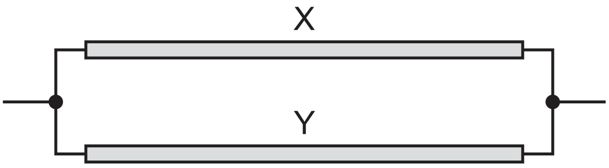
36 Two identical wires X and Y, each of length L and radius r, are connected in parallel as shown.



The total resistance of this combination is R_1.

Wire X is replaced with a wire of the same material with length L and radius $2r$.

The total resistance of the new combination is R_2.

What is the ratio $\dfrac{R_1}{R_2}$?

A $\dfrac{2}{5}$ **B** $\dfrac{2}{3}$ **C** $\dfrac{3}{2}$ **D** $\dfrac{5}{2}$

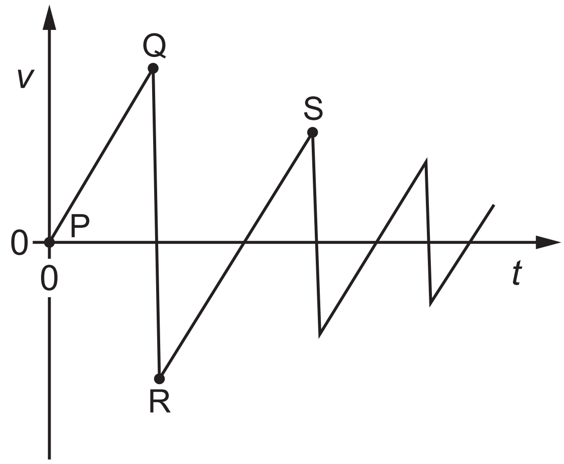
5 A goods train passes through a station at a constant speed of $10\,\mathrm{m\,s^{-1}}$ at time $t = 0$. An express train is at rest at the station. The express train leaves the station with a uniform acceleration of $0.5\,\mathrm{m\,s^{-2}}$ just as the goods train goes past. Both trains move in the same direction on straight, parallel tracks.

At which time t does the express train overtake the goods train?

A 6 s **B** 10 s **C** 20 s **D** 40 s

6 A ball is held above the ground and released. It falls to the ground and bounces several times.

The graph shows the variation with time t of the velocity v of the ball.



Four points on the graph are labelled P, Q, R and S.

Which statement is **not** correct?

A The area under line PQ represents the initial height of the ball.

B The collisions of the ball with the ground are inelastic.

C The gradient of the line RS represents the acceleration due to free fall.

D The maximum upwards velocity of the ball is reached at point P.

10 An object of mass m moving with velocity $9.0\,m\,s^{-1}$ has a head-on elastic collision with a stationary object of mass $2m$.

After the collision, both objects are moving. No external forces act on the system.

What is the velocity of the object of mass $2m$ after the collision?

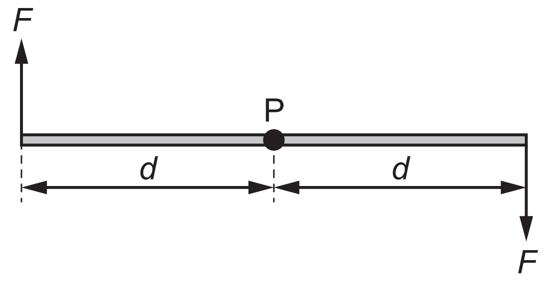
A $-6.0\,m\,s^{-1}$ **B** $-3.0\,m\,s^{-1}$ **C** $4.5\,m\,s^{-1}$ **D** $6.0\,m\,s^{-1}$

12 A rocket has a weight of W and an initial acceleration of a as the rocket leaves the ground vertically. The acceleration of free fall is g.

Which expression gives the initial upward force exerted on the rocket due to the engine?

