

- 1 The Earth may be considered as a uniform sphere of radius $6.37 \times 10^6 \text{ m}$.

Cambridge is at a point on the Earth's surface that has a latitude of 52.2° north of the Equator, as shown in Fig. 1.1.

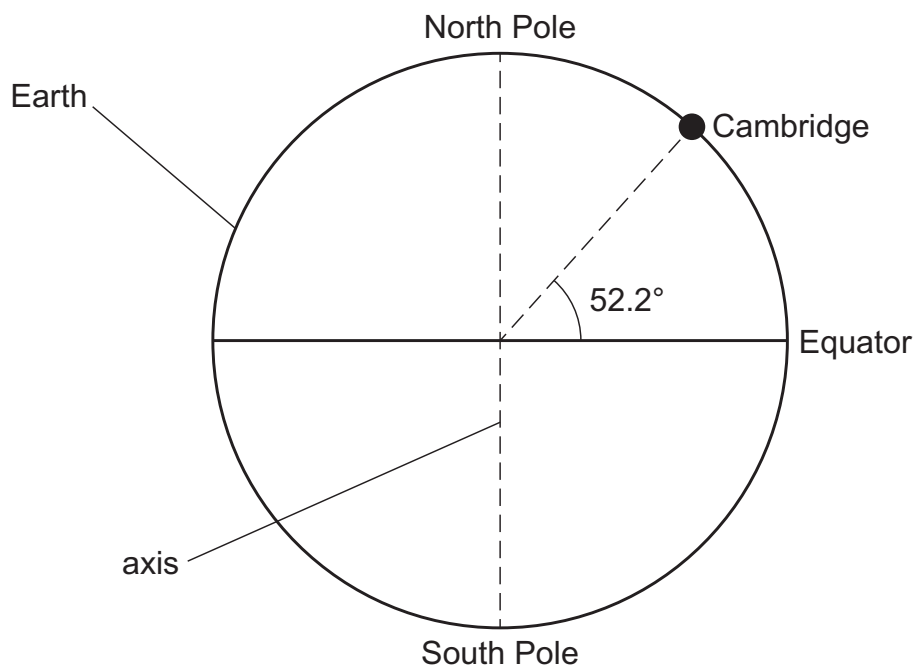


Fig. 1.1

As the Earth spins on its axis, Cambridge moves in a circle that is parallel to the Equator but with a smaller radius.

- (a) (i) Show that the radius of the circle around which Cambridge moves is $3.90 \times 10^6 \text{ m}$.

[1]

- (ii) Calculate the speed at which Cambridge moves around the circle.

speed = ms^{-1} [3]

- (b) A student of mass 58.6 kg stands on horizontal ground in Cambridge.
- (i) Determine the magnitude of the resultant force that acts to cause the circular motion of the student.

resultant force = N [2]

- (ii) On Fig. 1.2, draw an arrow to show the direction of the resultant force that acts on the student.

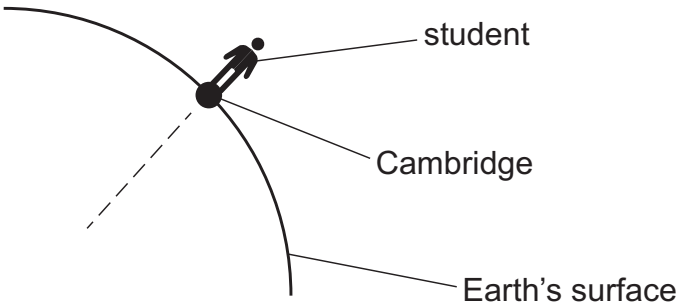


Fig. 1.2 (not to scale)

[1]

- (iii) On Fig. 1.3, draw labelled arrows from the student to show the directions of the forces that act on the student to cause the resultant force in (b)(ii).

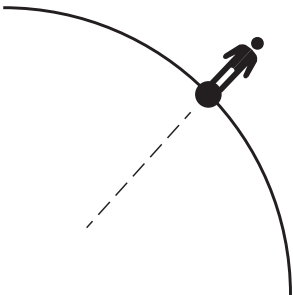


Fig. 1.3 (not to scale)

[2]

[Total: 9]

3 (a) Define gravitational field at a point.

.....
 [1]

(b) Fig. 3.1 shows an isolated point mass of mass M .

