

3 (a) Define gravitational field at a point.

.....
 [1]

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

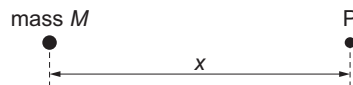


Fig. 3.1

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.

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 [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.

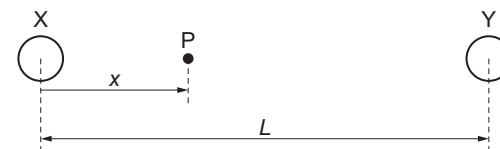


Fig. 3.3

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 $x = L - R$.

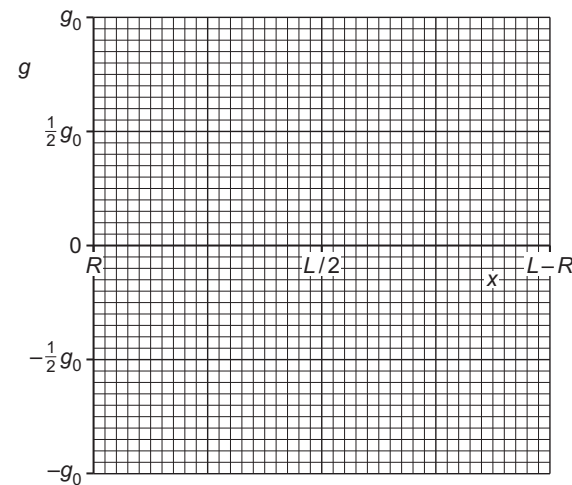


Fig. 3.4

[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.

$\phi = \dots\dots\dots$ unit $\dots\dots\dots$ [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.

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 [1]

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

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 [1]

[Total: 9]

1 (a) Define gravitational field.

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 [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.

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 [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]