A $\dfrac{Wa}{g} + W$ **B** $\dfrac{Wa}{g}$ **C** $\dfrac{Wa}{g} - W$ **D** $Wa + W$

14 Two forces, each of magnitude F, act in opposite directions on a rod.



Each force acts on the rod at a distance d from the pivot P.

What is the torque of this couple about P?

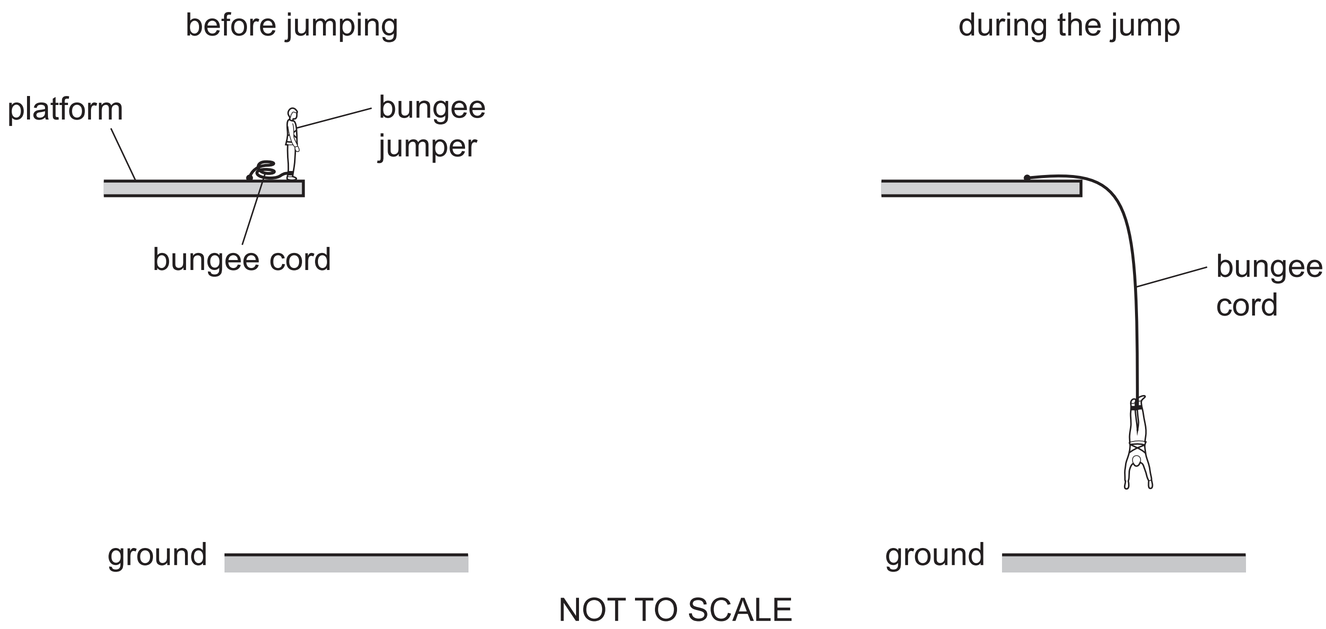
A 0 **B** $F \times d$ **C** $2F \times d$ **D** $2F \times 2d$

15 A man of weight 600 N stands with both feet flat on the ground.

What is a reasonable estimate of the pressure exerted on the ground by the weight of the man?

A 1×10^0 Pa **B** 1×10^2 Pa **C** 1×10^4 Pa **D** 1×10^6 Pa

18 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



When the jumper makes the jump, his initial gravitational potential energy relative to the ground is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

