Section B

Answer **one** question from this section in the spaces provided.

8 **(a)** A steel sphere of mass 0.29 kg is suspended in equilibrium from a vertical spring. The centre of the sphere is 8.5 cm from the top of the spring, as shown in Fig. 8.1.

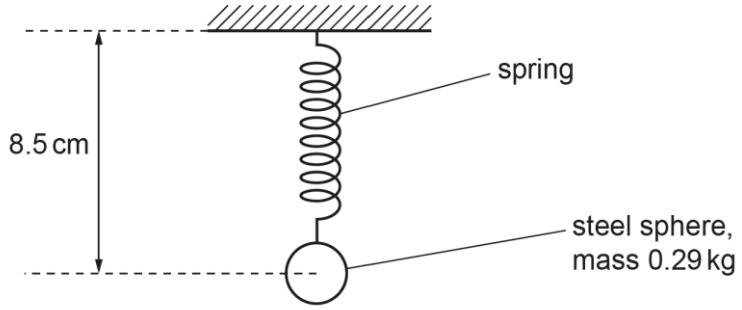

Fig. 8.1

The sphere is now set in motion so that it is moving in a horizontal circle at constant speed, as shown in Fig. 8.2.

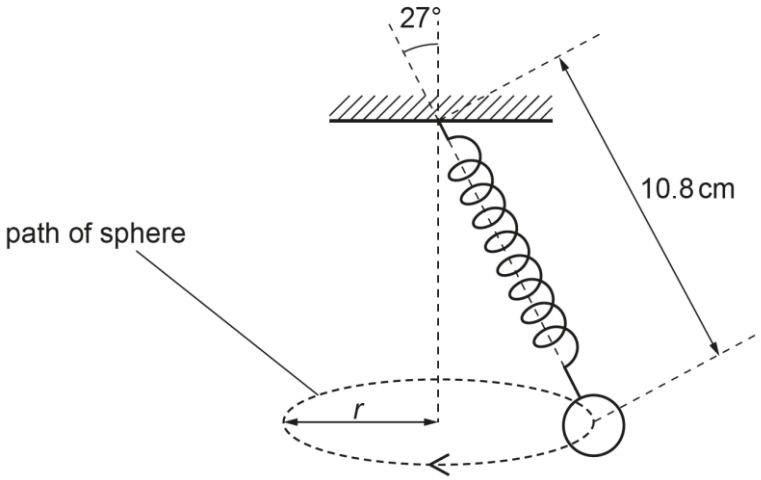

Fig. 8.2

The distance from the centre of the sphere to the top of the spring is now 10.8 cm.

(i) Explain, with reference to the forces acting on the sphere, why the length of the spring in Fig. 8.2 is greater than in Fig. 8.1

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……[3]

(ii) The angle between the linear axis of the spring and vertical is 27°.

1. Show that the radius r of the circle is 4.9 cm.

[1]

2. Show that the tension in the spring is 3.2 N.

[2]

3. The spring obeys Hooke's law.

Calculate the spring constant, in N cm^{-1} of the spring.

spring constant = …… N cm^{-1} [2]

(iii) **1.** Use the information in **a(ii)** to determine the centripetal acceleration of the sphere.

centripetal acceleration = …… m s^{-2} [2]

2. Calculate the period of the circular motion of the sphere.

period = …… s [2]

(b) Two stars A and B have their surfaces separated by a distance of 1.4 x 10^{12} m, as illustrated in Fig. 8.3.

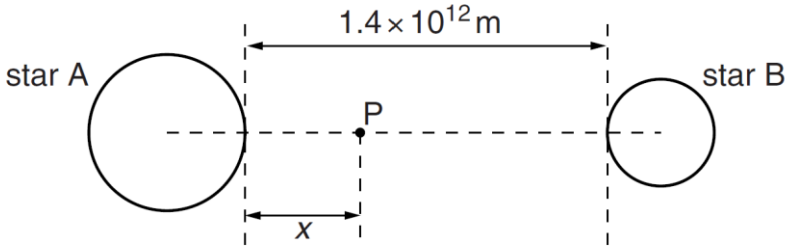

Fig. 8.3

Point P lies on the line joining the centres of the two stars. The distance *x* of point P from the surface of star A may be varied.

The variation with distance *x* of the gravitational potential ϕ at point P is shown in Fig. 8.4.

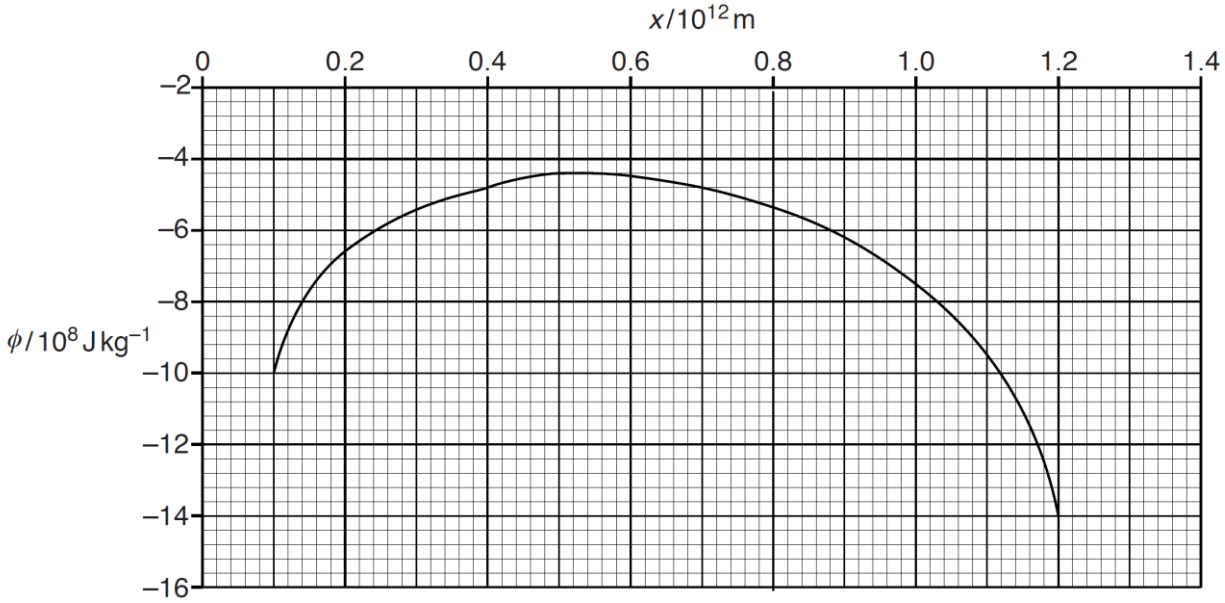

Fig. 8.4

(i) Using Fig. 8.4, state and explain the distance *x* at which the gravitational field strength is zero.

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…… [2]

(ii) A rock of mass 180 kg moves along the line joining the centres of the two stars, from star A towards star B.

1. Use data from Fig. 8.4 to calculate the change in kinetic energy of the rock when it moves from the point where $x = 0.1 \times 10^{12}$ m to the point where $x = 1.2 \times 10^{12}$ m.

State whether this change is an increase or a decrease.

change = …… J

……[3]

2. At a point where $x = 0.1 \times 10^{12}$ m, the speed of the rock is v.

Determine the minimum speed v such that the rock reaches the point where $x = 1.2 \times 10^{12}$ m.

minimum speed = ... m s^{-1} [3]

[Total: 20]