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.

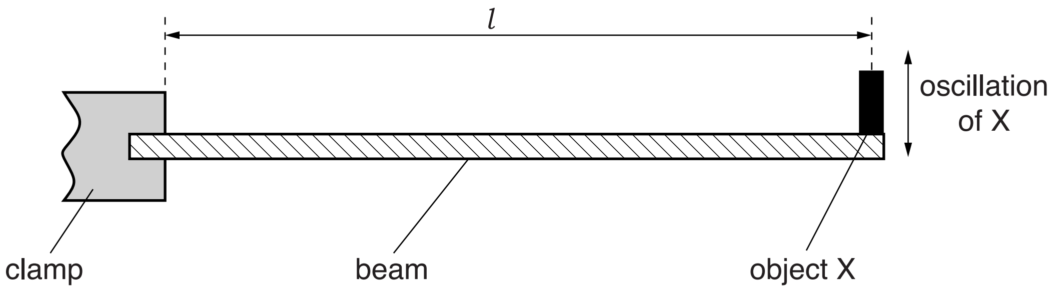

Fig. 1.1

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 $\mathrm{kg\,m^{-1}\,s^{-2}}$.

[1]

2. Determine the SI base units of K.

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

(ii) Data in SI units for the oscillations of X are shown in Fig. 1.2.

quantity	value	uncertainty
T	0.45	± 2.0%
l	0.892	± 0.2%
M	0.2068	± 0.1%
K	1.48×10^5	± 1.5%

Fig. 1.2

Calculate E and its actual uncertainty.

E = ... ± .... $kg\,m^{-1}\,s^{-2}$ [4]

2 The signal from a microwave detector is recorded on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 2.1.

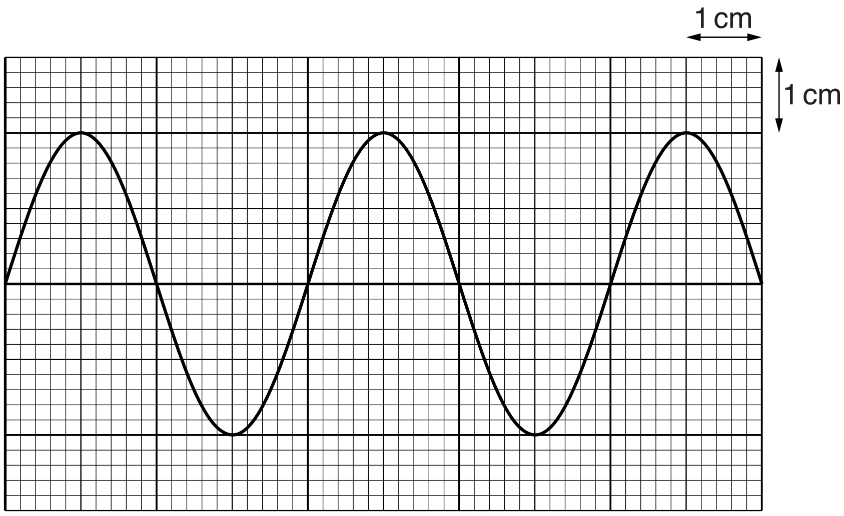

Fig. 2.1

The time-base setting on the c.r.o. is $50\,\text{ps}\,\text{cm}^{-1}$.

(a) Using Fig. 2.1, determine the wavelength of the microwaves.

wavelength = ... m [4]

(b) The signal from a radio wave detector is recorded on the same c.r.o.
The wavelength of the radio waves is 1.5×10^3 m.

Determine the time-base setting required to display the same number of oscillations on the c.r.o. as shown in Fig. 2.1.

time-base setting = ... unit........................ [2]

3 **(a)** An object is moved from point P to point R either by a direct path or by the path P to Q to R, as shown in Fig. 3.1.