A on the platform before the jump

B on the way down before the cord has started to extend

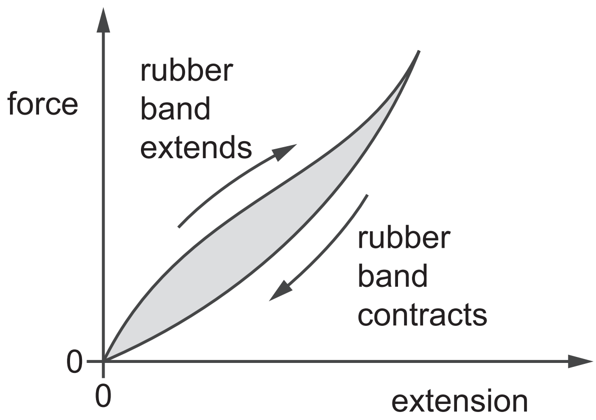
C on the way down as he decelerates

D at the bottom of the jump when he is stationary

22 What are the SI base units of stress?

A $kg\,m\,s^{-2}$ **B** $kg\,m^{-1}\,s^{-2}$ **C** $kg\,m^{-2}\,s^{-2}$ **D** $kg\,m^{-3}\,s^{-2}$

23 The diagram shows a force–extension graph for a rubber band as the band is extended and then the stretching force is decreased to zero.



What can be deduced from the graph?

A The rubber band does **not** return to its original length when the force is decreased to zero.

B The rubber band obeys Hooke's law for the extensions shown.

C The rubber band remains elastic for the extensions shown.

D The shaded area represents the work done in extending the rubber band.

24 Which row is correct for sound waves?

	can travel in a vacuum	can be polarised	can diffract through a gap
A	no	no	yes
B	yes	no	no
C	no	yes	no
D	no	yes	yes

39 The number of electrons in a neutral atom of an isotope of plutonium, ${}^{239}_{94}Pu$, is changed to produce a charged atom (ion) W.

W has an overall charge of $+1.6 \times 10^{-19}$ C.

How many protons, neutrons and electrons are in W?

	protons	neutrons	electrons
A	94	145	93
B	94	145	95
C	238	94	239
D	239	94	238

1 Fig. 1.1 shows a horizontal turntable.

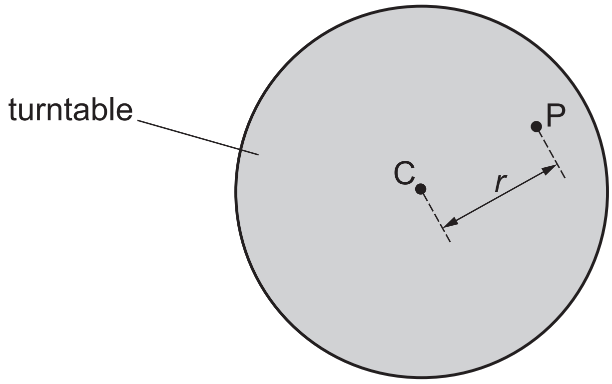


Fig. 1.1

Point C is at the centre of the turntable. Point P is a distance r from the centre.

Fig. 1.2 shows a side view of a d.c. motor attached to the turntable with a belt.

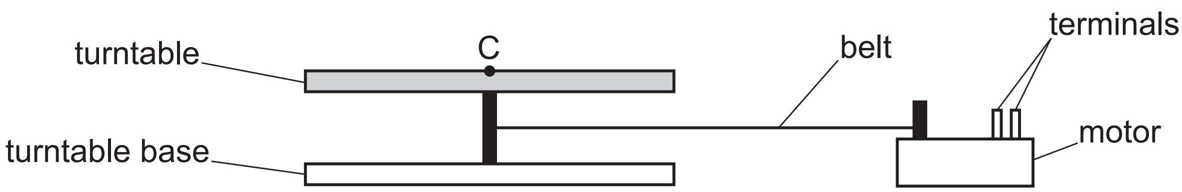


Fig. 1.2

The motor is used to rotate the turntable at frequency f_0. The motor is switched off and the turntable continues to rotate at frequency f_0.

A sphere of adhesive putty of mass m is dropped onto the turntable at point P. The frequency of the turntable is now f.

It is suggested that f is related to m by the relationship

$$\frac{Kf_0}{f} = \beta K + mr^2$$

where β and K are constants.

