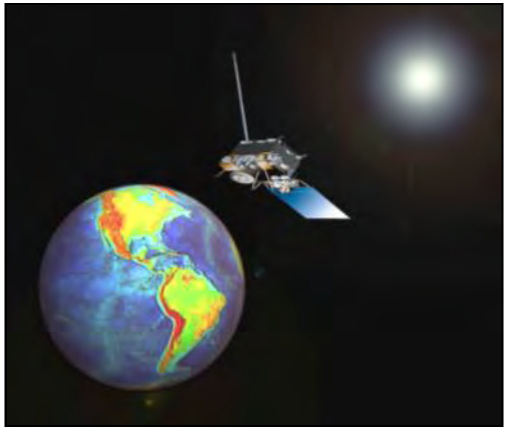
- **PRACTICE QUESTIONS (5)**

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 m^2 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 m^2 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.

1 Calculate the ***gravitational attraction force*** between : *11*

(a) The Earth and the Moon.

(b) The proton and the electron in an atom of hydrogen, given that :

- Electron rest mass = **9.11×10^{-31} kg.**
- Proton rest mass = **1.67×10^{-27} kg.**
- Electron's orbital radius = **10^{-10} 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.**

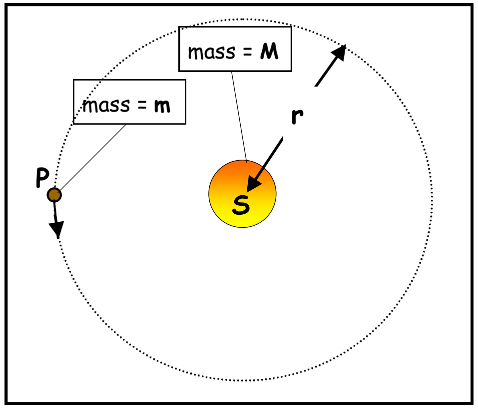
3 (a) Sketch the pattern of field lines of the gravitational field surrounding a **uniform spherical mass.**

(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 x 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)

5 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 x mass of Moon.
radius of Earth = 3.7 x 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.**

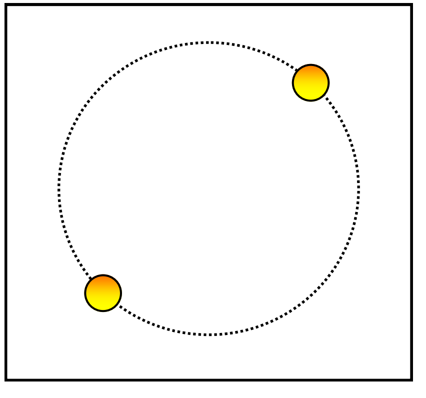
(d) (i) Write down an algebraic expression for **g at the surface of a planet** in terms of its mass **M** and radius **R.**

(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.

(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 : $v = 2\pi R/T$

(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)