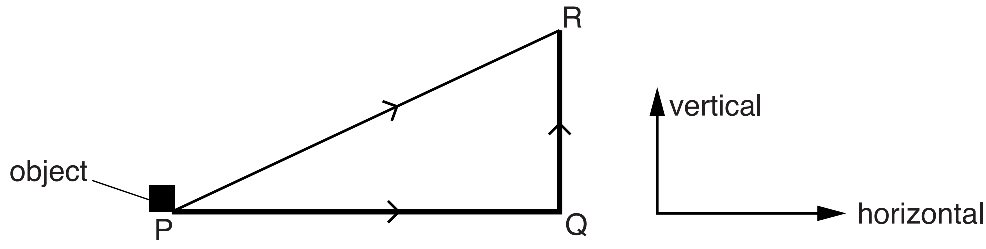

Fig. 3.1

P and Q are on the same horizontal level. R is vertically above Q.

Explain whether the work done moving the object against the gravitational field is the same or different along paths PR and PQR.

....

....

....

....[2]

(b) A ball is thrown with an initial velocity V at an angle θ to the horizontal, as shown in Fig. 3.2.

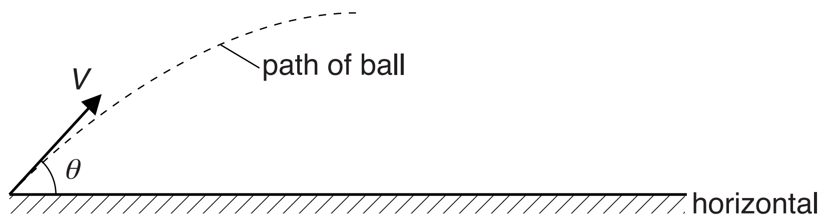

Fig. 3.2 (not to scale)

The variation with time t of the height h of the ball is shown in Fig. 3.3.

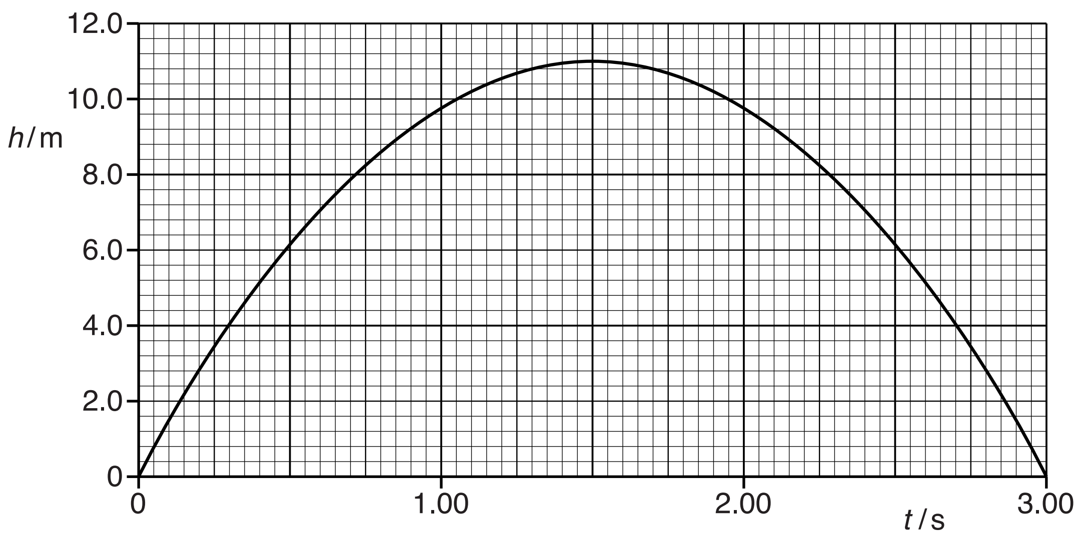

Fig. 3.3

Air resistance is negligible.

(i) the time to reach maximum height to determine the vertical component V_v of the velocity of the ball for time $t = 0$.

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

(ii) The horizontal displacement of the ball at $t = 3.00$ s is 25.5 m.
On Fig. 3.4, draw the variation with t of the horizontal displacement x of the ball.