Plan a laboratory experiment to test the relationship between f and m.

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for β and K.

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

[15]

1 **(a)** State Newton's law of gravitation.

....

....

.... [2]

(b) A planet may be considered as a uniform sphere.

A satellite is in circular orbit of period T around the planet at a height h above the surface. The height of the orbit can be adjusted by use of the satellite's rocket engines.

Fig. 1.1 shows the variation with h of $T^{\frac{2}{3}}$.

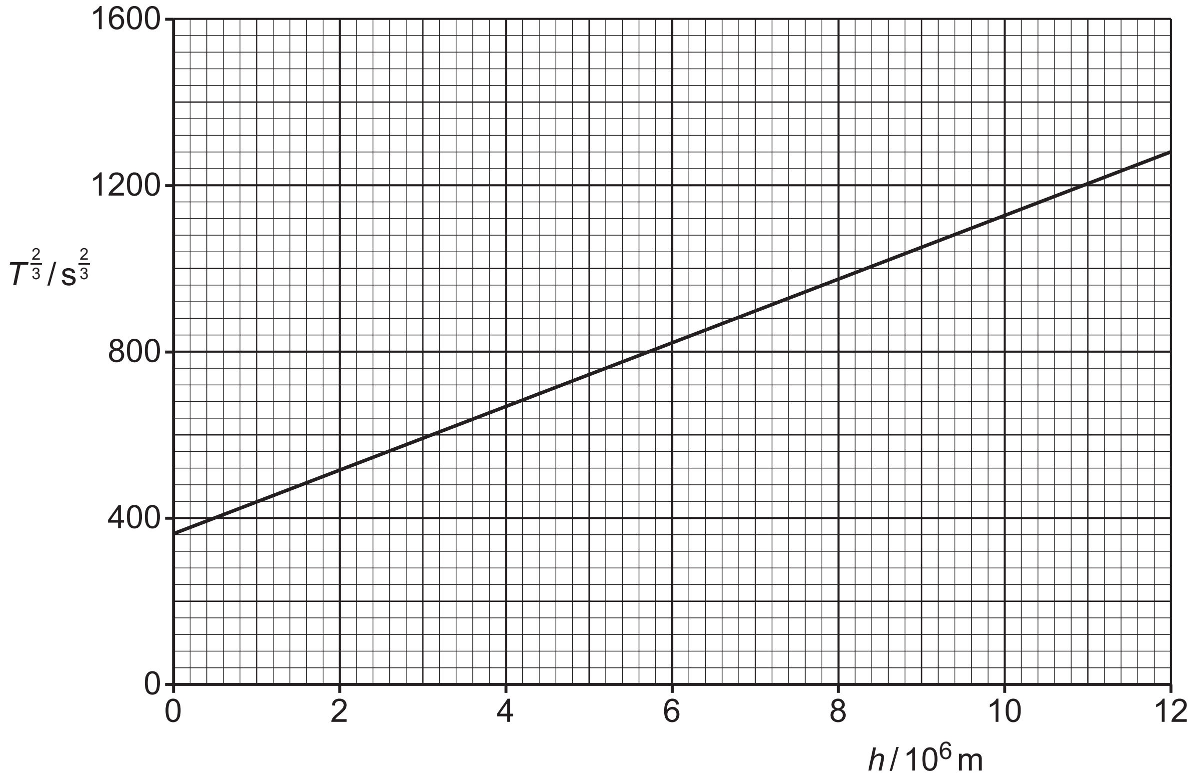


Fig. 1.1

(i) By reference to forces, explain why the orbit of the satellite is circular.

....

....

.... [2]

(ii) Use Newton's law of gravitation to show that h and T are related by

$$(h + B)^3 = \frac{GA}{4\pi^2}T^2$$

where G is the gravitational constant and A and B are constants that depend on the properties of the planet.

