12. Motion in a Circle

12.1 Kinematics of uniform circular motion

Paper 4

Question Paper

1 **(a)** Define the radian.

.....

..... [1]

(b) A circular metal disc spins horizontally about a vertical axis, as shown in Fig. 1.1.

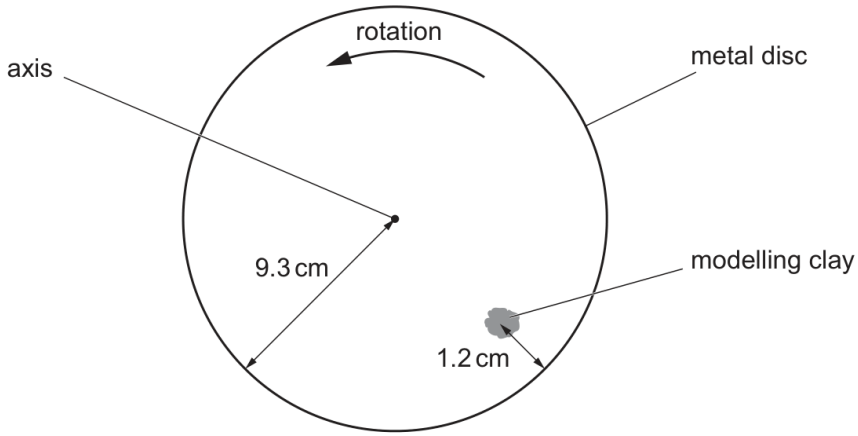


Fig. 1.1 (not to scale)

A piece of modelling clay is attached to the disc.

For the instant when the piece of modelling clay is in the position shown, draw on Fig. 1.1:

(i) an arrow, labelled V, showing the direction of the velocity of the modelling clay [1]

(c) The metal disc in Fig. 1.1 has a radius of 9.3 cm.
The centre of gravity of the modelling clay is 1.2 cm from the rim of the disc and moves with a speed of 0.68 m s^{-1}.

(i) Calculate the angular speed ω of the disc.

ω = ... rad s^{-1} [2]

(d) A second piece of modelling clay is attached to the disc in the position shown in Fig. 1.2.

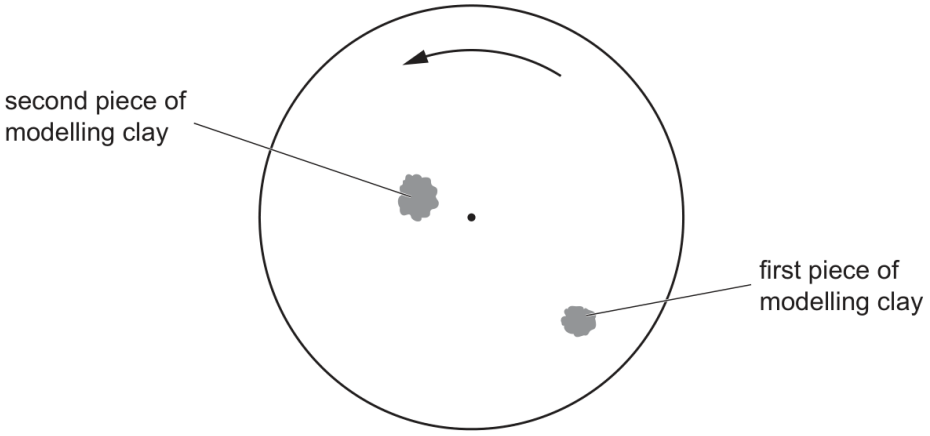


Fig. 1.2

The second piece of modelling clay has a larger mass than the first piece.

By placing **one** tick (✓) in each row, complete Table 1.1 to show how the quantities indicated compare for the two pieces of modelling clay.

Table 1.1

quantity	less for second piece than first piece	same for both pieces	greater for second piece than first piece
angular speed			
linear speed			
acceleration			

[3]

2 A metal wheel consists of an axle A, eight spokes and a rim, as shown in Fig. 1.1.

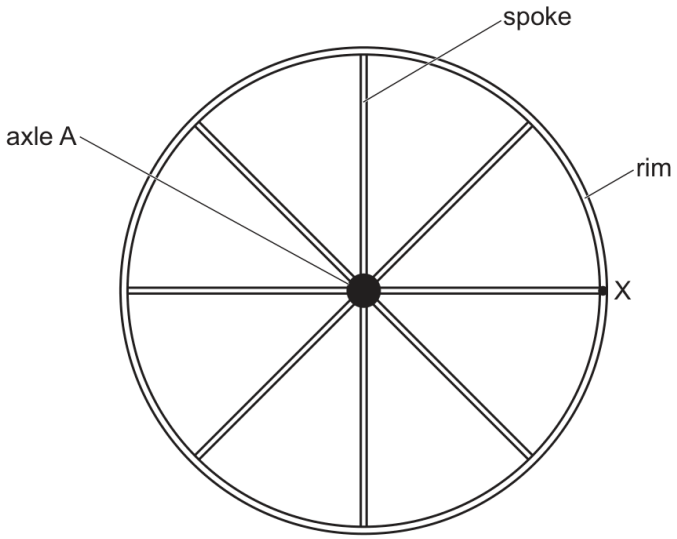


Fig. 1.1

Point X is on the rim at the end of one of the spokes.

