

Revision Sheet

A-Level Physics · Unit 13 Gravitational fields

6 vocabulary items · 39 marks of exam questions (4 questions)

Part 1 · Vocabulary review

(6 items). The terms this unit is examined on most. Mark it yourself

from the answer key.

Section A · Chinese to English

Write the English word.

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|----|-------|-----|
| 1. | <hr/> | [1] |
| 2. | <hr/> | [1] |
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| 4. | <hr/> | [1] |
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| 6. | <hr/> | [1] |

Part 2 · Exam questions (39 marks, 4 questions) begins on the next page. They are ordered easy to difficult and none of them has been set before.

- 7 (a) Explain how the force(s) on a satellite can result in the satellite being in a circular orbit around a planet.

.....

.....

..... [2]

- (b) The Earth and the Moon may be considered to be uniform spheres that are isolated in space. The Earth has mass M , radius R and mean density ρ . The Moon, mass m , is in a circular orbit about the Earth with radius nR , as illustrated in Fig. 1.1.

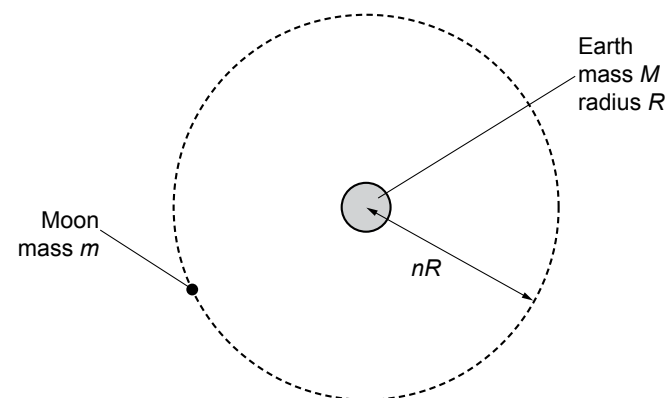


Fig. 1.1

The Moon makes one complete orbit of the Earth in time T .
Show that the mean density ρ of the Earth is given by the expression

$$\rho = \frac{3\pi n^3}{GT^2}$$

where G is the gravitational constant.

- (c) The radius R of the Earth is $6.38 \times 10^6 \text{ m}$ and the distance between the centre of the Earth and the centre of the Moon is $3.84 \times 10^8 \text{ m}$.
The period T of the orbit of the Moon about the Earth is 27.3 days.

Use the expression in (b) to calculate ρ .

$$\rho = \dots\dots\dots \text{ kg m}^{-3} \text{ [3]}$$

[Total: 9]

- 8 (a) (i) Define gravitational potential at a point.

.....
.....
..... [2]

- (ii) Starting from the equation for the gravitational potential due to a point mass, show that the gravitational potential energy E_p of a point mass m at a distance r from another point mass M is given by

$$E_p = -\frac{GMm}{r}$$

where G is the gravitational constant.

[1]

- (b) Fig. 1.1 shows the path of a comet of mass $2.20 \times 10^{14} \text{ kg}$ as it passes around a star of mass $1.99 \times 10^{30} \text{ kg}$.

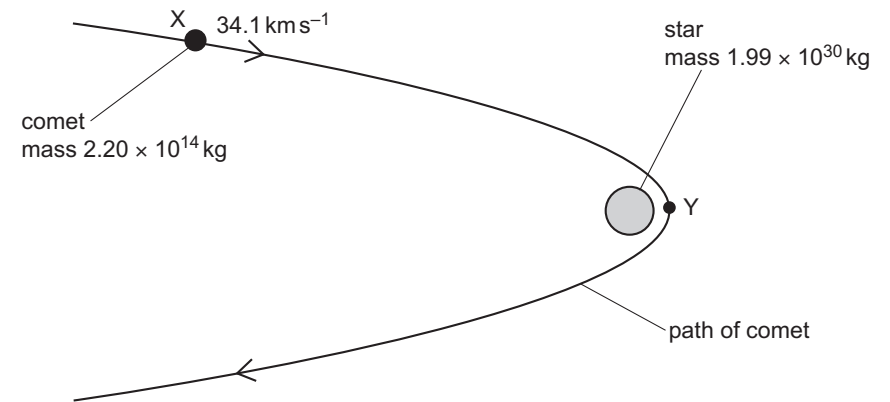


Fig. 1.1 (not to scale)

At point X, the comet is $8.44 \times 10^{11} \text{ m}$ from the centre of the star and is moving at a speed of 34.1 km s^{-1} .

