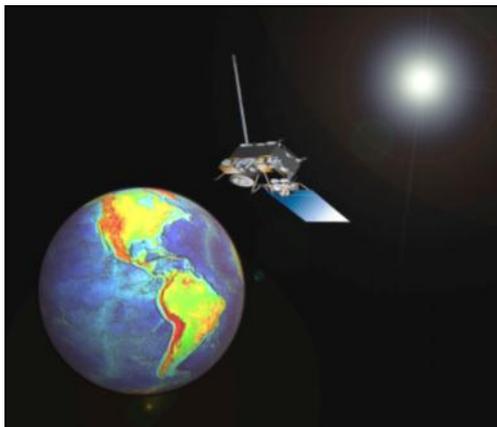


• PRACTICE QUESTIONS (5)

1

Use the data shown below to calculate the *orbital radius* and hence the *height above the Earth's surface* of a *geostationary* satellite.



- Mass of the Earth = 6.0×10^{24} kg.
- Mean radius of the Earth = 6400 km.
- Rotational period of the Earth = 24 hours.
- Universal gravitational constant, G = 6.67×10^{-11} N m² kg⁻².

2 Use the Internet to find out about the history of some of the *GEOSTATIONARY* artificial satellites.

HOMEWORK QUESTIONS

- $G = 6.67 \times 10^{-11}$ N m² kg⁻². $g = 9.81$ N kg⁻¹ (m s⁻²)
- **EARTH** - mean radius = 6400 km; mass = 6.0×10^{24} kg.
- **MOON** - mean radius = 1740 km; mass = 7.4×10^{22} kg.
mean distance from Earth = 3.8×10^8 m.
- **SUN** - mean radius = 700 000 km; mass = 2.0×10^{30} kg.
mean distance from Earth = 1.5×10^{11} m.

2 Using the data provided at the start at the start of the **Homework Questions**, calculate :

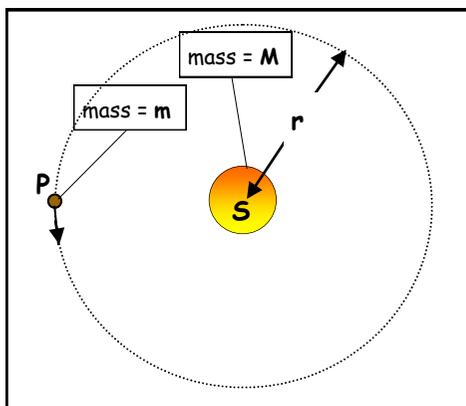
- (a) The **Earth's gravitational field strength at the Moon**.
- (b) The **gravitational force exerted by the Earth on the Moon**.
- (c) The magnitude of the **Moon's acceleration towards the Earth**.

3 (a) Sketch the pattern of field lines of the gravitational field surrounding a **uniform spherical mass**.

(b) On the diagram you have drawn for (a) :

- (i) Mark two points **X** and **Y** where the gravitational field strength has the **same magnitude but is in opposite directions**.
- (ii) Mark a point **Z** where the gravitational field strength is **0.25 × the gravitational field strength at X and in the same direction**.

- 4 A planet P of mass (m) orbits the Sun of mass (M) in a circular orbit of radius (r), as shown in the diagram.



The speed of the planet in its orbit is (v).

- (a) On the diagram, draw an arrow to represent the **linear velocity** of P.

Label the arrow V .

Draw a second arrow representing the **direction of the force acting on P**. Label this arrow F .

- (b) (i) Write down an expression, in terms of r and v , for the **magnitude of the centripetal acceleration** on P.
 (ii) Write down an expression, in terms of m , r and v , for the **magnitude of the force F acting on P**.
 (iii) Write down an expression, in terms of m , M , r and G , for the **magnitude of the gravitational force F exerted by the Sun on the planet**.
- (c) From observations of the motions of the planets around the Sun, **KEPLER** found that the square of the period of revolution of a planet around the Sun (T^2), was proportional to r^3 .
- (i) Write down an expression for T in terms of the speed (v) of the planet and the radius (r) of its orbit.
- (ii) Use your answers to (b) (ii), (b) (iii) and (c) (i) to show that **KEPLER'S** relation $T^2 \propto r^3$ would be expected.