[3]

(iii) Use the gradient and intercept of the line in Fig. 1.1 to determine values for A and B. Give units with your answers.

A = ... unit ....

B = ... unit ....

[5]

[Total: 12]

1 **(a)** Define gravitational potential at a point.

....

....

.... [2]

(b) A satellite X, of mass M, orbits a planet at a constant distance $4R$ from the centre of the planet, as shown in Fig. 1.1.

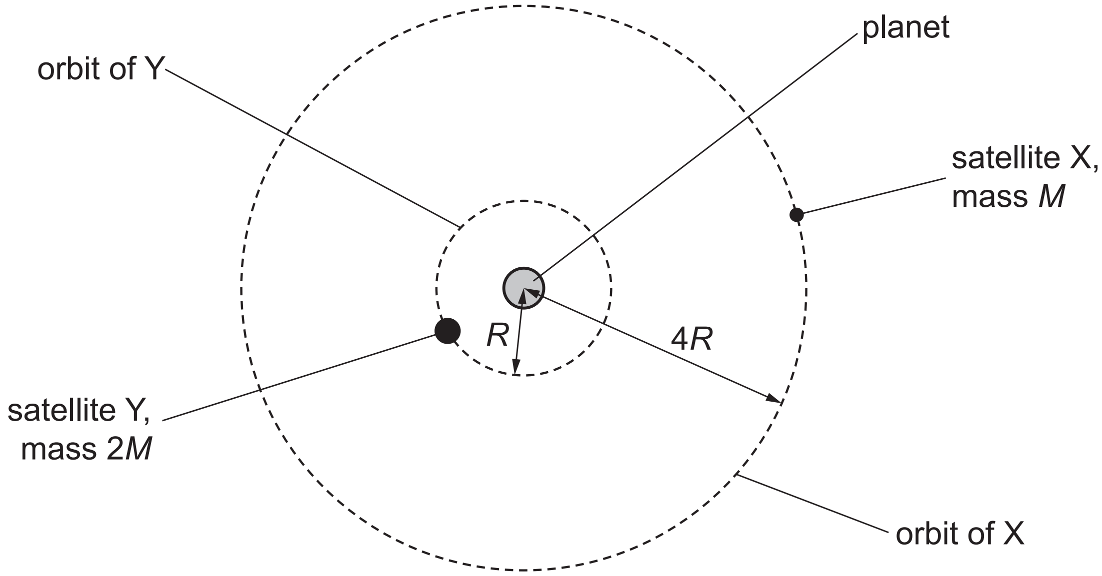


Fig. 1.1 (not to scale)

A second satellite Y, of mass $2M$, orbits the planet with orbital radius R.

The gravitational potential at X due to the planet is $-\Phi$. The planet is a uniform sphere.

(i) Explain why the gravitational potential at X is negative.

....

....

.... [2]

(ii) State an expression, in terms of Φ, for the gravitational potential at Y due to the planet.

gravitational potential = ... [2]

(iii) Complete Table 1.1 by giving expressions, in terms of some or all of M, R and Φ, for the quantities indicated for each of the satellites X and Y.

Table 1.1

	satellite X	satellite Y
gravitational field strength at satellite due to planet		
gravitational potential energy of satellite		

[4]

[Total: 10]

2 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. 2.1.

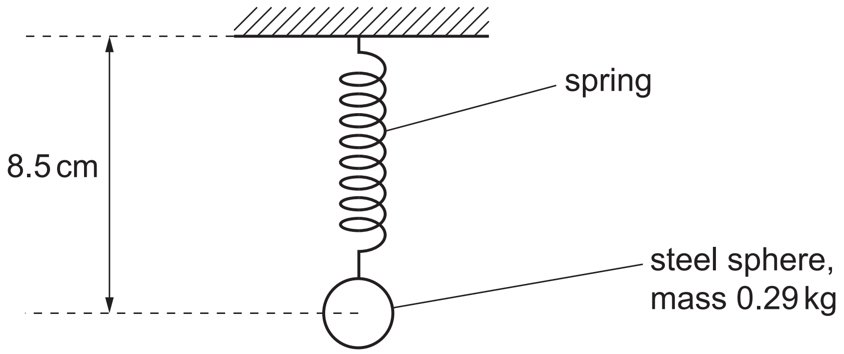


Fig. 2.1

The sphere is now set in motion so that it is moving in a horizontal circle at constant speed, as shown in Fig. 2.2.

