1 **(a)** Two forces, with magnitudes 5.0 N and 12 N, act from the same point on an object.
Calculate the magnitude of the resultant force R for the forces acting

(i) in opposite directions,

R = ... N [1]

(ii) at right angles to each other.

R = ... N [1]

(b) An object X rests on a smooth horizontal surface. Two horizontal forces act on X as shown in Fig. 1.1.

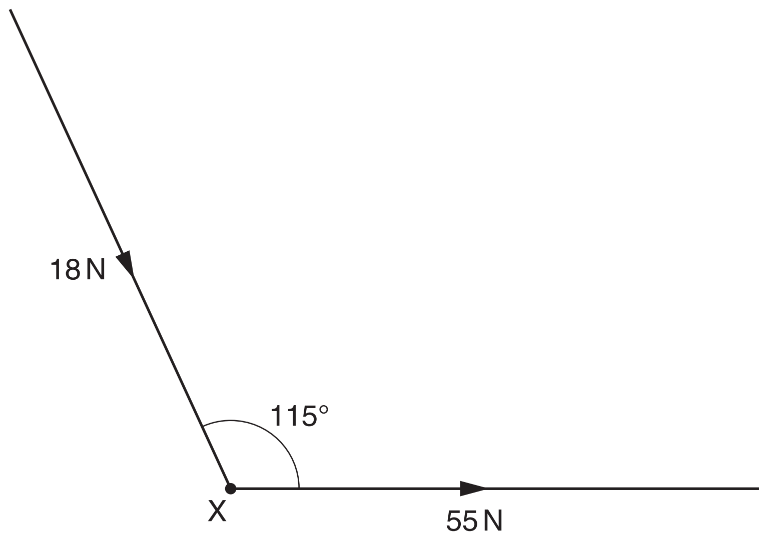

Fig. 1.1 (not to scale)

A force of 55 N is applied to the right. A force of 18 N is applied at an angle of 115° to the direction of the 55 N force.

(i) the resolution of forces or a scale diagram to show that the magnitude of the resultant force acting on X is 65 N.

[2]

(ii) Determine the angle between the resultant force and the 55 N force.

angle = ... ° [2]

(c) A third force of 80 N is now applied to X in the opposite direction to the resultant force in **(b)**.

The mass of X is 2.7 kg.

Calculate the magnitude of the acceleration of X.

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

[Total: 9]

2 **(a)** State Newton's second law of motion.

....

....[1]

(b) A constant resultant force F acts on an object A. The variation with time t of the velocity v for the motion of A is shown in Fig. 2.1.

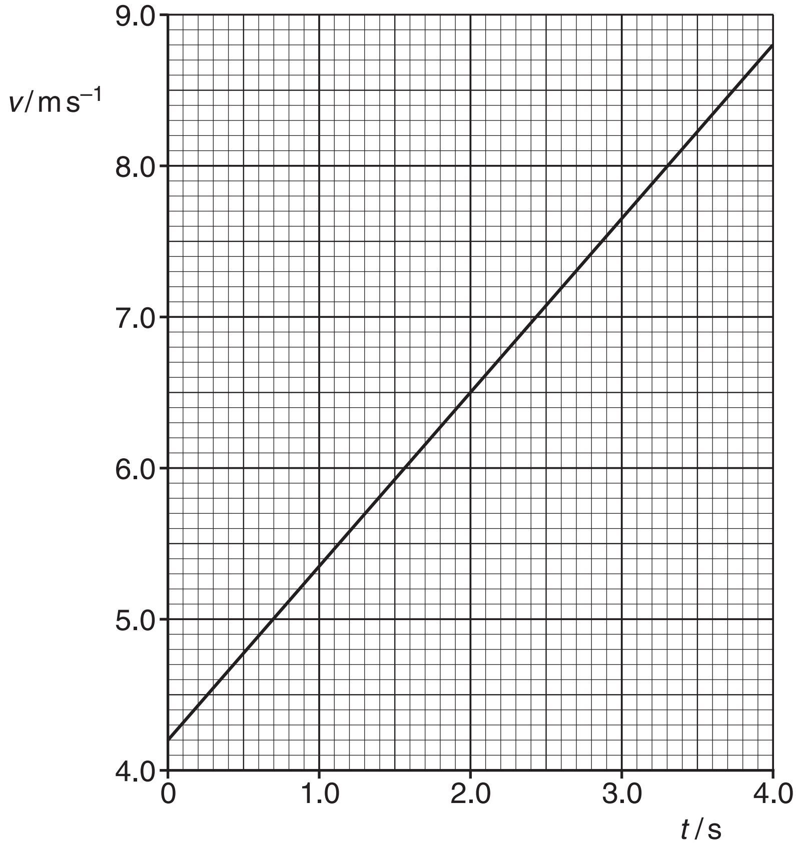

Fig. 2.1

The mass of A is 840 g.

