9 (a) A satellite orbits the Earth of mass M in a circular path of radius r.

(i) Show that the period T of the satellite is given by the expression

$$T^2 = \frac{4\pi^2}{GM} r^3$$

[3]

(ii) A satellite is orbiting the Earth above the equator with a period of 28 hours. The mass of the Earth is 5.98×10^{24} kg.

1. Calculate the radius of the satellite's orbit.

radius = ... m [2]

2. The mass of the satellite is m.

For the satellite in orbit, show that its kinetic energy E_K is given by

$$E_K = \frac{GMm}{2r}$$

[2]

3. Hence, determine the kinetic energy of the satellite which has a mass of 1200 kg.

kinetic energy = ... J [1]

4. The satellite is then moved into a new orbit, gaining 1.14×10^9 J of gravitational potential energy in the process.

Calculate the satellite's loss in kinetic energy.

loss in kinetic energy = ... J [3]

(b) A binary star consists of two stars that orbit about a fixed point C, as shown in Fig. 9.2.

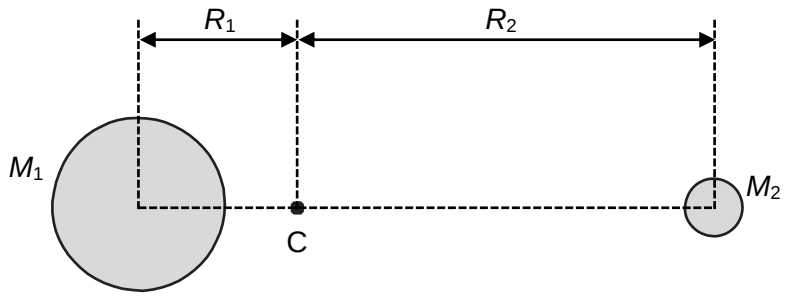

Fig. 9.2

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. Rotating about point C, both stars have the same angular speed of 4.98×10^{-8} rad s^{-1}.

(i) Explain why the centripetal force acting on the two stars are equal in magnitude.

.....

.....

.....

..... [2]

(ii) Calculate the period of orbit of each star.

period = ... years [2]

(iii) Show that the ratio of the masses of the stars is given by the expression

$$\frac{M_1}{M_2} = \frac{R_2}{R_1}$$

[1]

(iv) Given that $\frac{M_1}{M_2} = 3.0$ and the separation between the stars is 3.2×10^{11} m, calculate the radius R_1.

R_1 = ... m [2]

(v) A planet orbits around the star of mass M_1 in the binary star system.

Suggest why the orbit of the planet is not circular.

.....

.....

.....

..... [2]

[Total: 20]

-- END OF PAPER 3 –

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