Gravitational Fields 2

Have a go at the following exam questions.

OCR, G484, JANUARY 2013

3 **(a)** State, in words, Newton's law of gravitation.

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.... **[1]**

(b) Fig. 3.1 shows the circular orbits of two of Jupiter's moons: Adrastea, **A**, and Megaclite, **M**.

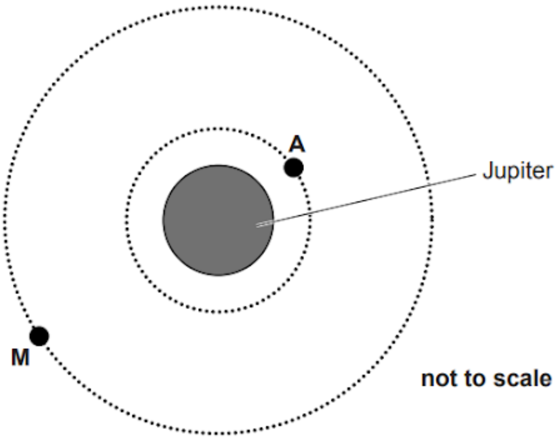

Fig. 3.1

Use the following data in the calculations below.

orbital radius of **A** = 1.3×10^8 m
orbital period of **A** = 7.2 hours
gravitational field strength at orbit of **A** = $7.5\,N\,kg^{-1}$
orbital radius of **M** = 2.4×10^{10} m

Calculate

(i) the mass of Jupiter

mass = ... kg **[3]**

(ii) the gravitational field strength at the orbit of **M**

gravitational field strength = ... $N\,kg^{-1}$ **[2]**

(iii) the orbital period of **M**.

orbital period = ... hours **[3]**

[Total: 9]

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5. *(a)* The mass of the planet Mercury is 3.30×10^{23} kg and its radius is 2440 km.

(i) Calculate the gravitational field strength on the surface of Mercury. [2]

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(ii) Calculate the gravitational potential on the surface of Mercury. [2]

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(iii) Explain briefly why the potential is negative. [1]

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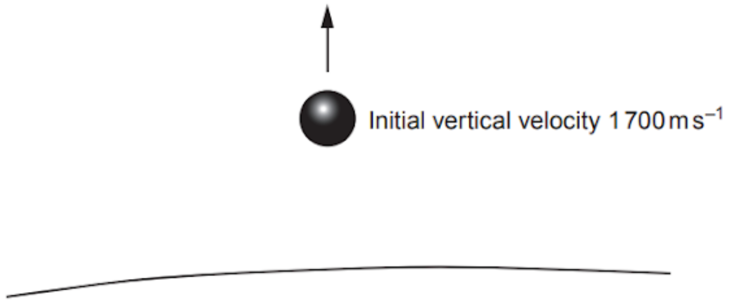
(b) A projectile of mass 0.454 kg is fired upwards from Mercury's surface with an initial vertical velocity of $1\,700\,\mathrm{m\,s^{-1}}$.



(i) Calculate the total energy of the projectile as it is being launched. [3]

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(ii) Use the principle of conservation of energy to calculate the maximum height that the projectile reaches (Mercury has no atmosphere so that air resistance is negligible). [3]

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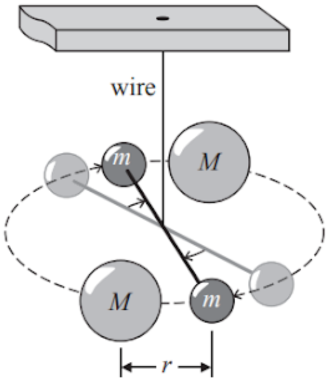
15 In the 18th century Henry Cavendish devised an experiment to determine the average density of the Earth. This involved the first laboratory determination of the universal gravitational constant G.

A light horizontal rod with a small metal sphere at each end was hung from a fixed point by a very thin wire. Two large lead spheres were then brought close to the small spheres causing the rod to oscillate and then settle into a new position of equilibrium.



(a) In a modern version of the experiment the following data was obtained:

mass of large lead sphere $M = 160$ kg

mass of small sphere $m = 0.75$ kg

distance $r = 0.23$ m

gravitational force between adjacent large and small spheres $F = 1.5 \times 10^{-7}$ N.

Use this data to calculate a value for G.

(2)

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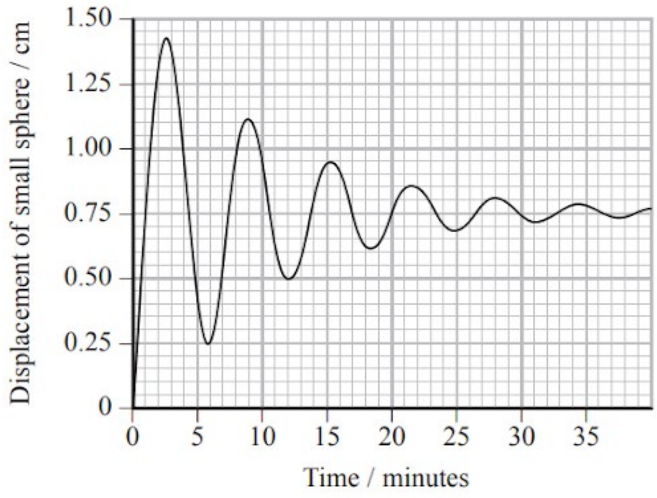
G = ... $\text{Nm}^2\ \text{kg}^{-2}$

(b) The graph shows how the displacement of one of the small spheres varies with time.



(i) Use the graph to determine the period of oscillation of the sphere.

(2)

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Period = ...

(ii) The amplitude of the oscillation decreases with each cycle.

Explain why this effect is observed.

(2)

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