Measurements and uncertainties structured questions

1 A source of radio waves sends a pulse towards a reflector . The pulse returns from the reflector and is detected at the same point as the source. The emitted and reflected pulses are recorded on a cathode-ray oscilloscope (c.r.o.) as shown in Fig. 1.1.

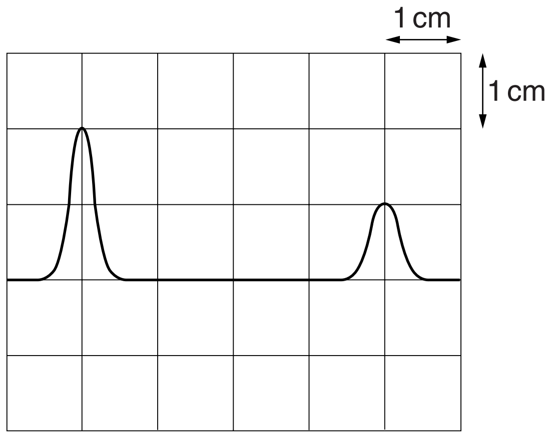

Fig. 1.1

The time-base setting is $0.20\,\mu s\,cm^{-1}$.

(a) Using Fig. 1.1, determine the distance between the source and the reflector.

distance = ... m [4]

(b) Determine the time-base setting required to produce the same separation of pulses on the c.r.o. when sound waves are used instead of radio waves.
The speed of sound is $300\,m\,s^{-1}$.

....

....

....[3]

2 A cylindrical disc is shown in Fig. 2.1.

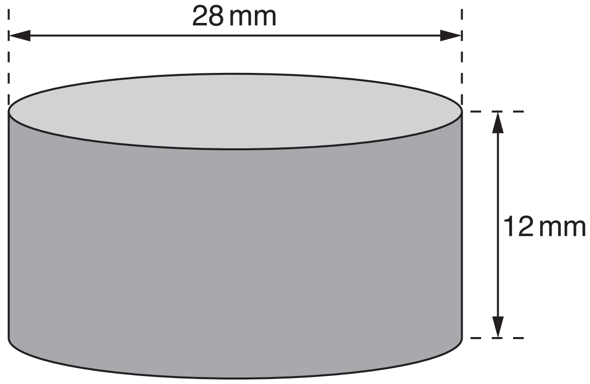

Fig. 2.1

The disc has diameter 28 mm and thickness 12 mm.
The material of the disc has density $6.8 \times 10^3\,\text{kg m}^{-3}$.

Calculate, to two significant figures, the weight of the disc.

weight = ... N [4]

3 The time T for a satellite to orbit the Earth is given by

$$T = \sqrt{\left(\frac{KR^3}{M}\right)}$$

where R is the distance of the satellite from the centre of the Earth,
M is the mass of the Earth,
and K is a constant.

(a) Determine the SI base units of K.

SI base units of K .... [2]

(b) Data for a particular satellite are given in Fig. 3.1.

quantity	measurement	uncertainty
T	8.64×10^4 s	± 0.5%
R	4.23×10^7 m	± 1%
M	6.0×10^{24} kg	± 2%

Fig. 3.1

Calculate K and its actual uncertainty in SI units.

K = ... ± .... SI units [4]

4 A microphone detects a musical note of frequency f. The microphone is connected to a cathode - ray oscilloscope (c.r.o.). The signal from the microphone is observed on the c.r.o. as illustrated in Fig. 4.1.

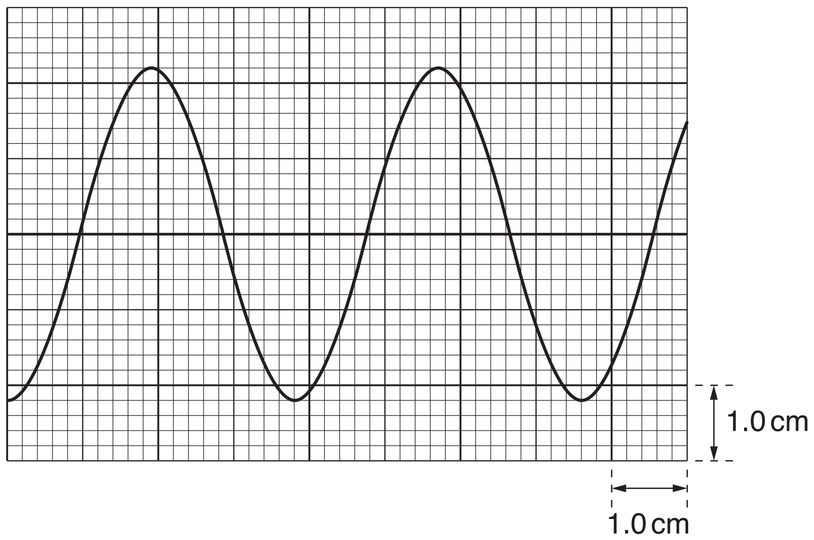

Fig. 4.1

The time-base setting of the c.r.o. is 0.50 ms cm^{-1}. The Y-plate setting is 2.5 mV cm^{-1}.

(a) Use Fig. 4.1 to determine

(i) the amplitude of the signal,

amplitude = ... mV [2]

(ii) the frequency *f*,

f = ... Hz [3]

(iii) the actual uncertainty in *f* caused by reading the scale on the c.r.o.

actual uncertainty = ... Hz [2]

(b) State *f* with its actual uncertainty.

f = ... ± .... Hz [1]

5 A coin is made in the shape of a thin cylinder, as shown in Fig. 5.1.

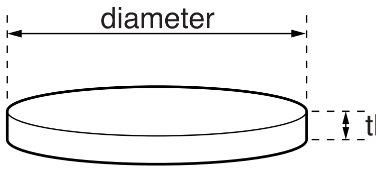

Fig. 5.1

Fig. 5.2 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. 5.2

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

ρ = ... $\mathrm{kg\,m^{-3}}$ [3]

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

percentage uncertainty = ... [3]

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

ρ = ... ± .... $\mathrm{kg\,m^{-3}}$ [1]

6 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. 6.1
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$\frac{V}{t}$ / $10^{-6}\,\mathrm{m^3\,s^{-1}}$	P / $10^3\,\mathrm{N\,m^{-2}}$	r / mm	l / m
1.20 ± 0.01	2.50 ± 0.05	0.75 ± 0.01	0.250 ± 0.001

Fig. 6.1

(a) Calculate the value of C.

C = ... $\mathrm{N\,s\,m^{-2}}$ [2]

(b) Calculate the uncertainty in C.

uncertainty = ... $\mathrm{N\,s\,m^{-2}}$ [3]

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

C = ... ± .... $\mathrm{N\,s\,m^{-2}}$ [1]