OCR
Oxford Cambridge and RSA

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.

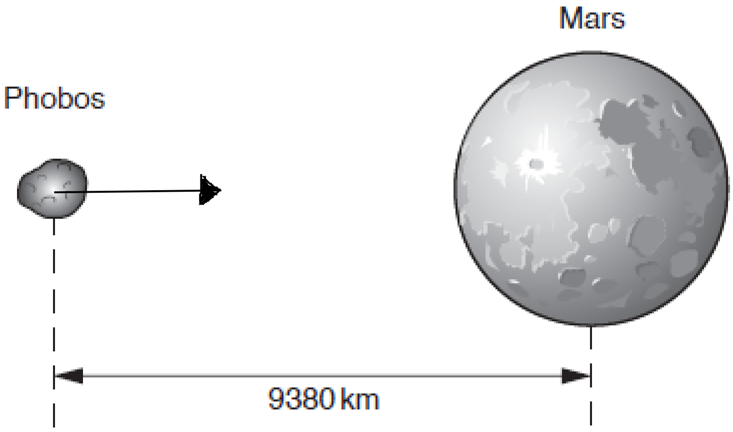

Fig. 17.1

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 $2.14 \times 10^3\,m\,s^{-1}$.

(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.

$T = \frac{2 \times \pi \times 9380000}{2.14 \times 10^3} = 27540$

T = ...2.75×10^4...... s **[2]**

(iii) Calculate the mass *M* of Mars.

Gravitational force = centripetal force

$\frac{GMm}{r^2} = \frac{mv^2}{r} \rightarrow GM = v^2 r \rightarrow M = \frac{v^2 r}{G} = \frac{(2.14 \times 10^3)^2 \times 9380 \times 10^3}{6.67 \times 10^{-11}}$

M = ...6.44×10^{23}...... kg **[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 / N kg^{-1}	r / km	lg (g / N kg^{-1})	lg (r / 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 / N kg^{-1}) against lg (r / km).

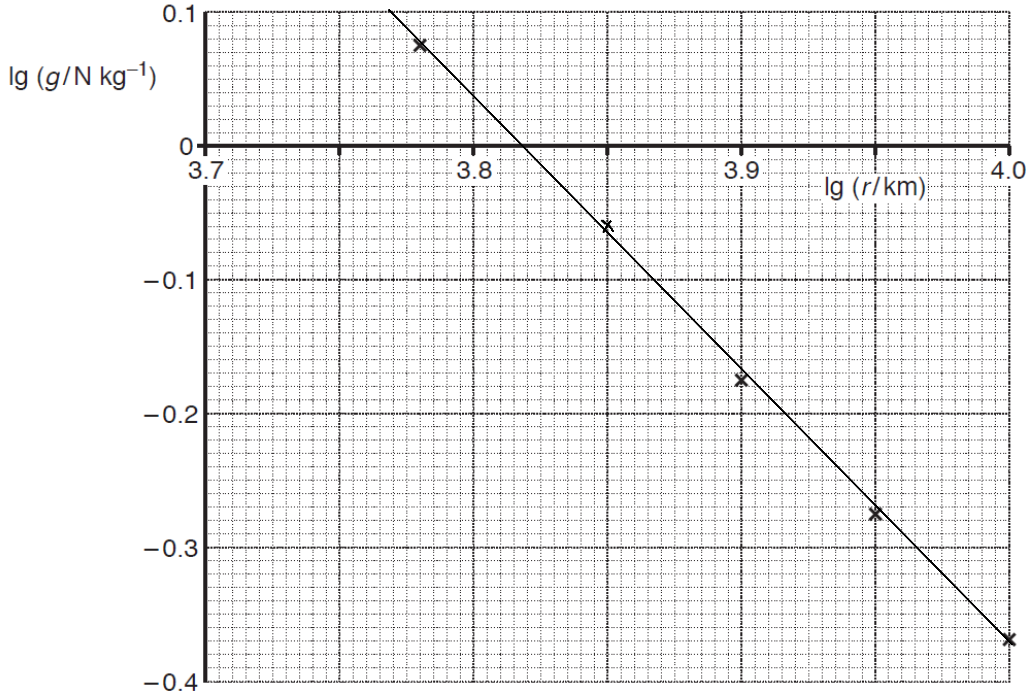

Fig. 17.2

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]**

gradient = $\frac{\Delta y}{\Delta x}$ = $\frac{0.1 - -0.37}{4 - 3.77}$ = 2.04

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

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

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 5.8×10^{10} 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**.

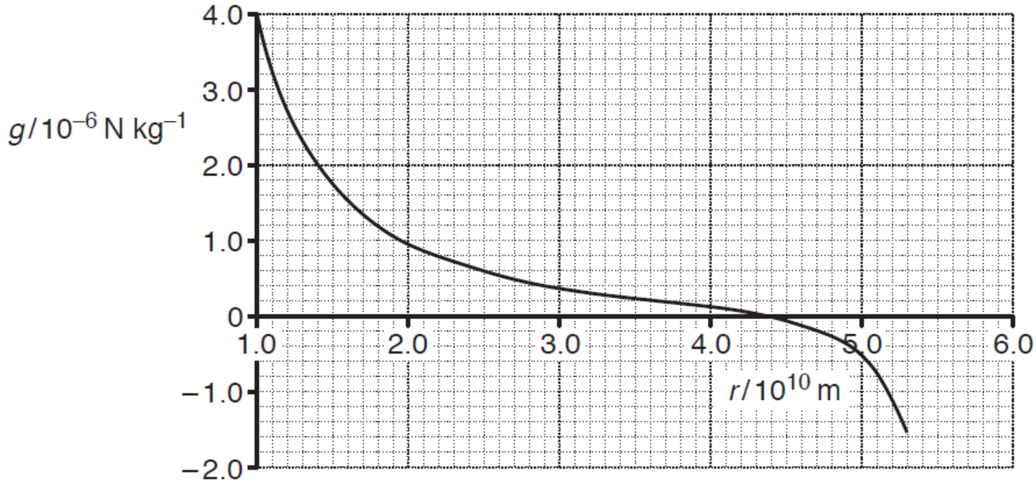

Fig. 17.3

[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 4.4×10^{10} 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 $\frac{\text{mass of Earth}}{\text{mass of Mars}}$.

At $r = R_E = 4.4 \times 10^{10}$ m

$g_{Earth} = g_{Mars}$

$\frac{GM_{Earth}}{R_E^2} = \frac{GM_{Mars}}{(5.8 \times 10^{10} - R_E)^2} \rightarrow \frac{M_{Earth}}{M_{Mars}} = \frac{R_E^2}{(5.8 \times 10^{10} - R_E)^2}$

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

Total Marks for Question Set 13: 16