At point Y, the comet passes its point of closest approach to the star. At this point, the comet is a distance of $6.38 \times 10^{10} \text{ m}$ from the centre of the star.

Both the comet and the star can be considered as point masses at their centres.

- (i) Calculate the magnitude of the change in the gravitational potential energy ΔE_p of the comet as it moves from position X to position Y.

$$\Delta E_p = \dots\dots\dots \text{ J } [2]$$

- (ii) State, with a reason, whether the change in gravitational potential energy in **(b)(i)** is an increase or a decrease.

.....
 [1]

- (iii) Use your answer in **(b)(i)** to determine the speed, in km s^{-1} , of the comet at point Y.

$$\text{speed} = \dots\dots\dots \text{ km s}^{-1} [3]$$

- (c) A second comet passes point X with the same speed as the comet in **(b)** and travelling in the same direction. This comet is gradually losing mass. The mass of this comet when it passes point X is the same as the mass of the comet in **(b)**.

Suggest, with a reason, how the path of the second comet compares with the path shown in Fig. 1.1.

.....
 [1]

[Total: 10]

- 9 (a) The point P in Fig. 1.1 represents a point mass.

On Fig. 1.1, draw lines to represent the gravitational field around P.



Fig. 1.1

[2]

- (b) A moon is in circular orbit around a planet.

Explain why the path of the moon is circular.

.....

 [2]

- (c) Many moons are in circular orbit about a planet.

The angular velocity of a moon is ω when the orbit of the moon has a radius r about the planet.

Fig. 1.2 shows the variation of r^3 with $1/\omega^2$ for these moons.

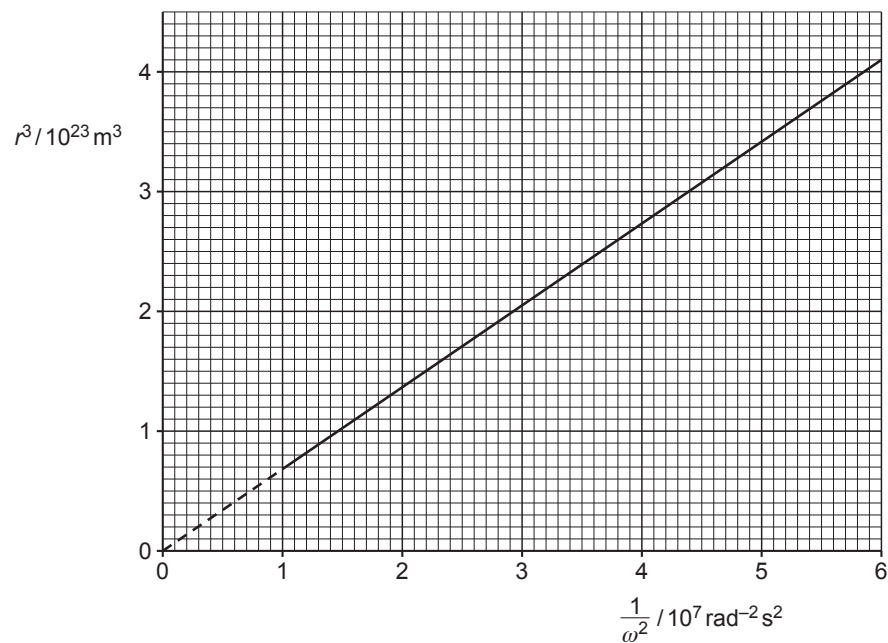


Fig. 1.2

- (i) Show that the mass M of the planet is given by the expression

$$M = \frac{\text{gradient}}{G}$$

where G is the gravitational constant.

- (ii) Use Fig. 1.2 and the expression in (c)(i) to show that the mass M of the planet is $1.0 \times 10^{26} \text{ kg}$.

[1]

- (iii) Determine the speed of a moon in orbit around the planet with an orbital radius of $1.2 \times 10^8 \text{ m}$.

speed = ms^{-1} [3]

[Total: 10]

[2]

10 (a) State the relationship between gravitational potential and gravitational field strength.

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..... [2]

(b) A moon of mass M and radius R orbits a planet of mass $3M$ and radius $2R$. At a particular time, the distance between their centres is D , as shown in Fig. 2.1.

