

A Level Physics A
H556/01 Modelling physics

Question Set 13

- 1 (a) Phobos is one of the two moons orbiting Mars. Fig. 17.1 shows Phobos and Mars.

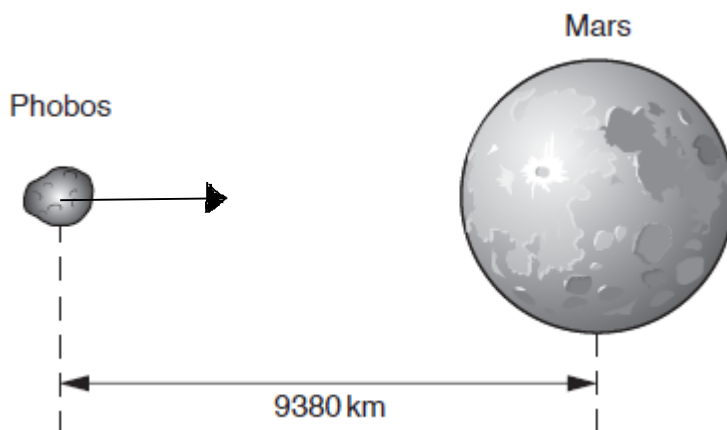


Fig. 17.1

The orbit of Phobos may be assumed to be a circle. The centre of Phobos is at a distance 9380 km from the centre of Mars and it has an orbital speed $2.14 \times 10^3 \text{ m s}^{-1}$.

- (i) On Fig. 17.1, draw an arrow to show the direction of the force which keeps Phobos in its orbit. [1]

- (ii) Calculate the orbital period T of Phobos.

$$T = \frac{2 \times \pi \times 9380000}{2.14 \times 10^3} = 27540 \quad T = \dots 2.75 \times 10^4 \dots \text{ s} \quad [2]$$

- (iii) Calculate the mass M of Mars.

Gravitational force = Centripetal force

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \rightarrow GM = v^2 r \quad M = \frac{(2.14 \times 10^3)^2 \times 9380 \times 10^3}{6.67 \times 10^{-11}} \quad M = \dots 6.44 \times 10^{23} \dots \text{ kg} \quad [3]$$

- (b) The gravitational field strength at a distance r from the centre of Mars is g .

The table below shows some data on Mars.

$g/\text{N kg}^{-1}$	r/km	$\lg(g/\text{N kg}^{-1})$	$\lg(r/\text{km})$
1.19	6000	0.076	3.78
0.87	7000	-0.060	3.85
0.67	8000	-0.174	3.90
0.53	9000	-0.276	3.95
0.43	10000	-0.367	4.00

- (i) Complete the table by calculating the missing values. [1]

(ii) Fig. 17.2 shows the graph of $\lg(g/\text{N kg}^{-1})$ against $\lg(r/\text{km})$.

