A2 Gravitation Practice Questions

**1 (a)** The Earth may be considered to be a uniform sphere of radius 6.38 106 m. Its mass is assumed to be concentrated at its centre.

Given that the gravitational field strength at the Earth’s surface is 9.81Nkg–1, show that

the mass of the Earth is 5.99 1024 kg.

[2]

**(b)** A satellite is placed in geostationary orbit around the Earth.

**(i)** Calculate the angular speed of the satellite in its orbit.

angular speed = ........................................ rad s–1 [3]

**(ii)** Using the data in **(a)**, determine the radius of the orbit.

radius = ........................................ m [3]

**1 (a)** Define gravitational potential.

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**(b)** Explain why values of gravitational potential near to an isolated mass are all negative.

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**(c)** The Earth may be assumed to be an isolated sphere of radius 6.4 103 km with its mass of 6.0 1024 kg concentrated at its centre. An object is projected vertically from the

surface of the Earth so that it reaches an altitude of 1.3 104km.

Calculate, for this object,

**(i)** the change in gravitational potential,

change in potential = ……………………………………. J kg–1

**(ii)** the speed of projection from the Earth’s surface, assuming air resistance is negligible.

speed = ……………………………………. ms–1

[5]

 **(d)** Suggest why the equation

*v*2 = *u*2 + 2*as*

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s not appropriate for the calculation in **(c)(ii)**.

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**3** A binary star consists of two stars that orbit about a fixed point C, as shown in Fig. 3.1.

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The star of mass *M*1 has a circular orbit of radius *R*1 and the star of mass *M*2 has a circular

orbit of radius *R*2. Both stars have the same angular speed ω, about C.

**(a)** State the formula, in terms of *G*, *M*1, *M*2, *R*1, *R*2 and ωfor

**(i)** the gravitational force between the two stars,

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**(ii)** the centripetal force on the star of mass *M*1.

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[2]

**(b)** The stars orbit each other in a time of 1.26 108 s (4.0 years). Calculate the angular

speed for each star.

angular speed = ................................... rad s–1 [2]

 **(c) (i)** Show that the ratio of the masses of the stars is given by the expression



[2]

**(ii)** The ratio M1/M2 is equal to 3.0 and the separation of the stars is 3.2 1011 m.

Calculate the radii *R*1 and *R*2.

*R*1 = ........................................ m

*R*2 = ........................................ m

[2]

**(d) (i)** By equating the expressions you have given in **(a)** and using the data calculated in

**(b)** and **(c)**, determine the mass of one of the stars.

mass of star = ......................................... kg

**(ii)** State whether the answer in **(i)** is for the more massive or for the less massive star.

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[4]

**4** If an object is projected vertically upwards from the surface of a planet at a fast enough

speed, it can escape the planet’s gravitational field. This means that the object can arrive at infinity where it has zero kinetic energy. The speed that is just enough for this to happen is known as the escape speed.

**(a) (i)** By equating the kinetic energy of the object at the planet’s surface to its total gain

of potential energy in going to infinity, show that the escape speed *v* is given by

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where *R* is the radius of the planet and *M* is its mass.

**(ii)** Hence show that *v*2 = 2*Rg*,

where *g* is the acceleration of free fall at the planet’s surface.

[3]

 **(b)** The mean kinetic energy *E*k of an atom of an ideal gas is given by

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where *k* is the Boltzmann constant and *T* is the thermodynamic temperature.

Using the equation in **(a)(ii)**, estimate the temperature at the Earth’s surface such that

helium atoms of mass 6.6 10–27 kg could escape to infinity.

You may assume that helium gas behaves as an ideal gas and that the radius of Earth is

6.4 106m.

5



