

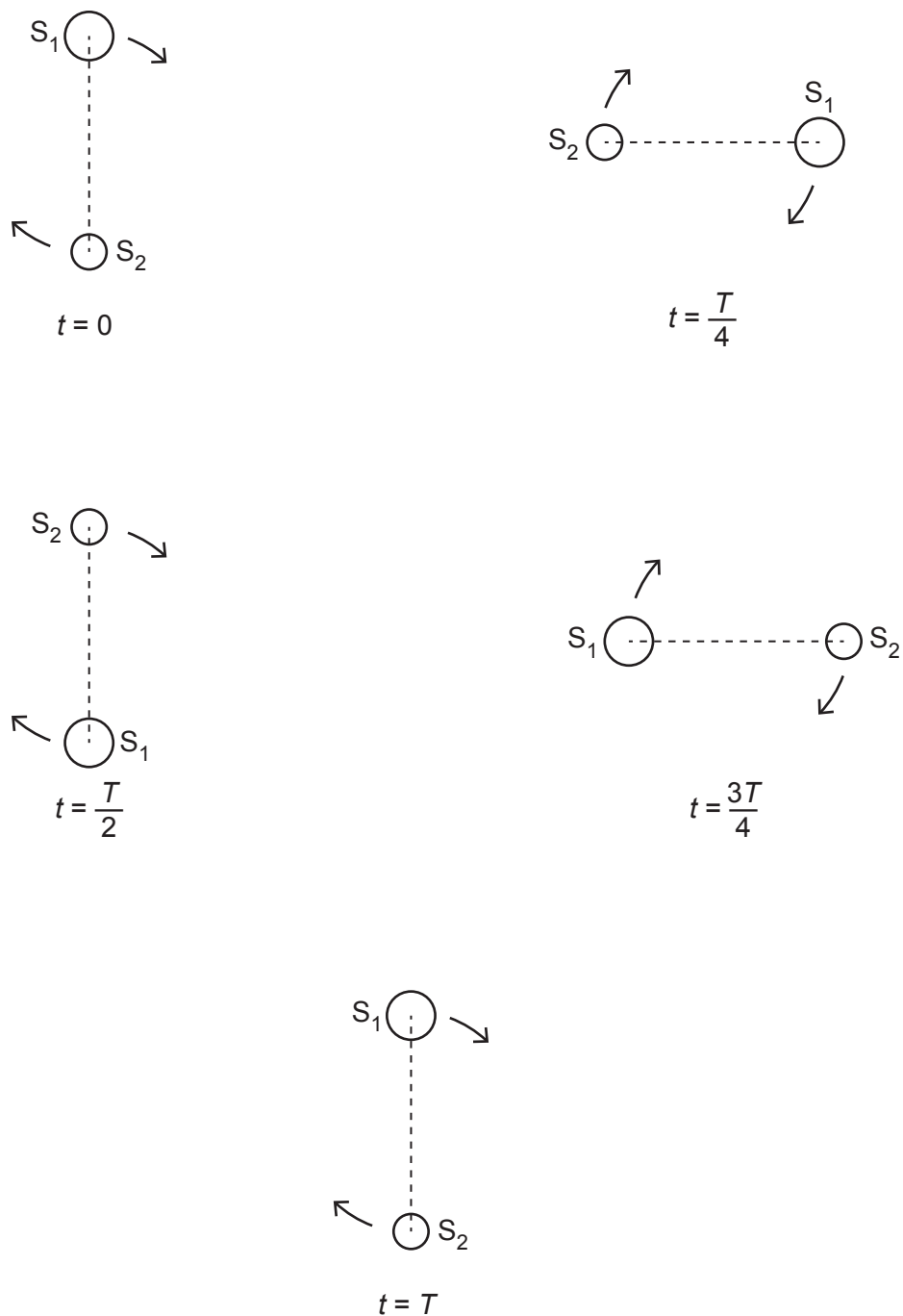
- 1 (a) State what is meant by a *gravitational force*.

.....  
 ..... [1]

- (b) A binary star system consists of two stars  $S_1$  and  $S_2$ , each in a circular orbit.

The orbit of each star in the system has a period of rotation  $T$ .

Observations of the binary star from Earth are represented in Fig. 1.1.



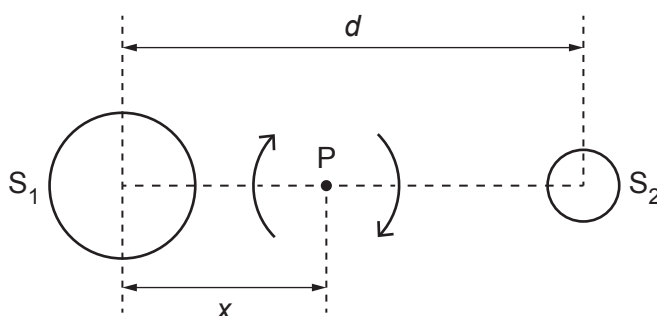
**Fig. 1.1** (not to scale)

Observed from Earth, the angular separation of the centres of  $S_1$  and  $S_2$  is  $1.2 \times 10^{-5}$  rad. The distance of the binary star system from Earth is  $1.5 \times 10^{17}$  m.

Show that the separation  $d$  of the centres of  $S_1$  and  $S_2$  is  $1.8 \times 10^{12}$  m.

[1]

- (c) The stars  $S_1$  and  $S_2$  rotate with the same angular velocity  $\omega$  about a point P, as illustrated in Fig. 1.2.



**Fig. 1.2** (not to scale)

Point P is at a distance  $x$  from the centre of star  $S_1$ . The period of rotation of the stars is 44.2 years.

- (i) Calculate the angular velocity  $\omega$ .

$$\omega = \dots \text{ rad s}^{-1} \quad [2]$$

- (ii) By considering the forces acting on the two stars, show that the ratio of the masses of the stars is given by

$$\frac{\text{mass of } S_1}{\text{mass of } S_2} = \frac{d-x}{x}.$$

[2]

- (iii) The mass  $M_1$  of star  $S_1$  is given by the expression

$$GM_1 = d^2(d-x)\omega^2$$

where  $G$  is the gravitational constant.

The ratio in (ii) is found to be 1.5.

Use data from (b) and your answer in (c)(i) to determine the mass  $M_1$ .

$$M_1 = \dots\dots\dots \text{ kg [3]}$$