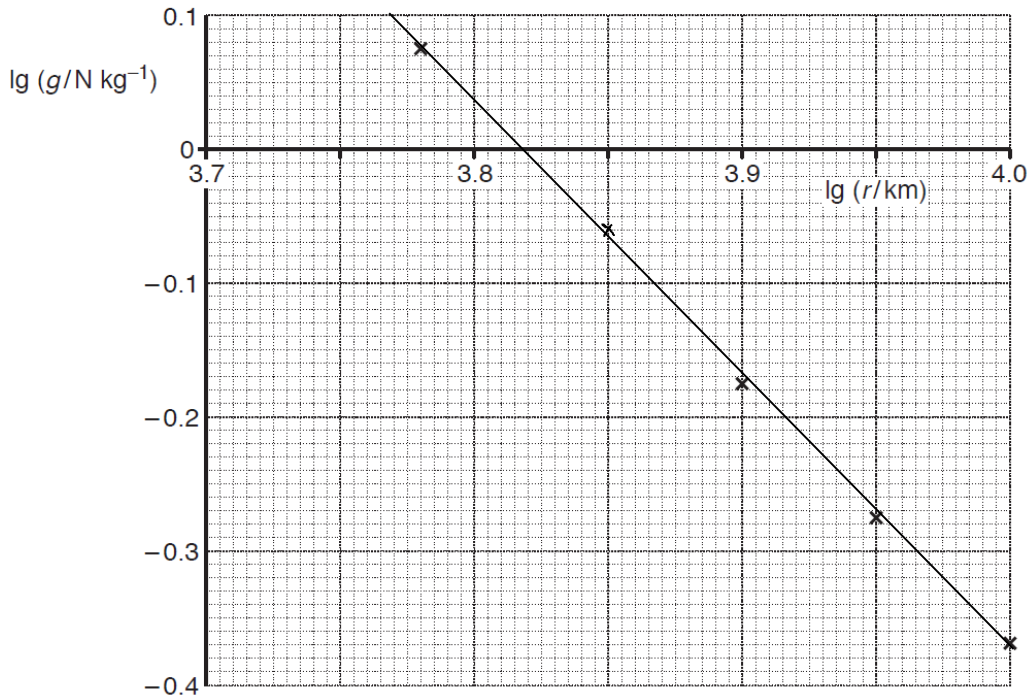


Fig. 17.2

1 Plot the missing data point on the graph and draw the straight line of best fit. [2]

2 Use Fig. 17.2 to show that the gradient of the straight line of best fit is -2 . [1]

$$\text{gradient} = \frac{\Delta y}{\Delta x} = \frac{0.1 - -0.37}{4 - 3.7} = 2.04$$

3 Explain why the gradient of the straight line of best fit is -2 . [2]

$$g = \frac{GM}{r^2} \rightarrow \log(g) = \log\left(\frac{GM}{r^2}\right) \rightarrow \log(g) = \log(GM) - 2\log(r)$$

(comparing to $y = c - mx$ so gradient $m = -2$)

(c) In July 2018, the closest distance between the centre of Mars and the centre of

Earth will be $5.8 \times 10^{10} \text{ m}$.

Fig. 17.3 shows the variation of the **resultant** gravitational field strength g between the two planets with distance r from the centre of the **Earth**.

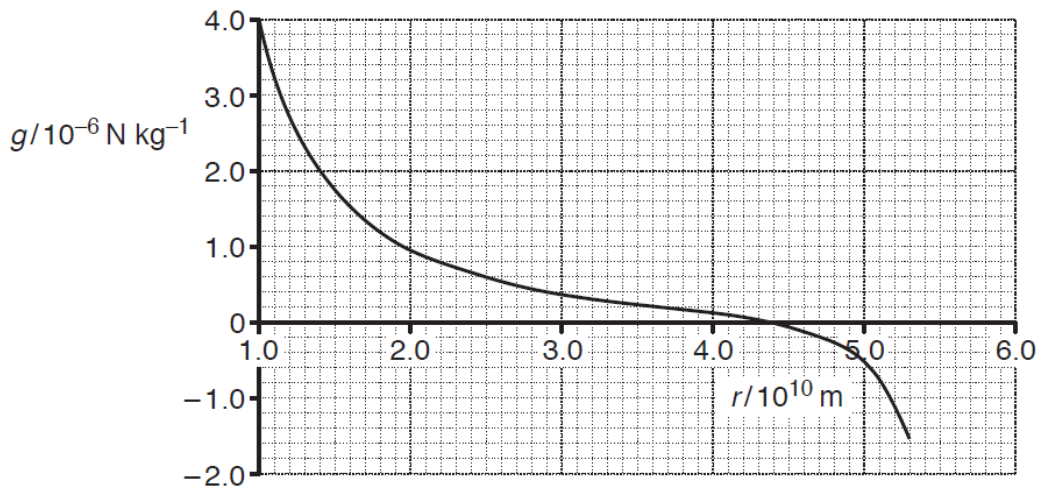


Fig. 17.3

[2]

(i) Explain briefly the overall shape of the graph in Fig. 17.3.

- The direction of g for Earth and Mars are in opposite directions
- At about $4.4 \times 10^{10} \text{ m}$ the g values are equal; since Mars has the smaller mass, this occurs closer to Mars.

(ii) Use the value of r when $g = 0$ from Fig. 17.3 to determine the ratio

$$\frac{\text{mass of Earth}}{\text{mass of Mars}} \quad \text{At } r = R_E = 4.4 \times 10^{10} \text{ m} \quad g_{\text{Earth}} = g_{\text{Mars}} \quad \rightarrow \quad \frac{M_{\text{Earth}}}{M_{\text{Mars}}} = \frac{R_E^2}{(5.8 \times 10^{11} - R_E)^2}$$

$$\frac{\text{mass of Earth}}{\text{mass of Mars}} = \dots\dots\dots 9.9 \dots\dots\dots [2]$$

Total Marks for Question Set 13: 16

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