1 **(a)** An electromagnetic wave has a wavelength of 85 μm.

(i) State the wavelength, in m, of the wave.

wavelength = ... m [1]

(ii) Calculate the frequency, in THz, of the wave.

frequency = ... THz [2]

(iii) State the name of the region of the electromagnetic spectrum that contains this wave.

.... [1]

(b) The current I in a coil of wire produces a magnetic field. The energy E stored in the magnetic field is given by

$$E = \frac{I^2 L}{2}$$

where L is a constant.

The manufacturer of the coil states that the value of L, in SI base units, is $7.5 \times 10^{-6} \pm 5\%$. The current I in the coil is measured as (0.50 ± 0.02) A.

The values of L and I are used to calculate E.

Determine the percentage uncertainty in the value of E.

percentage uncertainty = ... % [2]

[Total: 6]

2 **(a)** State what is meant by the *centre of gravity* of a body.

....

....

.... [2]

(b) A uniform wooden post AB of weight 45 N stands in equilibrium on hard ground, as shown in Fig. 2.1.

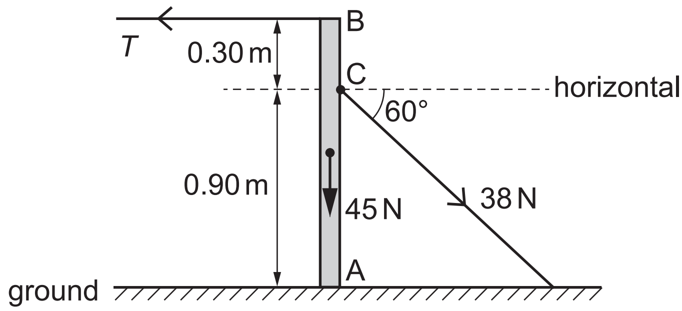

Fig. 2.1 (not to scale)

End A of the vertical post is supported by the ground. A horizontal wire with tension T is attached to end B of the post. Another wire, attached to the post at point C, is at an angle of 60° to the horizontal and has tension 38 N. The distances along the post of points A, B and C are shown in Fig. 2.1.

(i) Calculate the horizontal component of the force exerted on the post by the wire connected to point C.

horizontal component of force = ... N [1]

(ii) By considering moments about end A, determine the tension T.

T = ... N [2]

(iii) Calculate the vertical component of the force exerted on the post at end A.

force = ... N [1]

[Total: 6]

3 A ball is fired horizontally with a speed of $41.0\,\text{m}\,\text{s}^{-1}$ from a stationary cannon at the top of a hill. The ball lands on horizontal ground that is a vertical distance of 57 m below the cannon, as shown in Fig. 3.1.

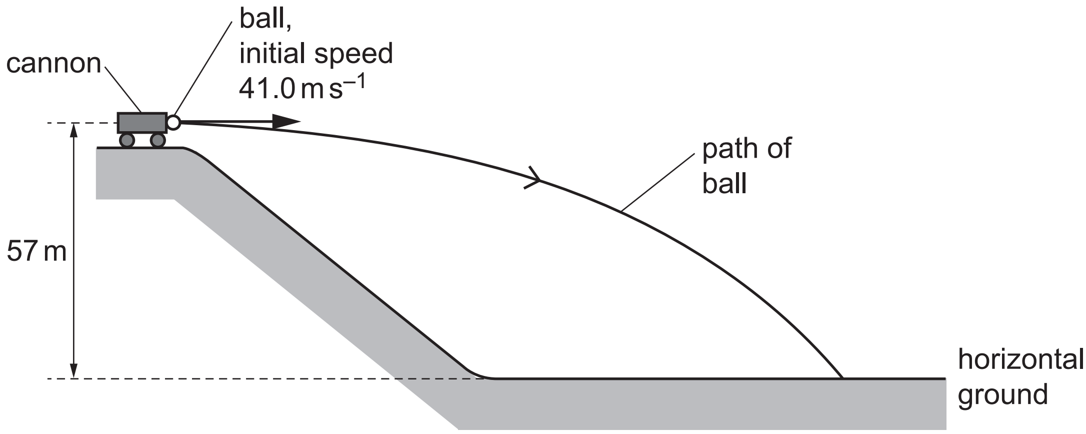

Fig. 3.1 (not to scale)

Assume air resistance is negligible.

