

3 (a) Define gravitational field at a point.

.....
 [1]

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

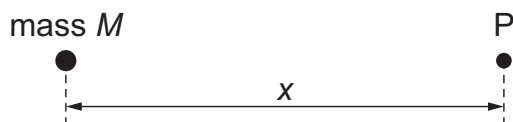


Fig. 3.1

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.

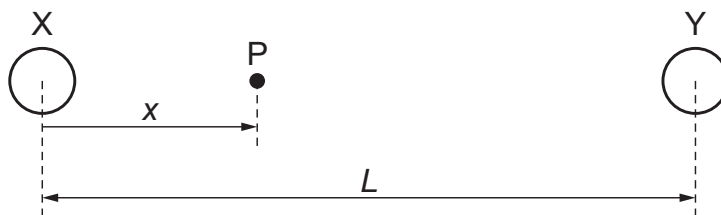


Fig. 3.3

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 $x = L - R$.

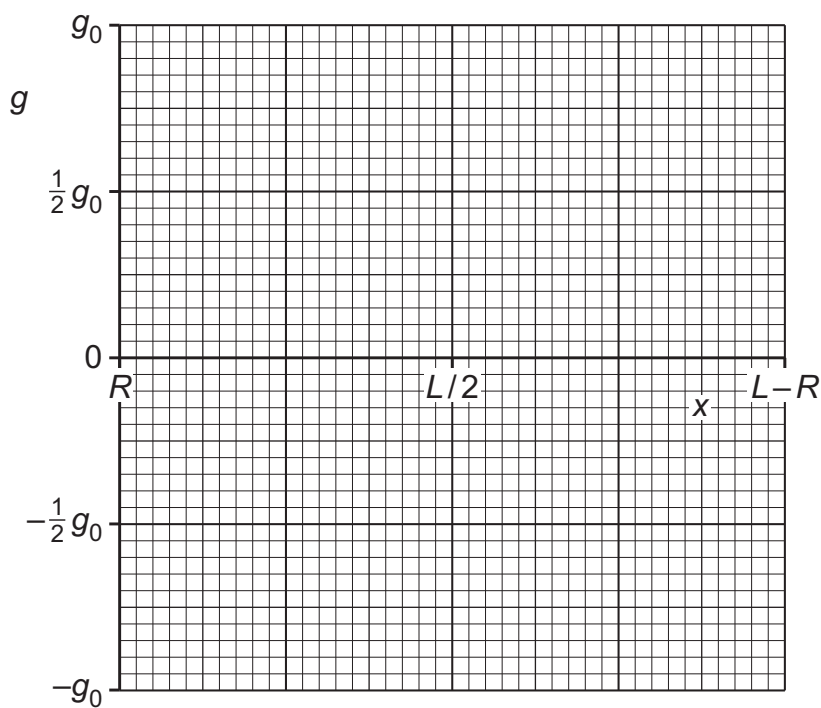


Fig. 3.4

[3]

[Total: 9]

1 (a) Define gravitational field.

.....
..... [1]

(b) The gravitational field strength g at a distance x from the centre of a uniform spherical planet of mass M is given by the expression

$$g = \frac{GM}{x^2}$$

where G is the gravitational constant and distance x is greater than the radius of the planet.

(i) Describe the pattern of the field lines outside the planet that represent the gravitational field due to the planet.

.....
.....
..... [2]

(ii) Explain why, for small changes in vertical height near the surface of the planet, g may be assumed to be constant.

.....
.....
..... [2]

(c) Assume that the Earth is a uniform sphere. For the Earth, the product GM is equal to $3.99 \times 10^{14} \text{m}^3 \text{s}^{-2}$.

(i) Determine a value, to three significant figures, for the radius R of the Earth.

$R =$ m [2]

(ii) Calculate the gravitational potential at the Earth’s surface. Give a unit with your answer.

gravitational potential = unit [2]

(d) Explain why the gravitational potential energy of two point masses is always negative.

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..... [2]

[Total: 11]

- 1 (a) (i) State what is indicated by the direction of the gravitational field line at a point in a gravitational field.

.....
..... [1]

- (ii) Explain, with reference to gravitational field lines, why the gravitational field near the surface of the Earth is approximately constant for small changes in height.

.....
.....
..... [2]

- (b) A large isolated uniform sphere has mass M and radius R .

Point P lies on a straight line passing through the centre of the sphere, at a variable displacement x from the centre, as shown in Fig. 1.1.

