For Examiner's Use

2 **(a)** A planet of mass m is in a circular orbit of radius x about a star of mass M, as illustrated in Fig. 2.1.

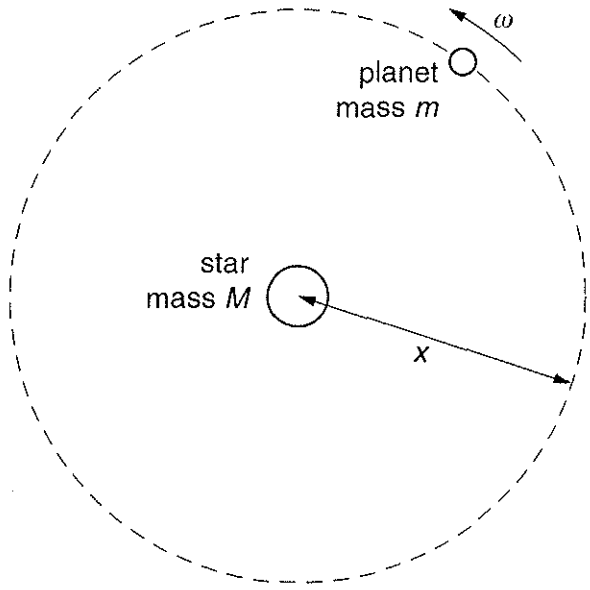

Fig. 2.1

The planet and the star may be considered to be point masses with their masses concentrated at their centres.
The planet has angular speed ω in its orbit about the star.

Show that ω and x are related by the expression

$$\omega^2 x^3 = GM,$$

where G is the gravitational constant.

[3]

For Examiner's Use

(b) The star μ-Arae is at a distance of 49.0 light-years from Earth. One light-year is the distance travelled in a vacuum by light in a time of 1.00 years.

μ-Arae has been discovered to have a planetary system. Data for its planets are given in Fig. 2.2.

planet	orbital period / Earth days	radius of orbit / m
μ-Arae b	643	
μ-Arae c	9.69	1.35×10^{10}
μ-Arae d	311	
μ-Arae e	4210	7.83×10^{11}

Fig. 2.2

(i) Calculate, to three significant figures, the distance, in km, of μ-Arae from Earth.

distance = ... km [2]

(ii) Use the relation in **(a)** and data from Fig. 2.2 to place the planets in order of orbital distance from μ-Arae.

nearest to μ-Arae ....

....

....

furthest from μ-Arae ....[1]

(iii) Use data from Fig. 2.2 for the planet μ-Arae c and for the planet μ-Arae e to calculate the mass of the star μ-Arae.

mass = ... kg [5]