(a) Show that the time taken for the ball to reach the ground, after being fired, is 3.4 s.

[2]

(b) Calculate the horizontal distance of the ball from the cannon at the point where the ball lands on the ground.

horizontal distance = ... m [1]

(c) Determine the magnitude of the displacement of the ball from the cannon at the point where the ball lands on the ground.

displacement = ... m [2]

4 **(a)** State Hooke's law.

....

.... [1]

(b) A spring is fixed at one end. A compressive force F is applied to the other end. The variation of the force F with the compression x of the spring is shown in Fig. 4.1.

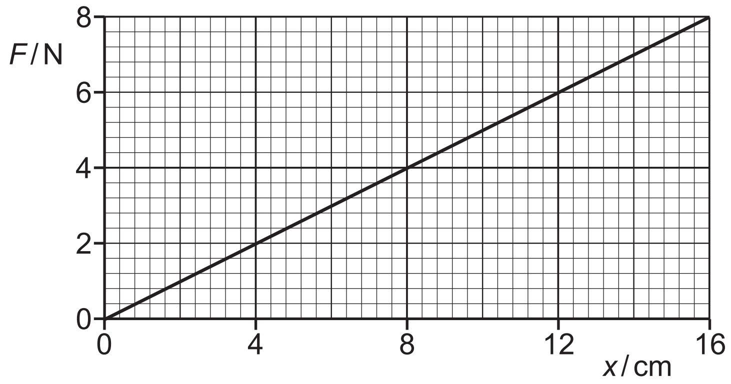

Fig. 4.1

Show that the elastic potential energy of the spring is 0.64 J when its compression is 16.0 cm.

[2]

(c) The spring in **(b)** is used to project a toy car along a track from point X to point Y, as illustrated in Fig. 4.2.

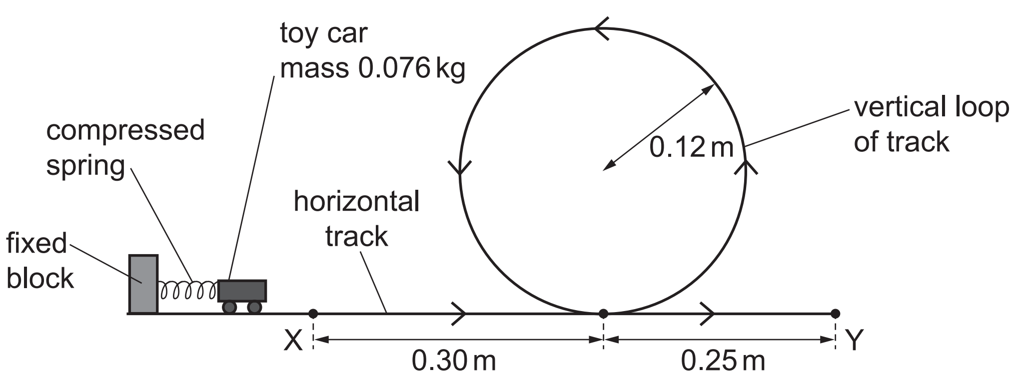

Fig. 4.2 (not to scale)

The spring is initially given a compression of 16.0 cm. The car of mass 0.076 kg is held against one end of the compressed spring. When the spring is released it projects the car forward. The car leaves the spring at point X with kinetic energy that is equal to the initial elastic potential energy of the compressed spring.

5 **(a)** A sound wave is detected by a microphone that is connected to a cathode-ray oscilloscope (CRO). The trace on the screen of the CRO is shown in Fig. 5.1.

