# 13. Gravitational Fields

## 13.1 Gravitational field

## Paper 4

Question Paper

**1** The Sun may be considered as a uniform sphere with a mass of $1.99 \times 10^{30}$ kg and a surface temperature of 5780 K.

A probe with a mass of 2.63 kg moves in a straight line towards the Sun.
When it is at a distance $x$ from the centre of the Sun, the probe measures the gravitational field strength $g$ due to the Sun and the radiant flux intensity $F$ of radiation from the Sun.

**(a)** Define gravitational field.

.....

..... [1]

**2** **(a)** **(i)** Define gravitational field.

.....

..... [1]

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

.....

..... [1]

**(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.

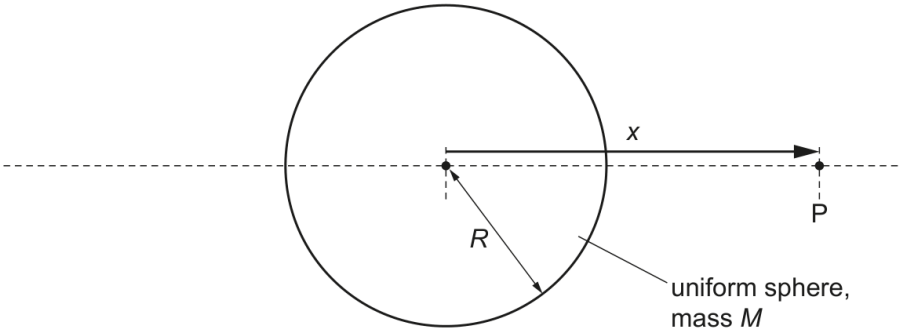



**Fig. 1.1**

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.

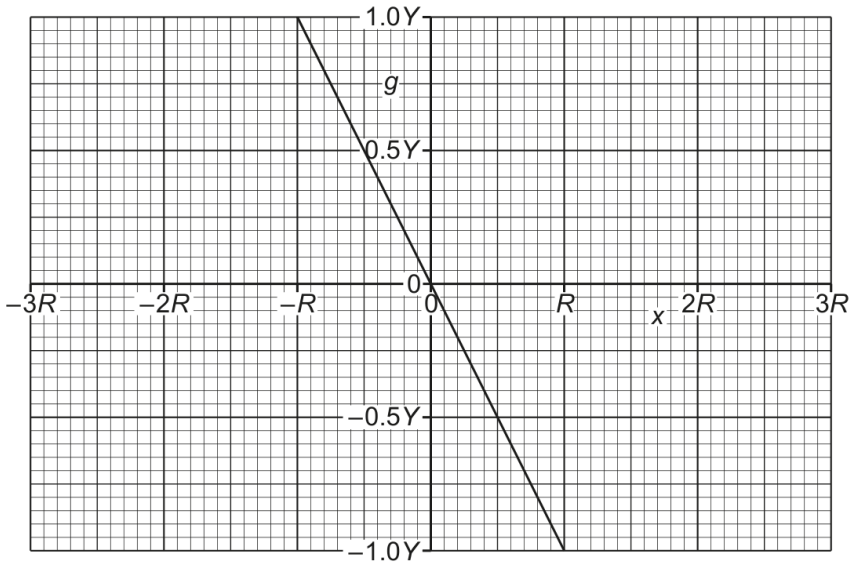



**Fig. 1.2**

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

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

.....

.....

..... [2]

**4** **(a)** Define gravitational field.

.....

..... [1]

**(b)** A spherical planet can be considered as a point mass at its centre.

**(i)** On Fig. 1.1, draw gravitational field lines outside the planet to represent the gravitational field due to the planet.

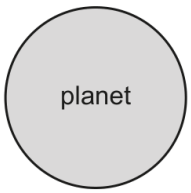



**Fig. 1.1**

[2]

**5** The Earth may be assumed to be an isolated uniform sphere with its mass of $6.0 \times 10^{24}$ kg concentrated at its centre.

A satellite of mass 1200 kg is in a circular orbit about the Earth in the Earth's gravitational field. The period of the orbit is 94 minutes.

**(a)** Define *gravitational field strength*.

.....

..... [1]

**6** **(a)** Define *gravitational field strength*.

.....

..... [1]

**(b)** An isolated planet is a uniform sphere of radius $3.39 \times 10^{6}$ m. Its mass of $6.42 \times 10^{23}$ kg may be considered to be a point mass concentrated at its centre. The planet rotates about its axis with a period of 24.6 hours.

For an object resting on the surface of the planet at the equator, calculate, to three significant figures:

**(iii)** the force per unit mass exerted on the object by the surface of the planet.

force per unit mass = ..... $N\,kg^{-1}$ [1]

**7** **(a)** **(i)** State what is meant by a *field of force*.

.....

.....

..... [2]

**(ii)** Define *gravitational field strength*.

.....

..... [1]

**8** **(a)** **(i)** A gravitational field may be represented by lines of gravitational force.
State what is meant by a *line of gravitational force*.

.....

.....

.....[1]

**9** **(a)** **(i)** State what is meant by *gravitational field strength*.

.....

.....

.....[1]

**(ii)** Explain why, at the surface of a planet, gravitational field strength is numerically equal to the acceleration of free fall.

.....

.....

.....[1]