1 In a physics lesson a student learns that the Earth is 81 times more massive than the Moon. Searching the Internet, she is surprised to discover that the gravitational field strength at the surface of the Earth is only 6 times greater than that at the surface of the Moon.

Use the above data to compare the radius of the Earth with that of the Moon.

(3)

(Total for Question 3 marks)

2 (a) The Moon orbits the Earth in a circular path.

Explain why the Moon maintains this circular path and what determines the radius of the path.

(2)

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(b) A bucket is swung in a vertical, circular path as shown.

The bucket is half filled with water and swung. The water stays in the bucket, even at the top of the circular path, as long as the speed of the bucket exceeds a certain value.

Explain why.

(3)

(Total for Question 5 marks)

3 The Moon takes 27.3 days to make one complete orbit of the Earth.

(a) (i) Show that the orbital angular velocity of the Moon is about 3×10^{-6} rad s^{-1}.

(2)

(ii) Calculate the radius of the Moon's orbit.

mass of Earth 6.4×10^{24} kg

(4)

Radius .....

(b) The Moon is gradually moving further away from the Earth because of the action of tides.

(i) State and explain how this increasing distance affects the moon's orbital period.

(2)

(ii) In 200 years the radius of the Moon's orbit is predicted to increase by 8 m.

Calculate the rate of increase of the radius of the orbit in cm per year.

(1)

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Rate of increase ..... cm per year

*(iii) In practice, the rate of increase of the orbital radius due to tidal action will not have been constant. Suggest why this rate of change might have been different in the very distant past.

(3)

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(Total for Question 12 marks)

***4** Describe the similarities and differences between electric and gravitational fields.

(6)

(Total for Question = 6 marks)

5 The first satellite weather picture was taken in 1960. Today more than 200 weather satellites are in use. Some of these satellites are in a geostationary orbit around the Earth, so that they remain at the same point above the Earth's surface all the time.

(a) (i) Show that the magnitude of the gravitational field strength g at a point outside of the Earth is given by

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

where r is the distance of the point from the centre of the Earth and M is the mass of the Earth.

(2)

(ii) Use this expression together with an expression for the centripetal acceleration to show that the radius of a satellite's orbit is given by

$$r^3 = \frac{GMT^2}{4\pi^2}$$

where T is the time for one orbit of the satellite.

(3)

(iii) Hence calculate a value for the radius of the geostationary orbit.

$M = 6.0 \times 10^{24}$ kg

(3)

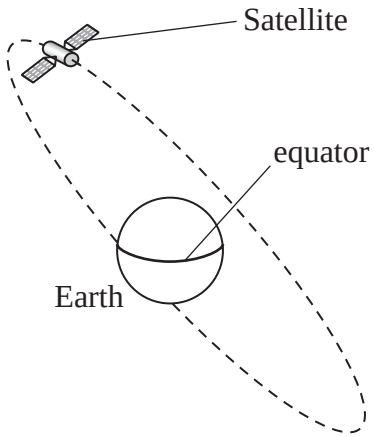
Radius =

(b) State why all geostationary satellites are in an orbit above the Earth's equator.

(1)

(Total for Question = 9 marks)

6 The Global Positioning System (GPS) is a network of satellites orbiting the Earth. The satellites are arranged in six different orbital planes at a height of 20 200 km above the Earth's surface. Wherever you are, at least four GPS satellites are 'visible' at any time. The diagram shows a single satellite.



(a) Show that the GPS satellites take about 40 000 s (12 hours) to complete one orbit about the Earth.

mass of the Earth $M_E = 6.0 \times 10^{24}$ kg

radius of the Earth $R_E = 6400$ km

(4)

(b) Communications satellites are placed in orbit with an orbital time of 24 hours.

Explain why it is essential for communications satellites to be in such an orbit.

(2)

(c) State how the orbit of a GPS satellite differs from that of a communications satellite.

(2)

(Total for Question = 8 marks)