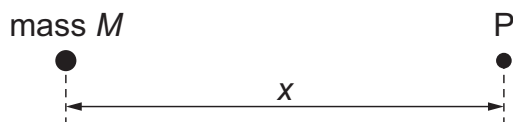


Fig. 3.1

Point P is at distance x from the point mass.

(i) By considering the force exerted by the point mass on a test mass of mass m placed at P, derive an equation for the gravitational field strength g at P, in terms of M and x . Identify any other symbols you use.

[2]

(ii) On Fig. 3.1, draw an arrow to indicate the direction of the gravitational field at P. [1]

(iii) Point Q is at distance $\frac{x}{2}$ from the point mass, on the opposite side of the mass from P, as shown in Fig. 3.2.



Fig. 3.2

Compare the gravitational field at Q with that at P.

.....

 [2]

- (c) Two identical isolated uniform spheres X and Y each have radius R . The centres of the spheres are separated by distance L , as shown in Fig. 3.3.

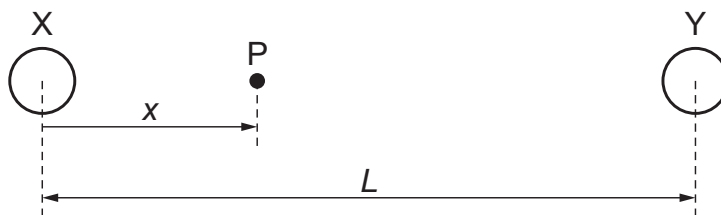


Fig. 3.3

Point P lies on the line joining the centres of X and Y, and is at a variable displacement x from the centre of sphere X.

The gravitational field strength at the surface of each sphere is g_0 .

On Fig. 3.4, sketch the variation with x of the gravitational field g at point P between $x = R$ and $x = L - R$.

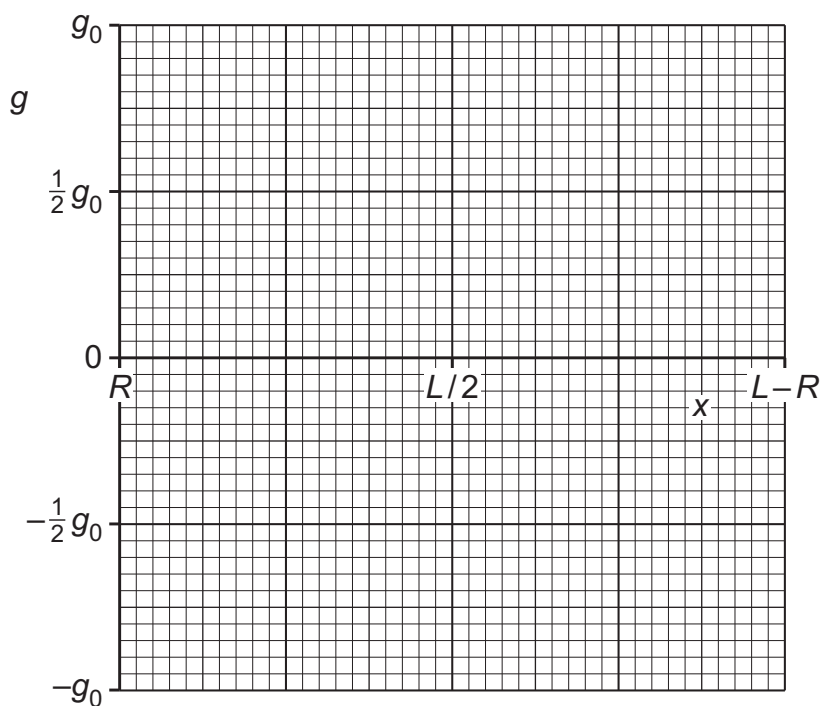


Fig. 3.4

[3]

[Total: 9]

1 (a) Define gravitational potential at a point.

.....

.....

..... [2]

(b) Mars is a planet that may be considered to be an isolated uniform sphere of radius $3.4 \times 10^6 \text{ m}$.

A satellite of mass 122 kg is in orbit around Mars at a constant height of $1.7 \times 10^6 \text{ m}$ above the surface of the planet.

The height of the orbit is increased to $6.8 \times 10^6 \text{ m}$ above the surface. This increases the gravitational potential energy of the satellite by $5.1 \times 10^8 \text{ J}$.

(i) Show that the mass of Mars is $6.4 \times 10^{23} \text{ kg}$.