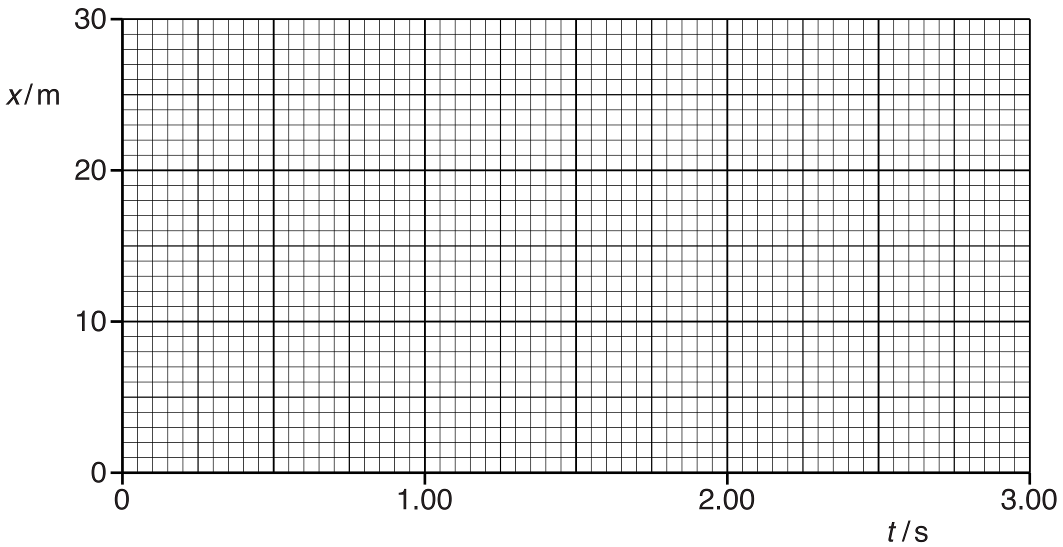

Fig. 3.4

[1]

(iii) the ball at maximum height, calculate the ratio

$$\frac{\text{potential energy of the ball}}{\text{kinetic energy of the ball}}.$$

ratio = ... [3]

(iv) In practice, air resistance is not negligible. State and explain the effect of air resistance on the time taken for the ball to reach maximum height.

....

....

....

....[2]

4 Fig. 4.1 shows a metal cylinder of height 4.5 cm and base area 24 cm^2.

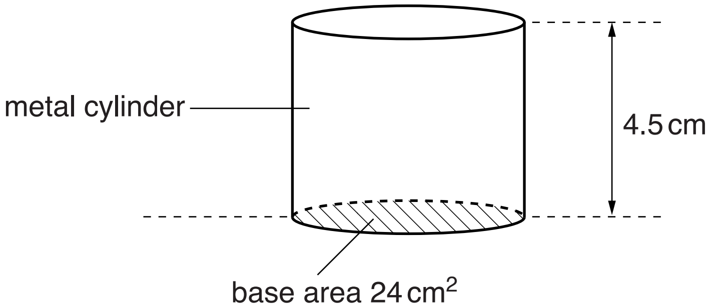

Fig. 4.1

The density of the metal is 7900 kg m^{-3}.

(a) Show that the mass of the cylinder is 0.85 kg.

[2]

(b) The cylinder is placed on a plank, as shown in Fig. 4.2.

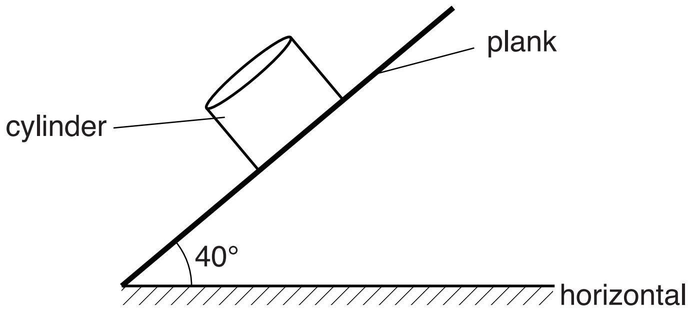

Fig. 4.2

The plank is at an angle of 40° to the horizontal.

Calculate the pressure on the plank due to the cylinder.

pressure = ... Pa [3]

(c) The cylinder then slides down the plank with a constant acceleration of $3.8\,\mathrm{m\,s^{-2}}$.
A constant frictional force *f* acts on the cylinder.

