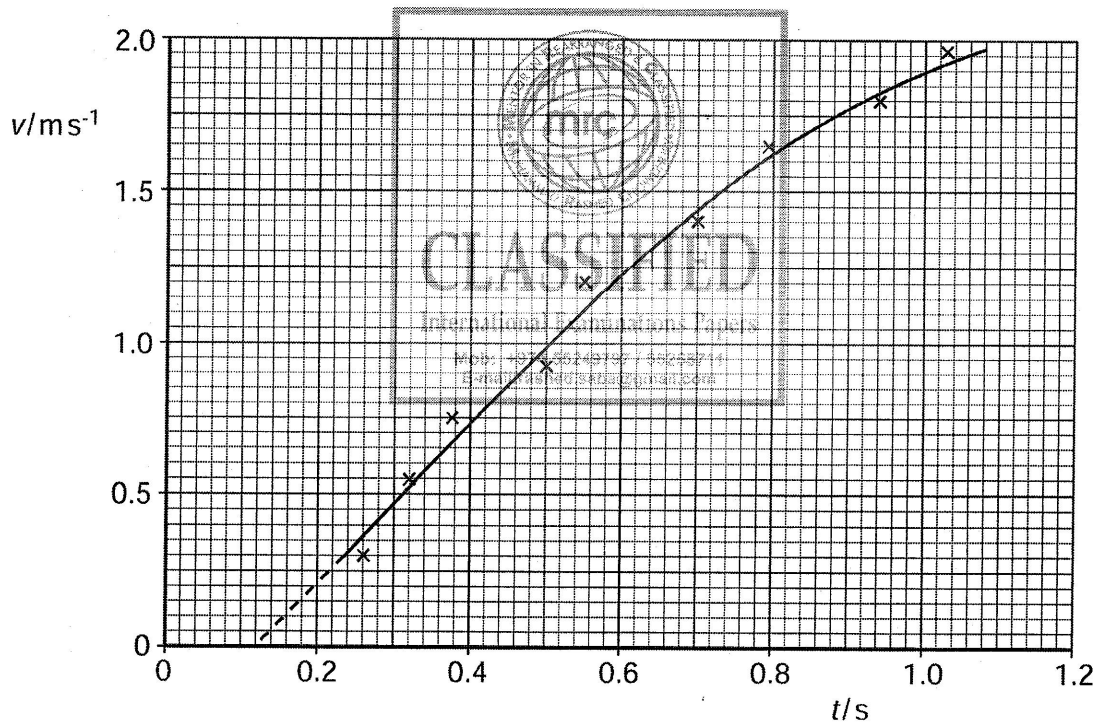


Fig. 2.2

(a) Use Fig. 2.2 to determine the acceleration of the trolley at the point on the graph where $t = 0.80$ s.

For Examiner's Use

acceleration = ... $m\,s^{-2}$ [4]

(b) **(i)** State whether the acceleration is increasing or decreasing for values of t greater than 0.6 s. Justify your answer by reference to Fig. 2.2.

.....

.....

..... [2]

(ii) Suggest an explanation for this change in acceleration.

.....

..... [1]

(c) Name the feature of Fig. 2.2 that indicates the presence of

(i) random error,

.....

..... [1]

(ii) systematic error.

.....

..... [1]

3 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.

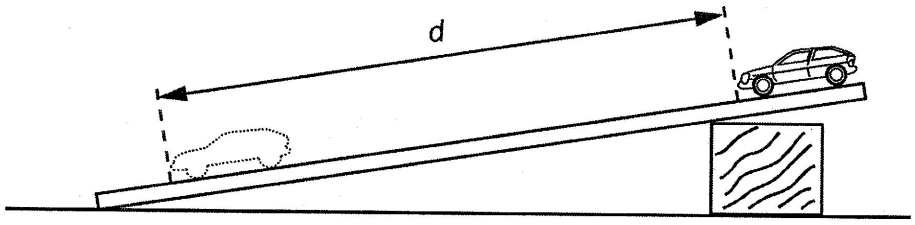


Fig. 3.1

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.