[3]

(ii) Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

$\phi =$ unit [2]

(c) The satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

(i) The orbit has a period of 25 hours.

State what can be deduced from this about the rotation of Mars on its axis.

.....

..... [1]

(ii) State **one** other feature of this orbit.

.....

..... [1]

[Total: 9]

- 2 (a) The magnitude of the gravitational potential on the surface of a planet of radius R is ϕ . The planet can be considered to be an isolated sphere.

On Fig. 2.1, sketch the variation of the gravitational potential with distance x from the centre of the planet for values of x between R and $4R$.

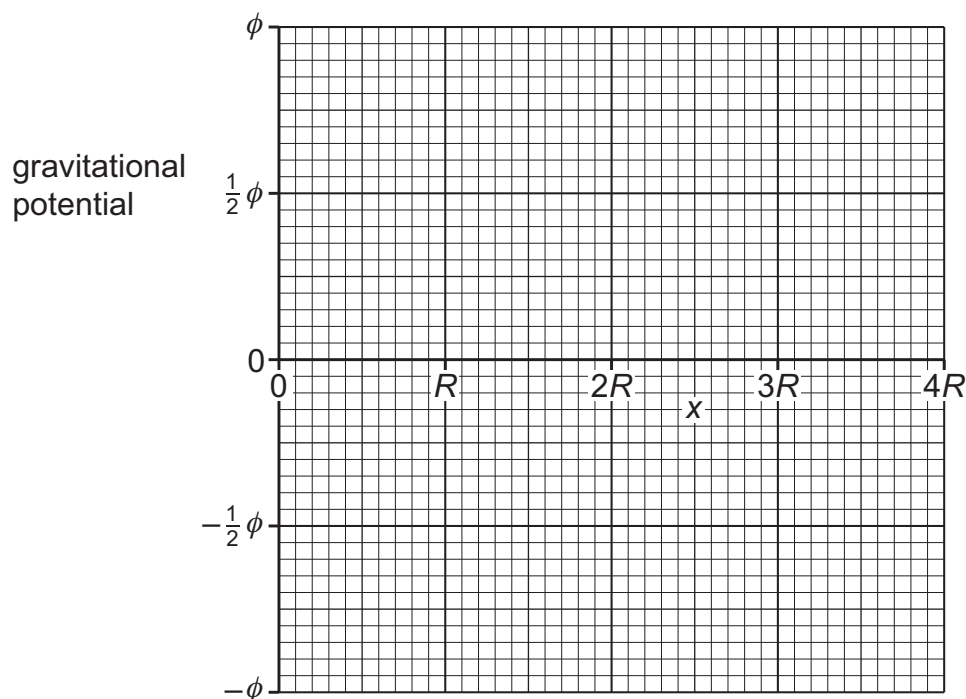


Fig. 2.1

[3]

- (b) A satellite is in a geostationary orbit above the Earth. At time $t = 0$, the magnitude of the gravitational potential due to the Earth at the location of the satellite is ϕ .

On Fig. 2.2, sketch the variation of the gravitational potential due to the Earth at the location of the satellite for values of t between $t = 0$ and $t = 24$ hours.