Calculate the frictional force *f*.

f = ... N [3]

5 **(a)** A progressive wave transfers energy. A stationary wave does not transfer energy. State two other differences between progressive waves and stationary waves.

1. ....

....

2. ....

.... [2]

(b) A stationary wave is formed on a stretched string between two fixed points A and B. The variation of the displacement y of particles of the string with distance x along the string for the wave at time $t = 0$ is shown on Fig. 5.1.

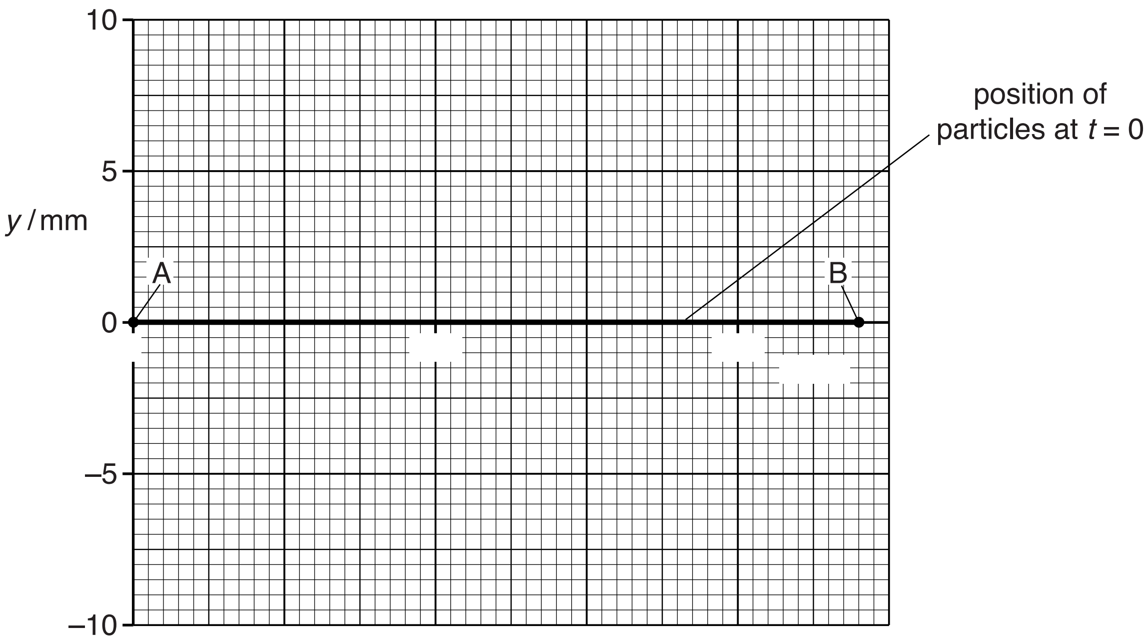

Fig. 5.1

The wave has a period of 20 ms and a wavelength of 1.2 m. The maximum amplitude of the particles of the string is 5.0 mm.

(i) On Fig. 5.1, draw a line to represent the position of the string at $t = 5.0$ ms. [2]

(ii) State the phase difference between the particles of the string at $x = 0.40$ m and at $x = 0.80$ m.

phase difference = ... unit .... [1]

(iii) State and explain the change in the kinetic energy of a particle at an antinode between $t = 0$ and $t = 5.0$ ms. A numerical value is not required.

....

....

....

.... [2]

6 **(a)** Define electromotive force (e.m.f.) for a battery.

....

.... [1]

(b) A battery of e.m.f. 6.0 V and internal resistance 0.50 Ω is connected in series with two resistors X and Y, as shown in Fig. 6.1.

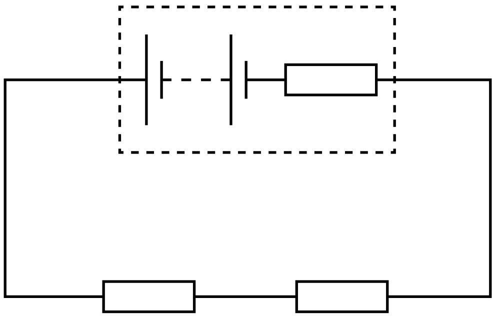

Fig. 6.1

The resistance of X is 4.0 Ω and the resistance of Y is 12 Ω.