Calculate, for the time $t = 0$ to $t = 4.0$ s,

(i) the change in momentum of A,

change in momentum = ... kg m s^{-1} [2]

(ii) the force F.

F = ... N [1]

(c) The force F is removed at t = 4.0 s. Object A continues at constant velocity before colliding with an object B, as illustrated in Fig. 2.2.

Fig. 2.2

Object B is initially at rest. The mass of B is 730 g.
The objects A and B join together and have a velocity of 4.7 m s^{-1}.

(i) By calculation, show that the changes in momentum of A and of B during the collision are equal and opposite.

[2]

(ii) Explain how the answers obtained in **(i)** support Newton's third law.

....

....

....

....[2]

(iii) By reference to the speeds of A and B, explain whether the collision is elastic.

....

....[1]

[Total: 9]

3 **(a)** Define *electric field strength.*

....

....[1]

(b) An electron is accelerated from point A to point B by a uniform electric field, as illustrated in Fig. 3.1.

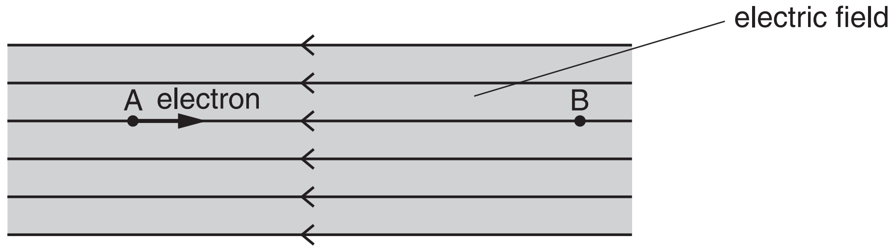

Fig. 3.1

The distance between A and B is 12 mm. The velocity of the electron at A is $2.5\,\mathrm{km\,s^{-1}}$ and at B is $18\,\mathrm{Mm\,s^{-1}}$.

Calculate

(i) the acceleration of the electron,

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

(ii) the change in kinetic energy of the electron,

change in kinetic energy = ... J [3]

(iii) the electric field strength.

electric field strength = ... $V\,m^{-1}$ [3]

(c) An α-particle moves from A to B in the electric field in **(b)**.

Describe and explain how the change in the kinetic energy of the α-particle compares with that of the electron. Numerical values are not required.

....

....

....

....

....[3]

[Total: 12]

4 A spring is supported so that it hangs vertically, as shown in Fig. 4.1.

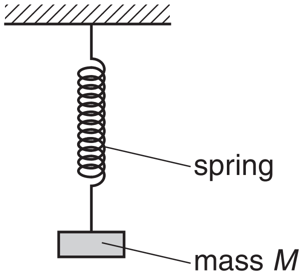

Fig. 4.1

Different masses are attached to the lower end of the spring. The extension x of the spring is measured for each mass M. The variation with x of M is shown in Fig. 4.2.