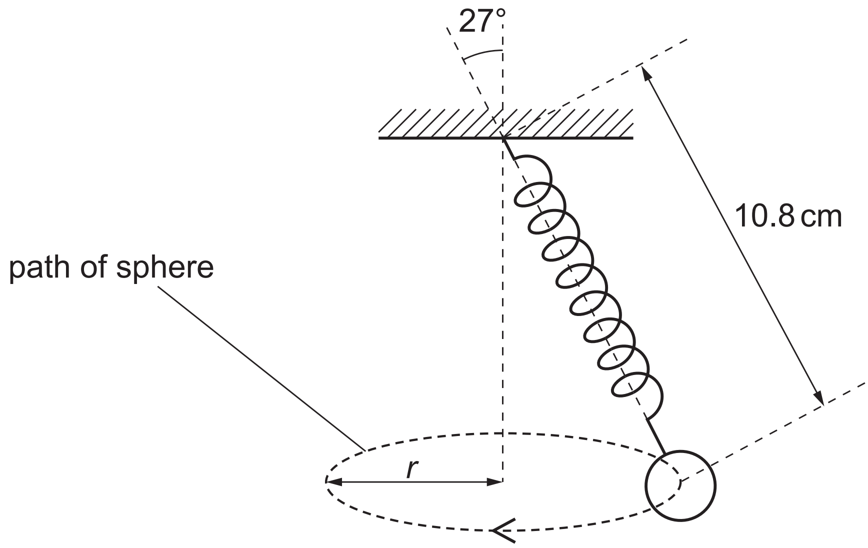


Fig. 2.2

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

(a) Explain, with reference to the forces acting on the sphere, why the length of the spring in Fig. 2.2 is greater than in Fig. 2.1.

....

....

....

....

.... [3]

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

(i) Show that the radius r of the circle is 4.9 cm.

[1]

(ii) Show that the tension in the spring is 3.2 N.

[2]

(iii) The spring obeys Hooke's law.

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

spring constant = ... $N\,cm^{-1}$ [2]

(c) **(i)** Use the information in **(b)** to determine the centripetal acceleration of the sphere.

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

(ii) Calculate the period of the circular motion of the sphere.

period = ... s [2]

[Total: 12]

1 **(a)** Define gravitational potential at a point.

....

....

.... [2]

(b) Artemis is a spherical planet that may be assumed to be isolated in space. The variation with distance x from the centre of Artemis of the gravitational potential ϕ is shown in Fig. 1.1.