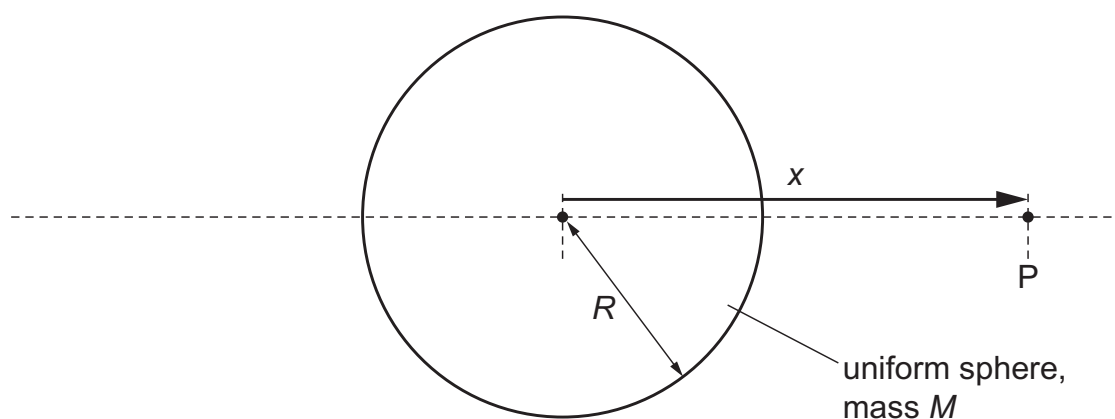


Fig. 1.1

Fig. 1.2 shows the variation with x of the gravitational field g at point P due to the sphere for the values of x for which P is inside the sphere.

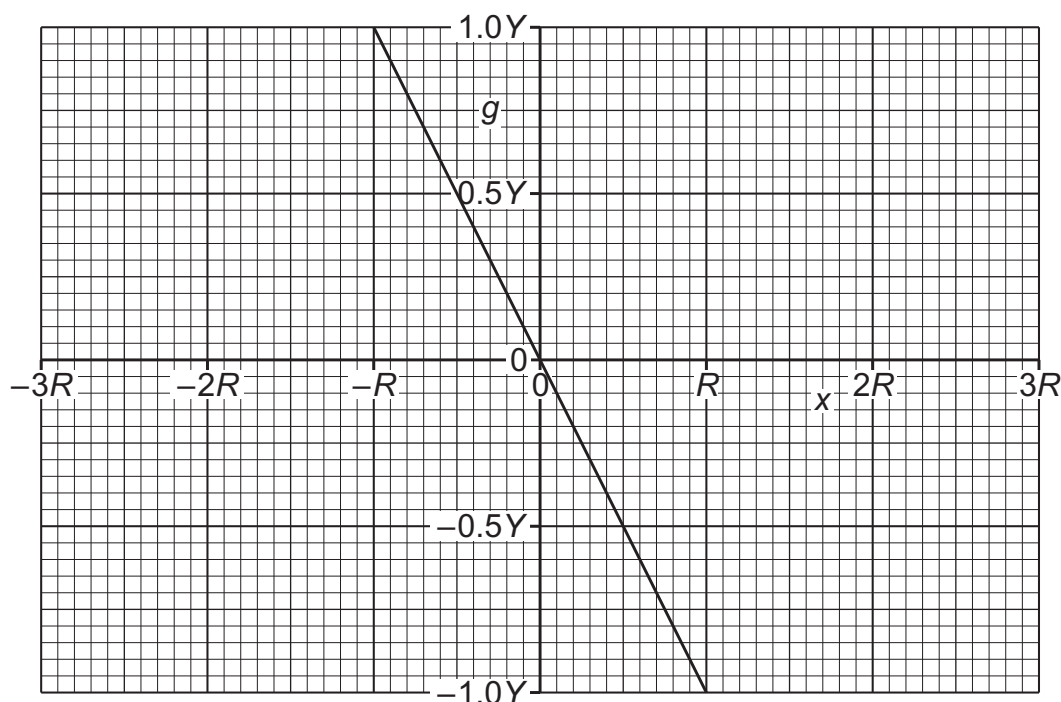


Fig. 1.2

The magnitude of the gravitational field at the surface of the sphere is Y .

- (i) Determine an expression for Y in terms of M and R . Identify any other symbols that you use.

[2]

- (ii) Explain why, at the surface of the sphere, g always has the opposite sign to x .

.....
.....
..... [2]

- (iii) Complete Fig. 1.2 to show the variation of g with x for values of x , up to $\pm 3R$, for which point P is outside the sphere.

[3]

[Total: 10]