The rim has a radius of 0.85 m.
The wheel is rotating clockwise with an angular speed of 140 rad s^{-1}.

(a) For point X, determine:

(i) the speed

speed = ... $m\,s^{-1}$ [2]

(b) There is a uniform magnetic field of flux density 0.18 T into the plane of the page.

(ii) Show that the time taken for point X to complete one revolution is 45 ms.

[1]

3 **(d)** Another satellite is in a circular orbit around the Earth with the same orbital radius and period as the satellite in **(c)**.

(i) Calculate the angular speed of the satellite in this orbit. Give a unit with your answer.

angular speed = ... unit ..... [2]

4 **(a)** Define the radian.

.....

..... [1]

(b) The minute hand of a clock revolves at constant angular speed around the face of the clock, completing one revolution every hour. A small piece of modelling clay is attached to the hand with its centre of gravity at a distance *L* from the fixed end of the hand, as shown in Fig. 1.1.

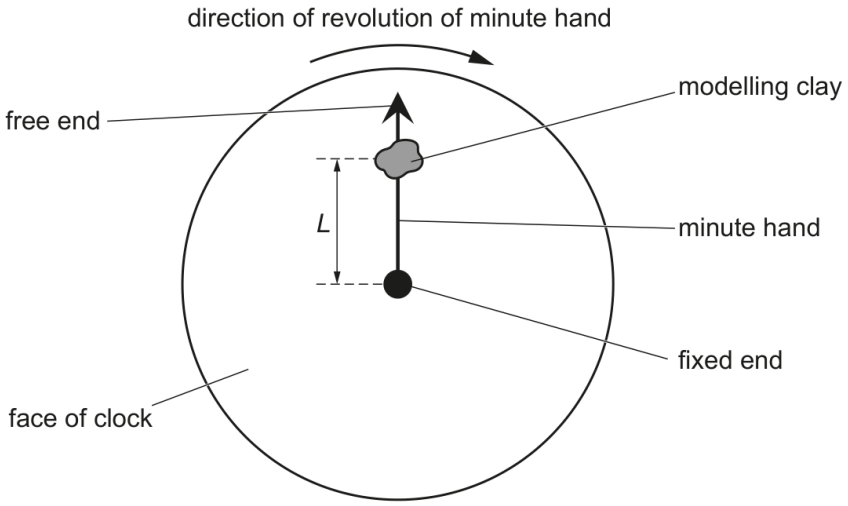


Fig. 1.1

Calculate the angular speed ω of the minute hand.

ω = ... rad s^{-1} [2]

(c) During a time interval of 1400 s, the centre of gravity of the piece of modelling clay in Fig. 1.1 moves through a total distance of 0.44 m.

(i) Calculate the angle through which the minute hand moves in this time interval.

angle = ... rad [1]

(ii) Determine distance *L*.

L = ... m [2]

5 **(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.

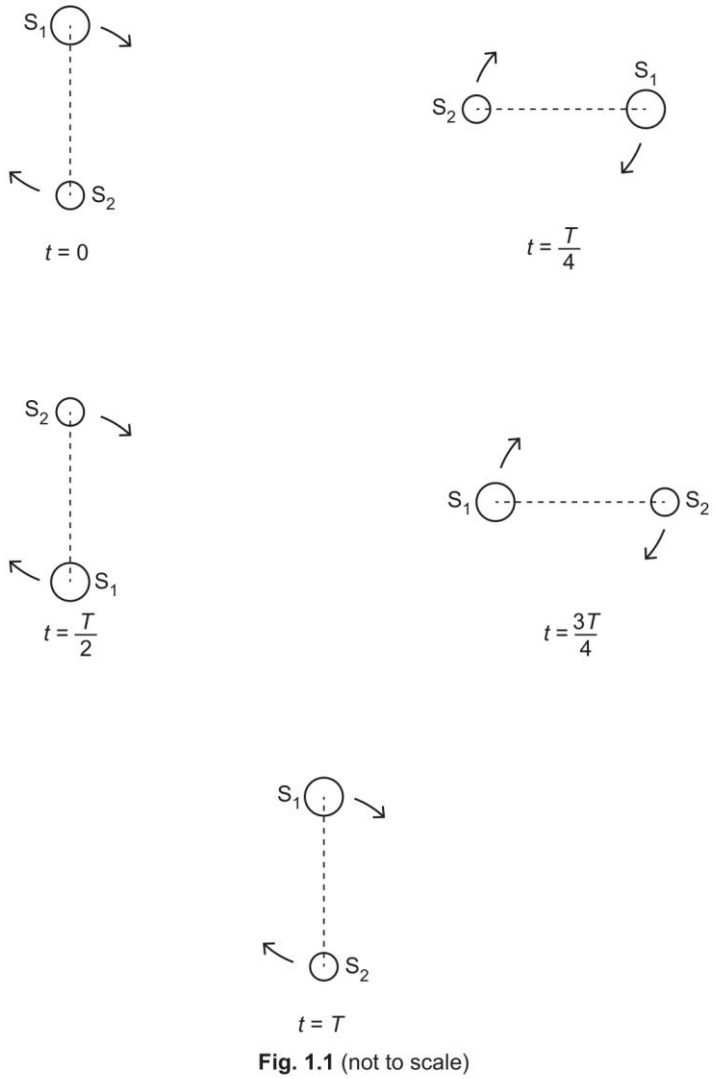


Fig. 1.1 (not to scale)