(OCR A2 Physics - Module 2824 - Specimen paper)

This question is about gravitational fields. You may assume that all the mass of the Earth, or the Moon, can be considered as a point mass at its centre. 12

- (a) It is possible to find the mass of a planet by measuring the gravitational field strength at the surface of the planet and knowing its radius.

(i) **Define gravitational field strength, g .**

(ii) Write down an expression for g at the surface of a planet in terms of its mass M and radius R .

(iii) Show that the mass of the Earth is 6.0×10^{24} kg, given that the radius of the Earth = 6400 km.

- (b) (i) Use the data below to show the value of g at the Moon's surface is about 1.7 N kg^{-1} .

mass of Earth = 81 × mass of Moon.

radius of Earth = 3.7 × radius of Moon.

(ii) **Explain** why a high jumper who can clear a 2m bar on Earth should be able to clear a 7m bar on the Moon. Assume that the high jump on the Moon is inside a 'space bubble' where Earth's atmospheric conditions exist.

(iii) The distance between the centres of the Earth and the Moon is 3.8×10^8 m. Assume that the Moon moves in a circular orbit about the centre of the Earth. Estimate the **period** of this orbit to the nearest day.

Mass of Earth = 6.0×10^{24} kg.

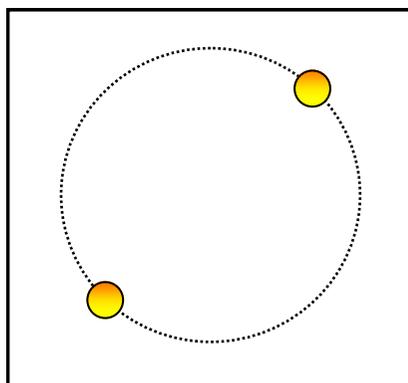
1 day = 8.6×10^4 s.

(OCR A2 Physics - Module 2824 - January 2003)

- 6 (a) Define gravitational field strength, g .
- (b) Explain why the acceleration due to gravity and the gravitational field strength at the Earth's surface have the same value.
- (c) A space probe, with its engines shut down, orbits Mars at a constant distance of 3500 km above the centre of the planet and in a time of 110 minutes.
- (i) Calculate the speed of the space probe.
- (ii) Show that the mass of Mars is about 6×10^{23} kg.
- (d) (i) Write down an algebraic expression for g at the surface of a planet in terms of its mass M and radius R .
- (ii) The acceleration due to gravity at the surface of Mars is 3.7 m s^{-2} . Calculate the radius of Mars in kilometres.

(OCR A2 Physics - Module 2824 - June 2008)

- 7 A binary star is a pair of stars which move in circular orbits around their common centre of mass. For stars of equal mass, they move in the same circular orbit, shown by the dotted line in the diagram opposite.



In this question, consider the stars to be point masses situated at their centres at opposite ends of a diameter of the orbit.

- (a) (i) Draw, on the diagram, arrows to represent the force acting on each star. 13

(ii) Explain why the stars must be diametrically opposite to travel in the circular orbit.

- (b) Newton's law of gravitation applied to the situation shown in the diagram, may be expressed as :

$$F = \frac{GM^2}{4R^2}$$

State what each of the symbols F , G , M and R represents.

- (c) (i) Show that the orbital period T of each star is related to its speed v by :

$$v = \frac{2\pi R}{T}$$

(ii) Show that the magnitude of the centripetal force required to keep each star moving in its circular path is :

$$F = \frac{4\pi^2 MR}{T^2}$$

(iii) Use equations from (b) and (ii) above to show that the mass of each star is given by :

$$M = \frac{16\pi^2 R^3}{GT^2}$$

- (d) Binary stars separated by a distance of 1×10^{11} m have been observed with an orbital period of 100 days. Calculate the mass of each star. (1 day = 86 400 s).

(OCR A2 Physics - Module 2824 - June 2004)