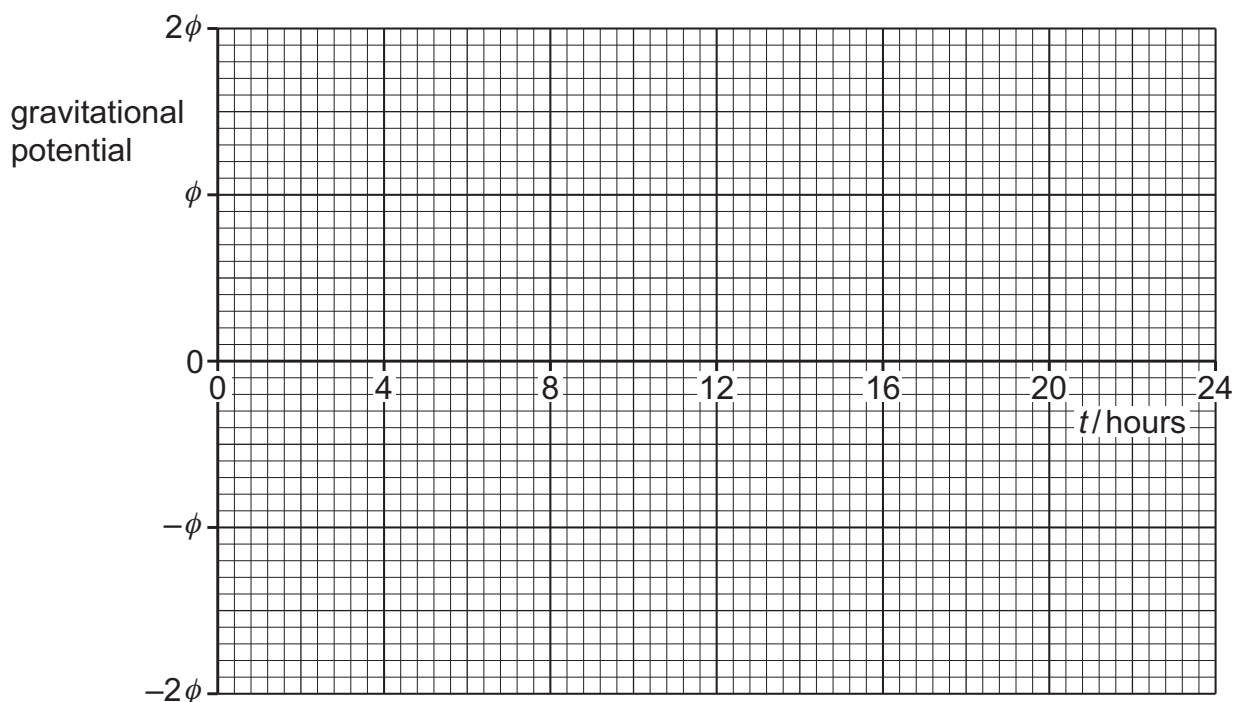


Fig. 2.2

[2]

(c) The electric potential difference (p.d.) between two parallel plates is V , as shown in Fig. 2.3.

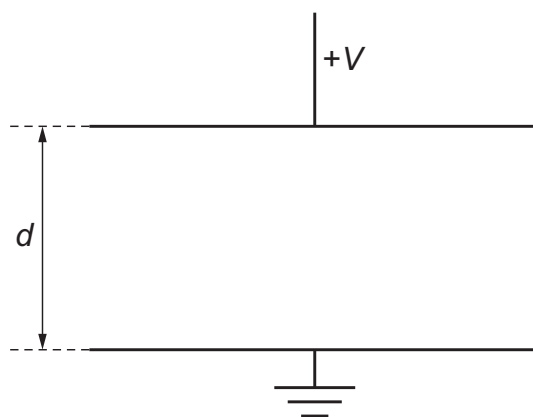


Fig. 2.3

The distance between the plates is d . The region between the plates is a vacuum.

On Fig. 2.4, sketch the variation of the electric potential with distance from the positive plate.

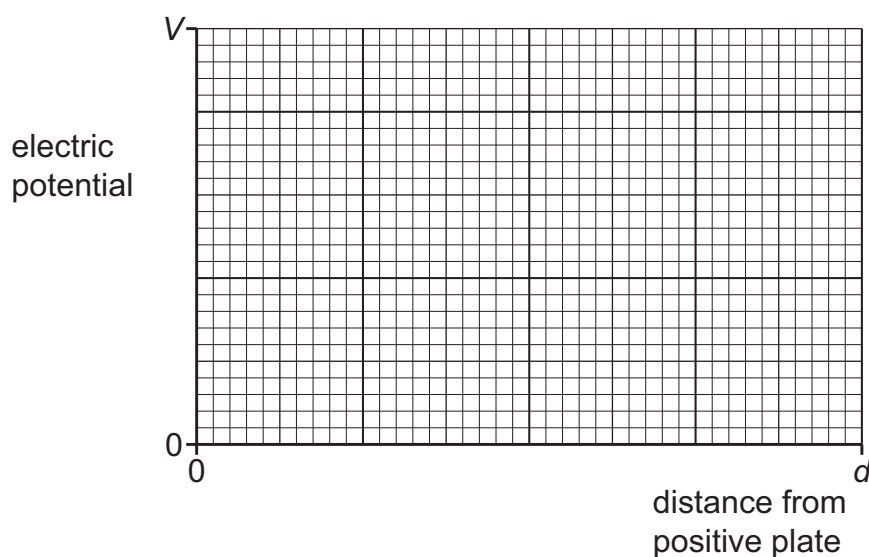


Fig. 2.4

[2]

[Total: 7]