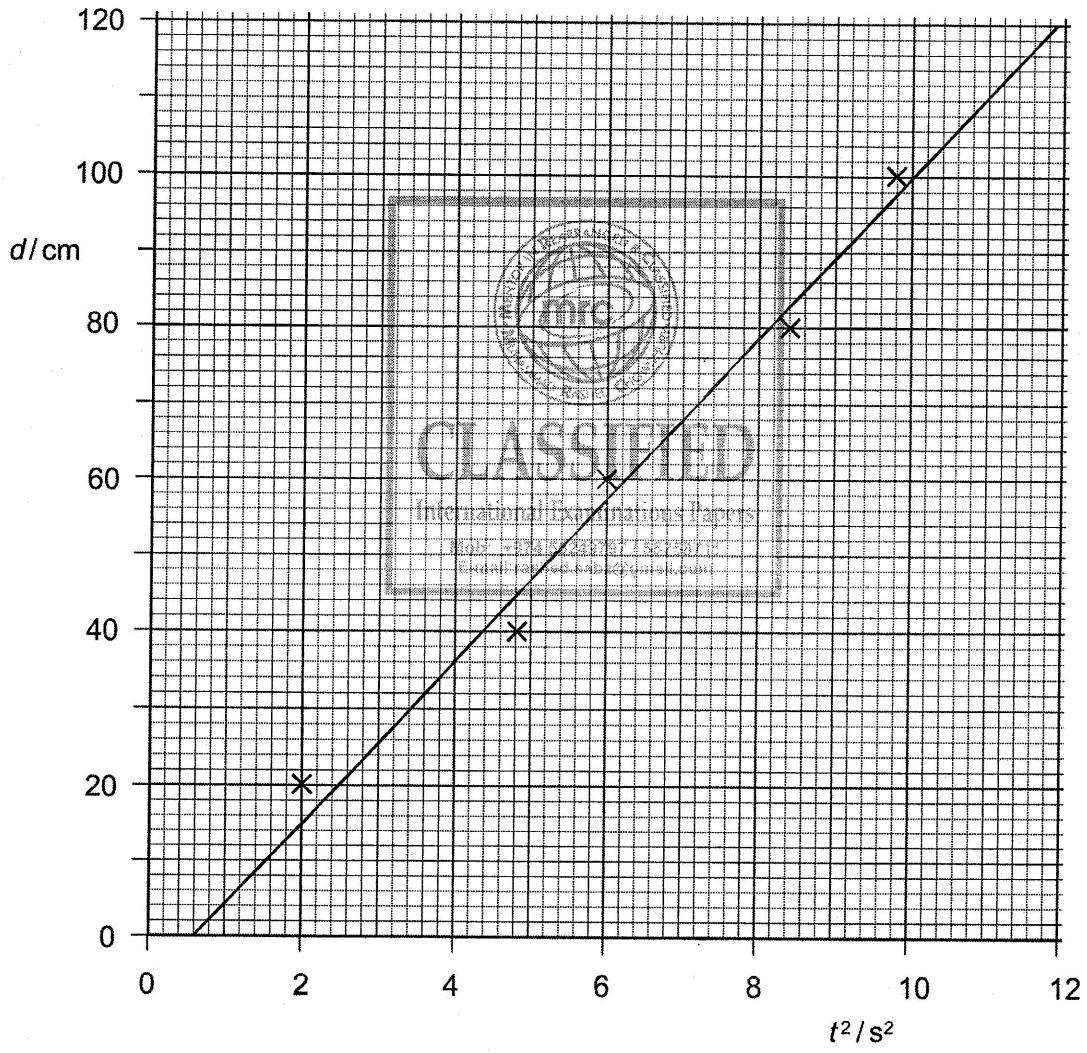


Fig. 3.2

For Examiner's Use

(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]

(b) **(i)** Determine the gradient of the line of the graph in Fig. 3.2.

gradient = ... [2]

(ii) Use your answer to **(i)** to calculate the acceleration of the toy down the slope.
Explain your working.

acceleration = ... $m\,s^{-2}$ [3]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** The drag force D on an object of cross-sectional area A, moving with a speed v through a fluid of density ρ, is given by

$$D = \frac{1}{2} C\rho A v^2$$

where C is a constant.

Show that C has no unit.

[2]

(b) A raindrop falls vertically from rest. Assume that air resistance is negligible.

(i) On Fig. 1.1, sketch a graph to show the variation with time t of the velocity v of the raindrop for the first 1.0 s of the motion.