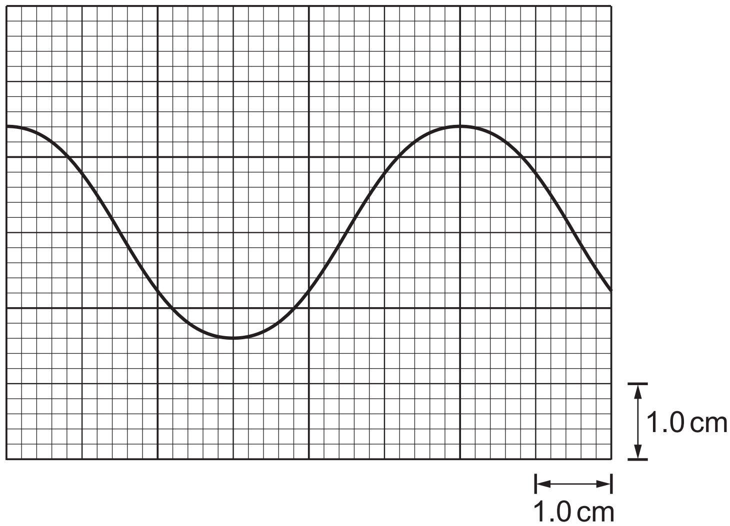

Fig. 5.1

The time-base setting of the CRO is $2.0 \times 10^{-5}\,\mathrm{s\,cm^{-1}}$.

(i) Determine the frequency of the sound wave.

frequency = ... Hz [2]

(ii) The intensity of the sound wave is now doubled. The frequency is unchanged. Assume that the amplitude of the trace is proportional to the amplitude of the sound wave.

On Fig. 5.1, sketch the new trace shown on the screen. [2]

(iii) The time-base is now switched off.

Describe the trace seen on the screen.

....

.... [1]

6 **(a)** Define *electric potential difference* (*p.d.*).

....

.... [1]

(b) A wire of cross-sectional area A is made from metal of resistivity ρ. The wire is extended. Assume that the volume V of the wire remains constant as it extends.

Show that the resistance R of the extending wire is inversely proportional to A^2.

[2]

(c) A battery of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R, as shown in Fig. 6.1.

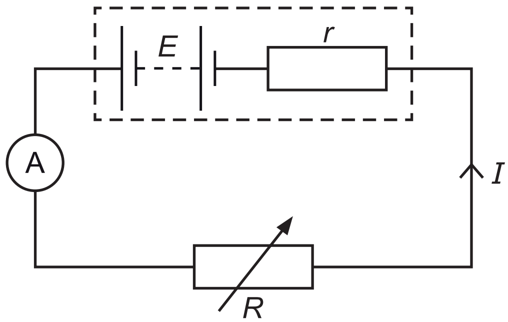

Fig. 6.1

The current in the circuit is I.

Use Kirchhoff's second law to show that

$$R = \left(\frac{E}{I}\right) - r.$$

[1]

7 Two vertical metal plates are separated by a distance d in a vacuum, as shown in Fig. 7.1.

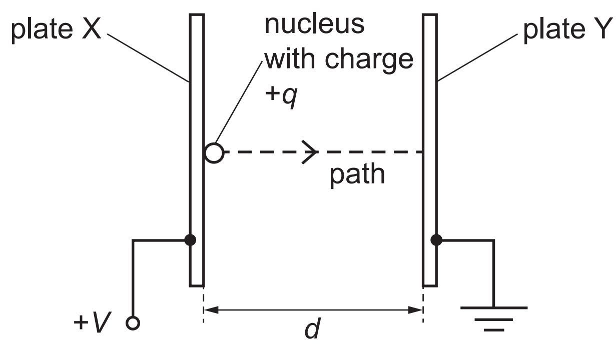

Fig. 7.1 (not to scale)

The potential difference (p.d.) between the plates is V. A nucleus with charge $+q$ is initially at rest on plate X. The nucleus is accelerated by the uniform electric field from plate X along a horizontal path to plate Y.

(a) State expressions, in terms of some or all of d, q and V, for:

(i) the magnitude of the electric field strength

electric field strength = ... [1]

(ii) the magnitude of the electric force acting on the nucleus

force = ... [1]

(iii) the kinetic energy of the nucleus when it reaches plate Y.

kinetic energy = ... [1]

(b) State the change, if any, in the kinetic energy of the nucleus on reaching plate Y when the following separate changes are made.

(i) The distance d is halved, but the p.d. V remains the same.

.... [1]

(ii) The nucleus is replaced by a different nucleus that is an isotope of the original nucleus with fewer neutrons.

.... [1]