

Gravitational Fields QP2

1 In October 2012, Felix Baumgartner completed his world record free-fall attempt, jumping from just above the atmosphere from a height of 36.6 km.

- (a) At the surface of the Earth the gravitational field strength has a magnitude of 9.81 N kg^{-1} . Calculate the magnitude of the gravitational field strength at the position from which Baumgartner jumped.

Earth radius = 6400 km

(3)

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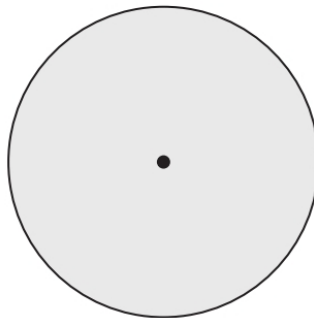
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Gravitational field strength =

- (b) The Earth is represented by the shaded circle in the diagram below. Add to the diagram to indicate the gravitational field around the Earth.

(2)



(c) Explain why the gravitational field can be thought of as approximately uniform over the distance of the jump.

(2)

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(Total for Question ... = 7 marks)

2 Mars is our nearest neighbour in the solar system. In August 2003 the distance between Mars and the Earth was the closest in recorded history at 5.6×10^{10} m.

mass of Mars = 6.4×10^{23} kg

mass of Earth = 6.0×10^{24} kg

Calculate the gravitational force between Mars and the Earth when they were at this distance.

(2)

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Gravitational force =

(Total for Question ... = 2 marks)

3 The Moon has an orbit around the Earth of radius 3.86×10^8 m, with a time period of 2.36×10^6 s.

(a) (i) Using the data provided, show that the product GM is about $4.1 \times 10^{14} \text{ m}^3 \text{ s}^{-2}$, where M is the mass of the Earth.

(3)

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(ii) At the surface of the Earth g is measured to be 9.81 N kg^{-1} .

Calculate a value for the radius of the Earth.

(2)

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Radius of the Earth =

(b) It has been estimated that, at any one time, there may be about a thousand small asteroids orbiting the Earth. These asteroids orbit at between five to ten times the distance of the Moon from the Earth. Most make no more than one orbit before being pulled out of this orbit by the Sun.

Suggest why these asteroids do not remain in a stable orbit around the Earth.

(2)

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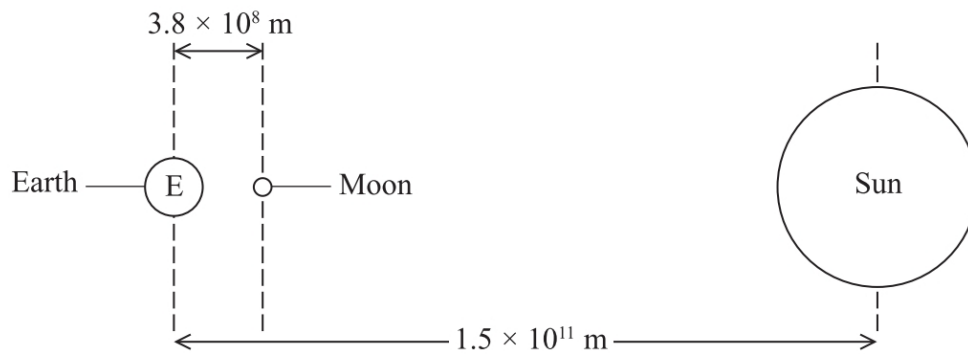
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(Total for Question = 7 marks)

4 Tides are caused by the gravitational forces exerted by the Sun and the Moon on the water in the Earth's oceans. The diagram below (not to scale) shows the distances from the Earth to the Sun and from the Earth to the Moon.



mass of Sun = $2.0 \times 10^{30} \text{ kg}$

mass of Moon = $7.0 \times 10^{22} \text{ kg}$

(a) Show that the gravitational force of the Sun on the Earth is about 200 times greater than the gravitational force of the Moon on the Earth.

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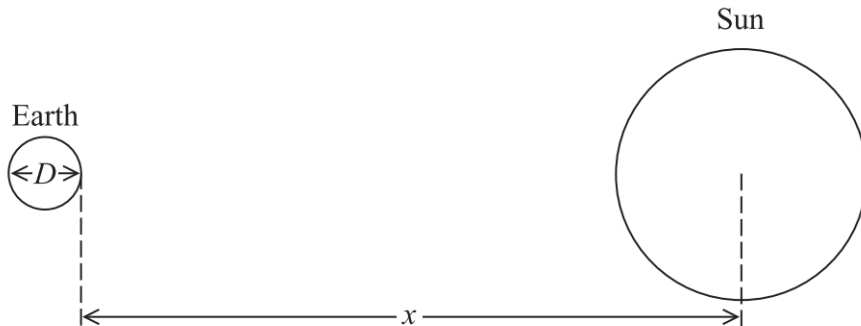
- (b) The tides depend on the difference in the gravitational field strength produced by the Sun and the Moon on opposite sides of the Earth.

Gravitational field strength at a point, due to the Sun, is given by $g = \frac{GM}{r^2}$

where $M =$ mass of Sun

$r =$ distance of the point from the centre of Sun (not to scale).

The diagram shows the Earth and the Sun.



- (i) State two expressions for the gravitational field strength at opposite sides of the Earth, due to the Sun.

(1)

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- (ii) Use these expressions to explain why the Sun has a relatively small effect on the tides.

(2)

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(Total for Question = 5 marks)

5 In a science fiction television programme the gravitational field strength on the Moon becomes equal to that of the Earth. The radius of the Moon stays constant.

- (a) Calculate the mass of the Moon that would be required for the gravitational field strength at its surface to equal the gravitational field strength at the surface of the Earth.

radius of the Moon = 1.74×10^6 m

(2)

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Mass of Moon required =

- (b) Explain why a more massive Moon would have no effect on the time taken for the Moon to orbit the Earth.

(2)

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- (c) Suggest what effect a more massive Moon would have at the Earth's surface.

(1)

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(Total for Question = 5 marks)