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.

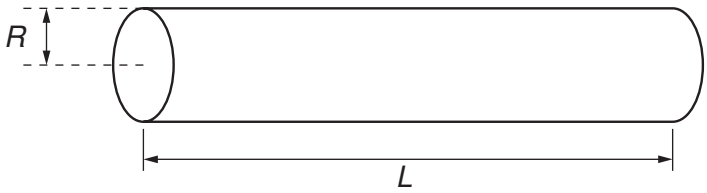

Fig. 1.1

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

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

Calculate the radius of the cylinder, with its uncertainty.

radius = ... ± ..... cm [5]

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

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

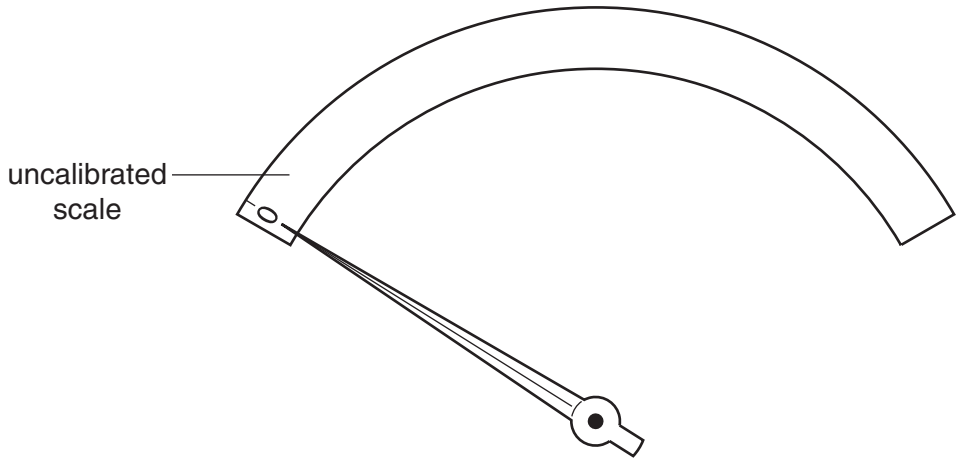

Fig. 1.1

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.

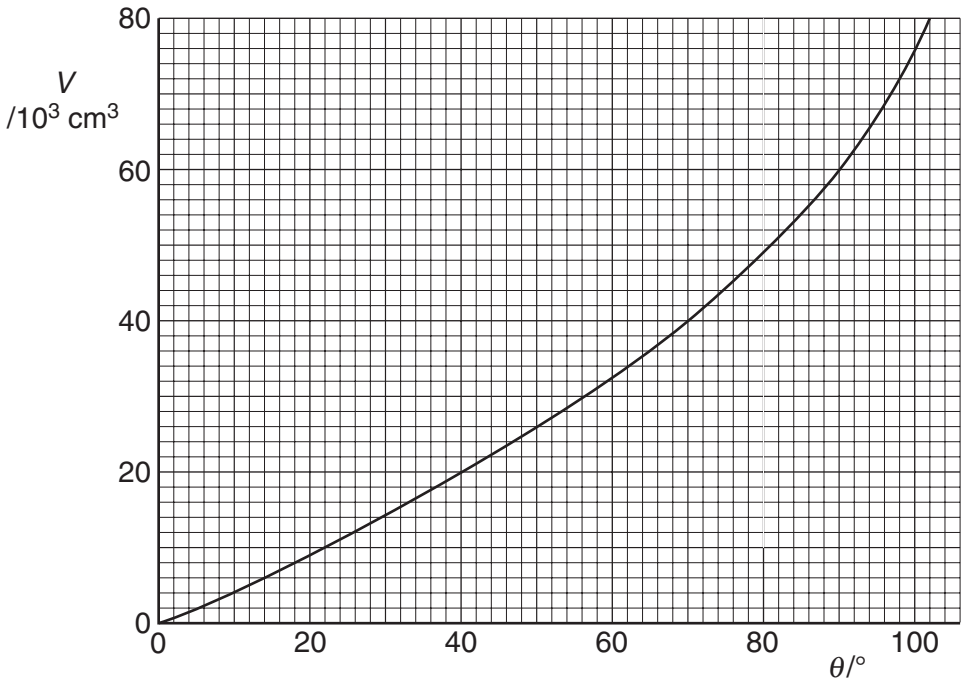

Fig. 1.2

(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.

1 **(a)** Derive the SI base unit of force.

SI base unit of force = ... [1]

(b) A spherical ball of radius r experiences a resistive force F due to the air as it moves through the air at speed v. The resistive force F is given by the expression

$$F = crv,$$

where c is a constant.

Derive the SI base unit of the constant c.

SI base unit of c = ... [1]

(c) The ball is dropped from rest through a height of 4.5 m.

(i) Assuming air resistance to be negligible, calculate the final speed of the ball.

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

(ii) The ball has mass 15 g and radius 1.2 cm.

The numerical value of the constant c in the equation in **(b)** is equal to 3.2×10^{-4} when measured using the SI system of units.

Show quantitatively whether the assumption made in **(i)** is justified.

[3]

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

For Examiner's Use

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

.....

..... [1]

(ii) State the units of pressure in base units.

..... [1]

(b) The pressure p at a depth h in an incompressible fluid of density ρ is given by

$$p = \rho g h,$$

where g is the acceleration of free fall.
Use base units to check the homogeneity of this equation.

.....

.....

.....

..... [3]

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.

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]

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

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

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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.

1 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]

2 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]