Oxford Cambridge and RSA

A level Physics A

H556/03 Unified physics

Question Set 9

1 A binary star is a pair of stars which move in circular orbits around their common centre of mass.

In this question consider the stars to be point masses situated at their centres.

(a) Fig. 3.1 shows a binary star where the mass of each star is m. The stars move in the same circular orbit.

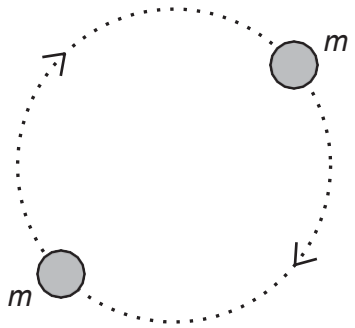

Fig. 3.1

(i) Explain why the stars of equal mass must always be diametrically opposite as they travel in the circular orbit.

[2]

(ii) The centres of the two stars are separated by a distance of $2R$ equal to 3.6×10^{10} m, where R is the radius of the orbit. The stars have an orbital period T of 20.5 days. The mass of each star is given by the equation

$$m = \frac{16\pi^2 R^3}{GT^2}$$

where G is the gravitational constant.

Calculate the mass m of each star in terms of the mass $M_\odot$ of the Sun.

1 day = 86400 s
$M_\odot = 2.0 \times 10^{30}$ kg

m = ...$M_\odot$ **[3]**

(iii) The stars are viewed from Earth in the plane of rotation.
The stars are observed using light that has wavelength of 656 nm in the laboratory. The observed light from the stars is Doppler shifted.

Calculate the maximum change in the observed wavelength $\Delta\lambda$ of this light from the orbiting stars. Give your answer in nm.

$\Delta\lambda$ = ... nm **[2]**

(b) Fig. 3.2 shows a binary star where the masses of the stars are 4*m* and *m*.

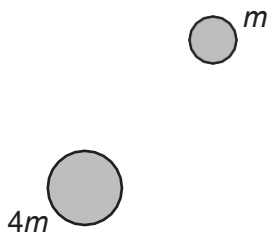

Fig. 3.2

(i) The centre of mass of the binary star lies at the surface of the star of mass 4*m*. Draw on **Fig. 3.2** two circles to represent the orbits of **both** stars. **[1]**

(ii) Explain why the smaller mass star travels faster in its orbit than the larger mass star.
[2]

Total Marks for Question Set 9: 10