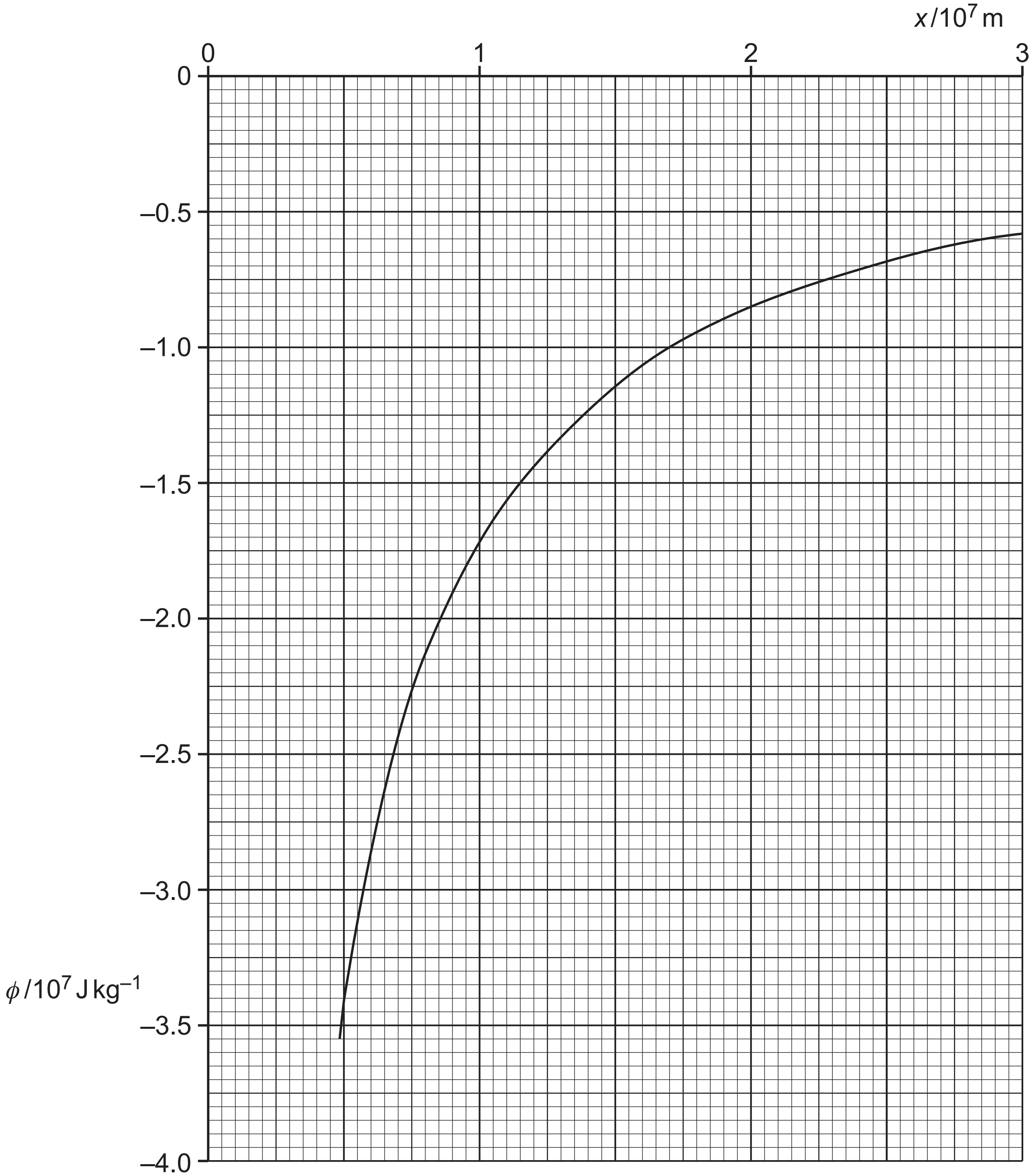


Fig. 1.1

(i) The radius of Artemis is 4800 km.

Determine the value of ϕ on the surface of Artemis.

ϕ = ... $\mathrm{J\,kg^{-1}}$ [1]

(ii) Show that the mass of Artemis is 2.55×10^{24} kg.

[1]

(iii) Calculate the gravitational field strength g on the surface of Artemis.

g = ... $\mathrm{N\,kg^{-1}}$ [2]

(iv) A satellite is in an orbit at a fixed position above a point on the surface of Artemis. The satellite is located above the equator of Artemis at a height above the surface where the gravitational potential is $-0.65 \times 10^{7}\,\mathrm{J\,kg^{-1}}$.

Calculate the period, in hours, of rotation of Artemis.

period = ... hours [4]

(c) State **one** similarity and **one** difference between gravitational potential due to a point mass and electric potential due to a point charge.

similarity ....

....

difference ....

....

[2]

[Total: 12]