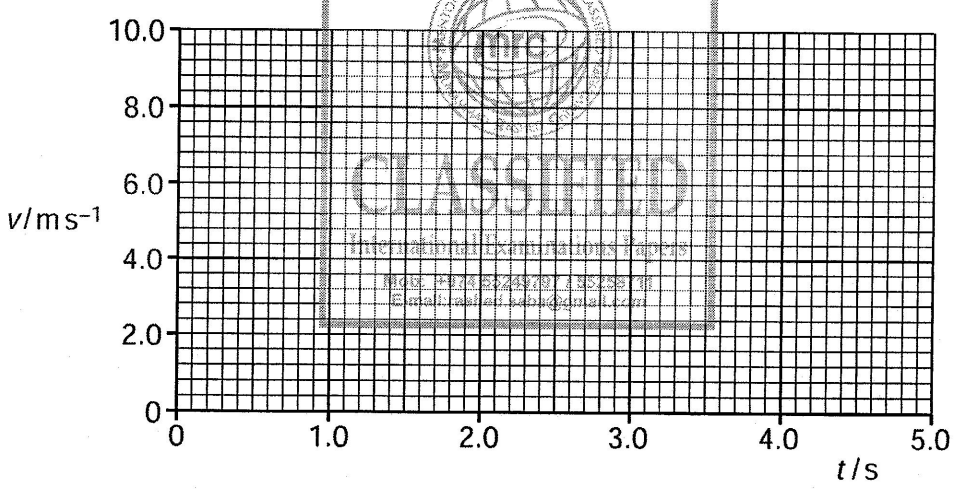


Fig. 1.1

[1]

(ii) Calculate the velocity of the raindrop after falling 1000 m.

velocity = ... $m s^{-1}$ [2]

(c) In practice, air resistance on raindrops is not negligible because there is a drag force. This drag force is given by the expression in **(a)**.

For Examiner's Use

(i) State an equation relating the forces acting on the raindrop when it is falling at terminal velocity.

[1]

(ii) The raindrop has mass 1.4×10^{-5} kg and cross-sectional area 7.1×10^{-6} m^2. The density of the air is 1.2 kg m^{-3} and the initial velocity of the raindrop is zero. The value of C is 0.60.

1. Show that the terminal velocity of the raindrop is about 7 m s^{-1}.

[2]

2. The raindrop reaches terminal velocity after falling approximately 10 m. On Fig. 1.1, sketch the variation with time t of velocity v for the raindrop. The sketch should include the first 5 s of the motion.

[2]

Answer **all** the questions in the spaces provided.

1 **(a)** Complete Fig. 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	scalar	vector
acceleration		
force		
kinetic energy		
momentum		
power		
work		

Fig. 1.1

[2]

(b) A floating sphere is attached by a cable to the bottom of a river, as shown in Fig. 1.2.

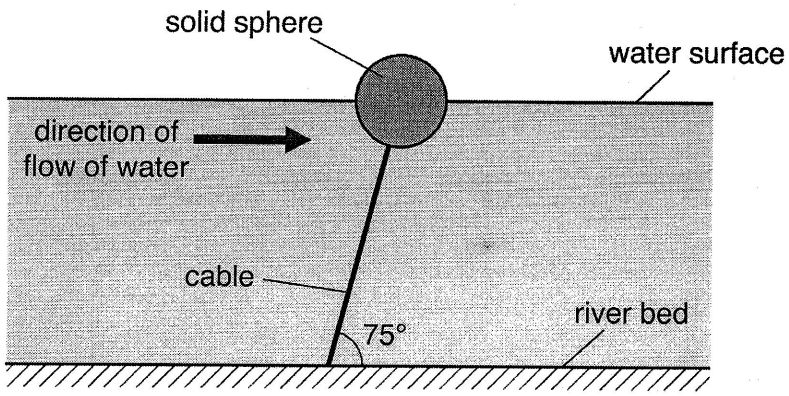


Fig. 1.2

The sphere is in equilibrium, with the cable at an angle of 75° to the horizontal. Assume that the force on the sphere due to the water flow is in the horizontal direction.

The radius of the sphere is 23 cm. The sphere is solid and is made from a material of density 82 kg m^{-3}.

(i) Show that the weight of the sphere is 41 N.

[2]

(ii) The tension in the cable is 290 N.

Determine the upthrust acting on the sphere.

upthrust = ... N [2]

(iii) Explain the origin of the upthrust acting on the sphere.

.....

.....

.....[1]

[Total: 7]

[Turn over

Answer **all** the questions in the spaces provided.

1 **(a)** Determine the SI base units of stress.
Show your working.

base units .....[2]

(b) A beam PQ is clamped so that the beam is horizontal. A mass M of 500 g is hung from end Q and the beam bends slightly, as illustrated in Fig. 1.1.