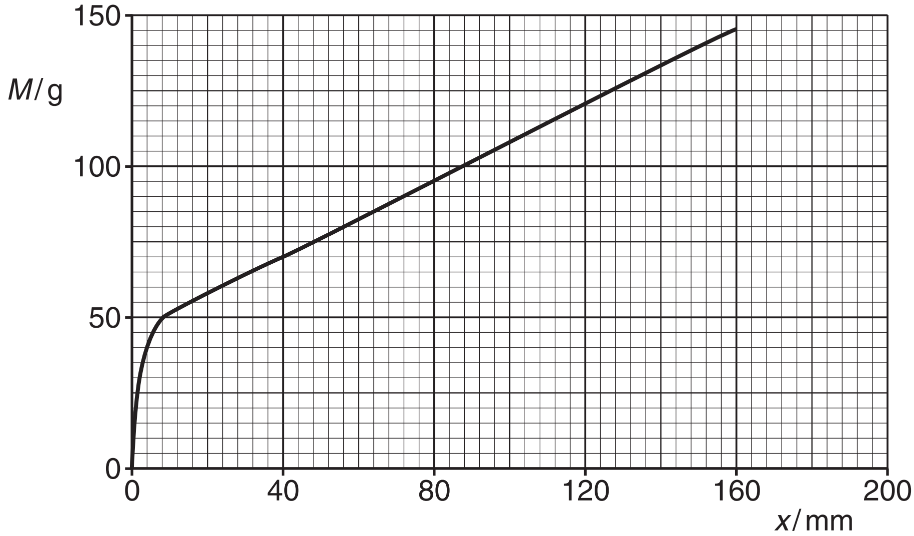

Fig. 4.2

(a) State and explain whether the spring obeys Hooke's law.

....

....[1]

(b) State the form of energy stored in the spring due to the addition of the masses.

....[1]

(c) Describe how to determine whether the extension of the spring is elastic.

....

....[1]

(d) Calculate the work done on the spring as it is extended from $x = 40.0\,\text{mm}$ to $x = 160\,\text{mm}$.

work done = ... J [3]

[Total: 6]

5 **(a)** A diffraction grating is used to determine the wavelength of light.

(i) Describe the diffraction of light at a diffraction grating.

....

....

....[2]

(ii) By reference to interference, explain

1. the zero order maximum,

....

....

....

2. the first order maximum.

....

....

[3]

(b) A diffraction grating is used with different wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of $\sin\theta$ is shown in Fig. 5.1.

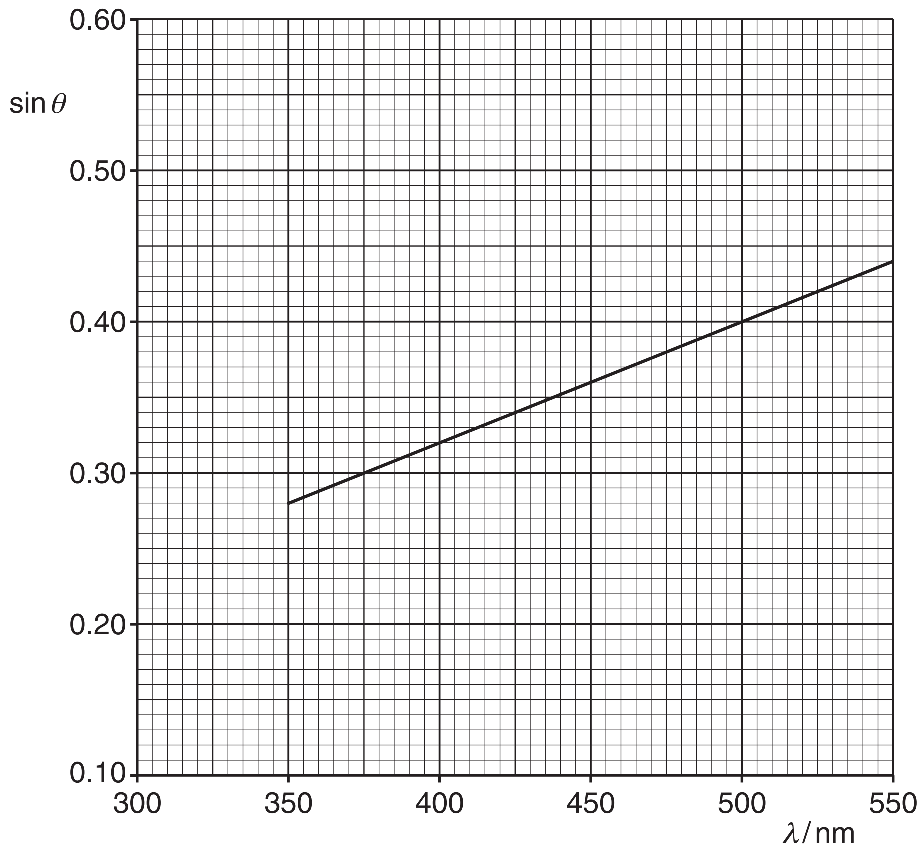

Fig. 5.1

(i) Determine the gradient of the line shown in Fig. 5.1.

gradient = ...[2]

(ii) the gradient determined in **(i)** to calculate the slit separation *d* of the diffraction grating.

d = ...m [2]

(iii) On Fig. 5.1, sketch a line to show the results that would be obtained for the first order maxima. [1]

[Total: 10]

6 **(a)** Describe the I–V characteristic of

(i) a metallic conductor at constant temperature,

....