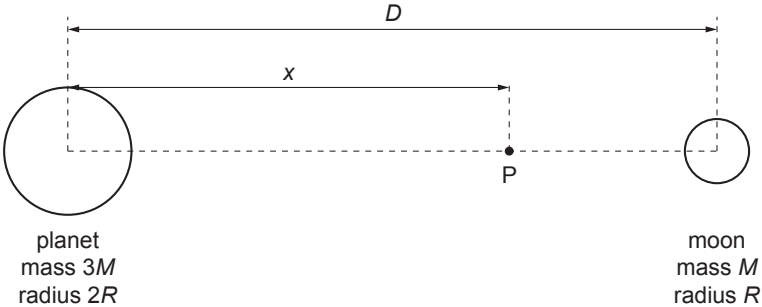


Fig. 2.1

Point P is a point along the line between the centres of the planet and the moon, at a variable distance x from the centre of the planet.

The variation with x of the gravitational potential ϕ at point P, for points between the planet and the moon, is shown in Fig. 2.2.

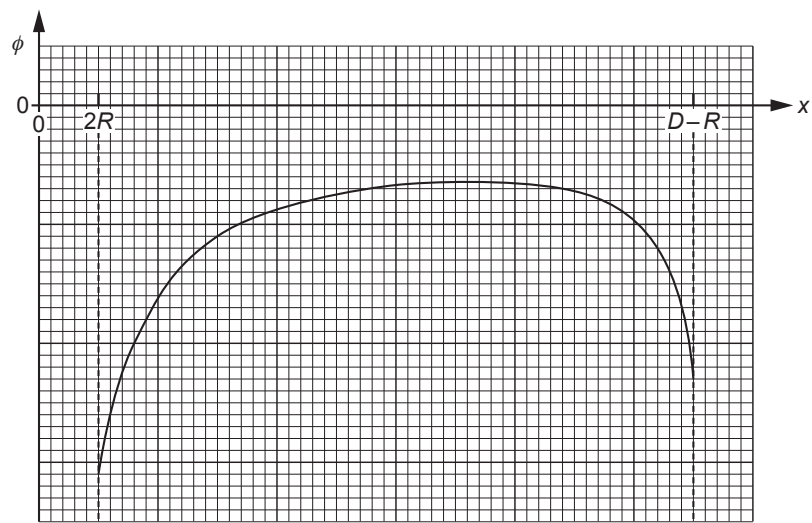


Fig. 2.2

(i) Explain why ϕ is negative throughout the entire range $x = 2R$ to $x = D - R$.

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..... [3]

(ii) One of the features of Fig. 2.2 is that ϕ is negative throughout.

Describe **two** other features of Fig. 2.2.

1.

.....

2.

..... [2]

(iii) On Fig. 2.3, sketch the variation with x of the gravitational field strength g at point P between $x = 2R$ and $x = D - R$.

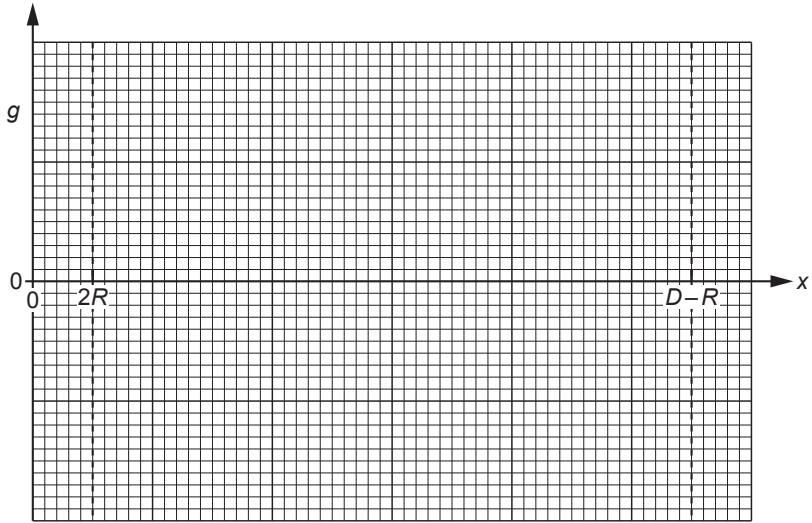


Fig. 2.3