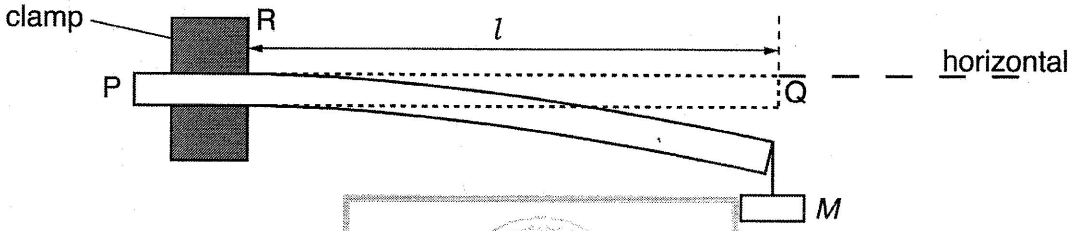


Fig. 1.1

The length l of the beam from the edge of the clamp R to end Q is 60.0 cm. The width b of the beam is 30.0 mm and the thickness d of the beam is 5.00 mm. The material of the beam has Young modulus E.

The mass M is made to oscillate vertically. The time period T of the oscillations is 0.58 s.

The period T is given by the expression

$$T = 2\pi \sqrt{\frac{4Ml^3}{Ebd^3}}.$$

(i) Determine E in GPa.

E = ...GPa [3]

(ii) The quantities used to determine E should be measured with accuracy and with precision.

1. Explain the difference between accuracy and precision.

accuracy: .....

.....

precision: .....

.....

[2]

2. In a particular experiment, the quantities l and T are measured with the same percentage uncertainty. State and explain which of these two quantities contributes more to the uncertainty in the value of E.

.....

.....

.....[1]

[Total: 8]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 The volume of fuel in the tank of a car is monitored using a meter as illustrated in Fig. 1.1.

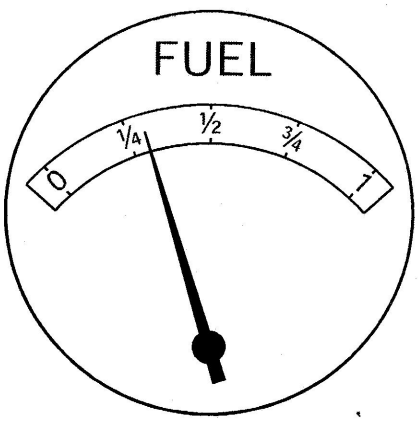


Fig. 1.1

The meter has an analogue scale. The meter reading for different volumes of fuel in the tank is shown in Fig. 1.2.

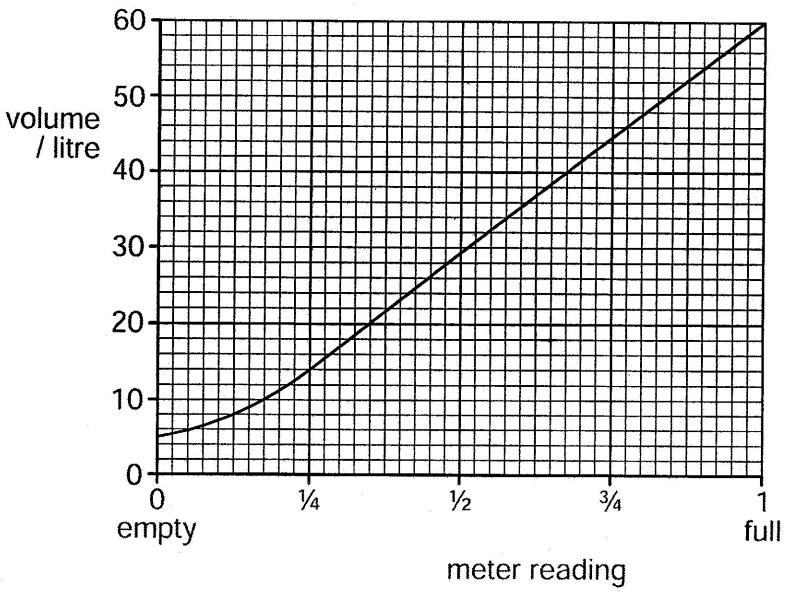


Fig. 1.2

The meter is calibrated in terms of the fraction of the tank that remains filled with fuel.

(a) The car uses 1.0 litre of fuel when travelling 14 km. The car starts a journey with a full tank of fuel.

For Examiner's Use

(i) Calculate the volume of fuel remaining in the tank after a journey of 210 km.

volume = ... litres [2]

(ii) Use your answer to **(i)** and Fig. 1.2 to determine the change in the meter reading during the 210 km journey.

from *full* to ..... [1]

(b) There is a systematic error in the meter.

(i) State the feature of Fig. 1.2 that indicates that there is a systematic error.

.....

..... [1]

(ii) Suggest why, for this meter, it is an advantage to have this systematic error.

.....

..... [1]