Calculate

(i) the current in the circuit,

current = ... A [2]

(ii) the terminal potential difference (p.d.) across the battery.

p.d. = ... V [1]

(c) A resistor Z is now connected in parallel with resistor Y in the circuit in **(b)**. The new arrangement is shown in Fig. 6.2.

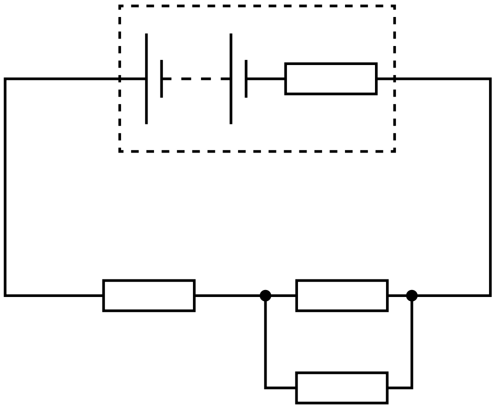

Fig. 6.2

Resistor Y is made from a wire of length l and diameter d. Resistor Z is a wire made from the same material as Y. The length of the wire for Z is $l/2$ and the diameter is $d/2$.

(i) Calculate the resistance R of the combination of resistors Y and Z.

R = ... Ω [3]

(ii) State and explain the effect on the terminal p.d. across the battery.

A numerical value is not required.

....

....

....

.... [2]

(d) the circuits given in **(b)** and **(c)**, show that the ratio

$$\frac{\text{power developed in the external circuit in Fig. 6.1}}{\text{power developed in the external circuit in Fig. 6.2}}$$

is approximately 0.8.

[3]

7 Two parallel, vertical metal plates in a vacuum are connected to a power supply and a switch, as shown in Fig. 7.1.

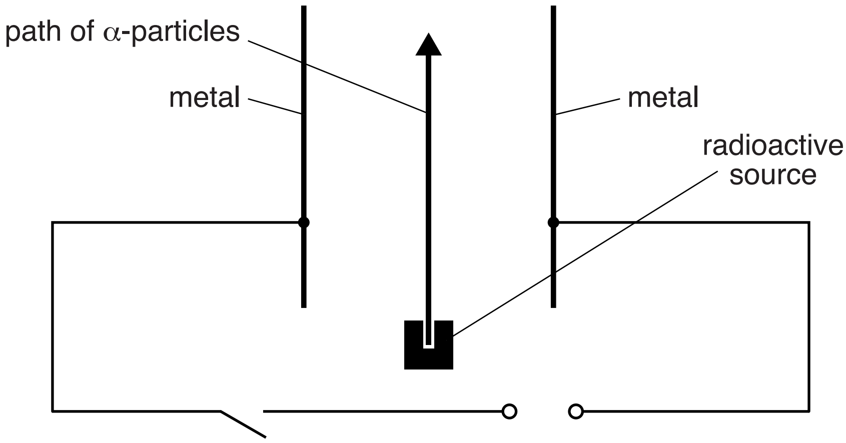

Fig. 7.1

A radioactive source emitting α-particles is placed below the plates. The path of the α-particles is shown on Fig. 7.1. The switch is closed producing a potential difference (p.d.) across the plates. This gives rise to a uniform electric field between the plates.

The separation of the plates is 12 mm.

(a) **(i)** On Fig. 7.1, draw the path of the α-particles. [1]

(ii) Explain why the metal plates are placed in a vacuum.

....

.... [1]

(iii) Calculate the p.d. required to produce an electric field of 140 MV m^{-1}.

p.d. = ... MV [2]

(b) The α-particle source is replaced by a β-particle source. By reference to the properties of α-radiation and β-radiation, suggest three possible differences in the deflection observed with β-particles.

1. ....

....

2. ....

....

3. ....

....
[3]

(c) Complete Fig. 7.2 to show the changes in the proton number *Z* and the nucleon number *A* of different radioactive nuclei when either an α-particle or a β-particle is emitted.

emitted particle	change in *Z*	change in *A*
α-particle		
β-particle		

Fig. 7.2

[1]