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

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

[1]

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

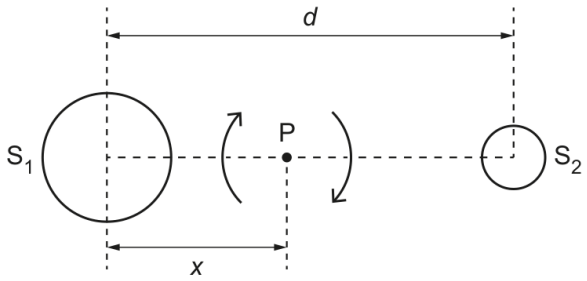


Fig. 1.2 (not to scale)

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 ω.

ω = ... rad s^{-1} [2]

6 **(b)** A small sphere S is attached to one end of a rod, as shown in Fig. 1.1.

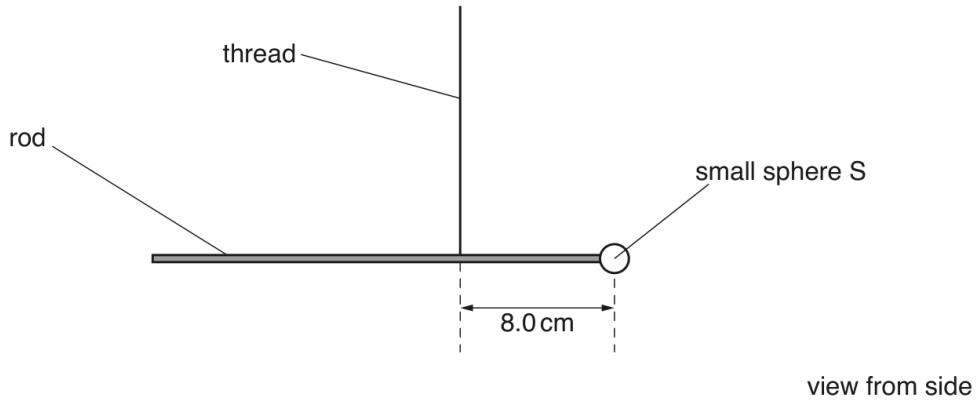


Fig. 1.1 (not to scale)

The rod hangs from a vertical thread and is horizontal.
The distance from the centre of sphere S to the thread is 8.0 cm.

A large sphere L is placed near to sphere S, as shown in Fig. 1.2.

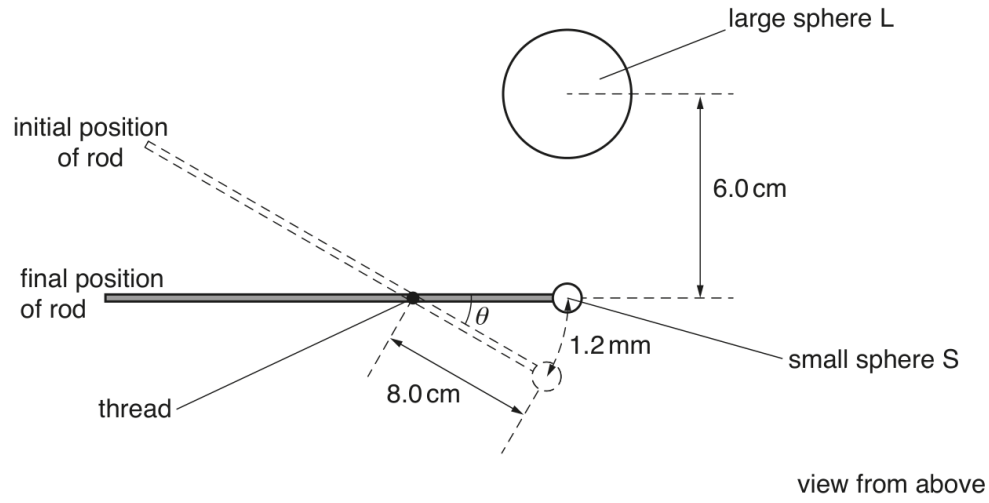


Fig. 1.2 (not to scale)

There is a force of attraction between spheres S and L, causing sphere S to move through a distance of 1.2 mm.
The line joining the centres of S and L is normal to the rod.

(i) Show that the angle θ through which the rod rotates is 1.5×10^{-2} rad.

[1]