....[1]

(ii) a semiconductor diode.

....

....

....[2]

(b) Two identical filament lamps are connected in series and then in parallel to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance, as shown in Fig. 6.1a and Fig. 6.1b.

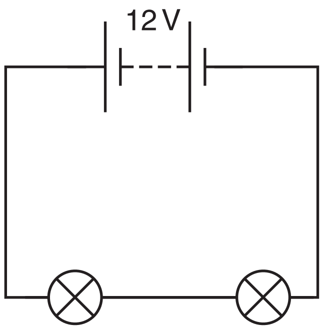

Fig. 6.1a

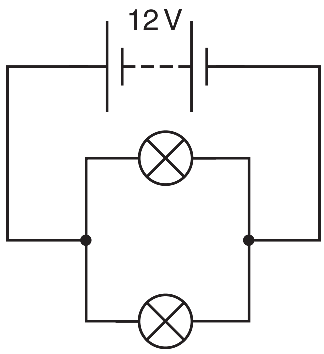

Fig. 6.1b

The I–V characteristic of each lamp is shown in Fig. 6.2.

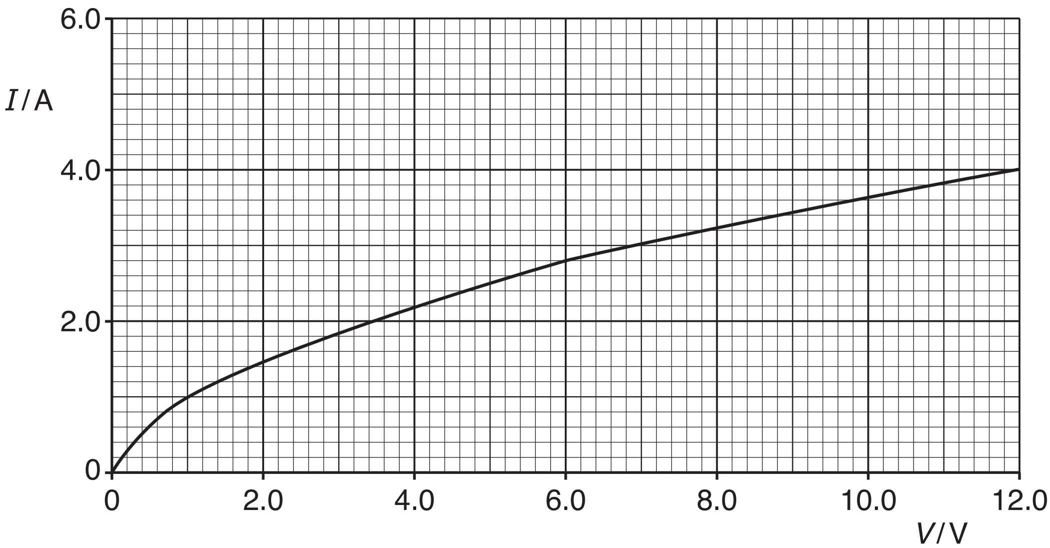

Fig. 6.2

(i) the information shown in Fig. 6.2 to determine the current through the battery in

1. the circuit of Fig. 6.1a,

current = ...A

2. the circuit of Fig. 6.1b.

current = ...A
[3]

(ii) Calculate the total resistance in

1. the circuit of Fig. 6.1a,

resistance = ...Ω

2. the circuit of Fig. 6.1b.

resistance = ...Ω
[3]

(iii) Calculate the ratio

$$\frac{\text{power dissipated in a lamp in the circuit of Fig. 6.1a}}{\text{power dissipated in a lamp in the circuit of Fig. 6.1b}}.$$

ratio = ...[2]

[Total: 11]

7 **(a)** The following particles are used to describe the structure of an atom.

electron neutron proton quark

Underline the fundamental particles in the above list. [1]

(b) The following equation represents the decay of a nucleus of $^{60}_{27}Co$ to form nucleus Q by β^- emission.

$$^{60}_{27}Co \rightarrow {}^{A}_{B}Q + \beta^- + x$$

(i) Complete Fig. 7.1.

	value
A	
B	

Fig. 7.1

[1]

(ii) State the name of the particle x.

....[1]

[Total: 3]