London Eye

The London Eye is a $120m$ diameter Ferris wheel holding 32 pods, each with a mass of $10\ tonnes$.

The wheel turns at a steady speed,
taking half an hour to complete a full turn.

1. Write down the time period of the rotation, in seconds.

2. Calculate the rotational speed of the wheel in revolutions per minute.

3. Work out the angular speed of the wheel.

4. Calculate the speed at which each pod moves.

5. Describe the direction of the velocity of a pod 20 minutes after being at the bottom in relation to the downward vertical.

6. Work out the centripetal acceleration of each pod.

7. Calculate the radial and tangential components of the reaction force acting on the pod when the angle with the downward vertical is $100°$. Hence write down the magnitude of the reaction force.

London Eye SOLUTIONS

The London Eye is a $120m$ diameter Ferris wheel holding 32 pods, each with a mass of 10 $tonnes$.

The wheel turns at a steady speed, taking half an hour to complete a full turn.

1. Write down the time period of the rotation, in seconds.

One turn takes half an hour, which is 30 minutes, or $\mathbf{1800\ seconds}$

2. Calculate the rotational speed of the wheel in revolutions per minute.

One revolution takes 30 minutes, which is $\frac{1}{30}$ of a revolution per minute: $\mathbf{0.0\dot{3}\ rpm}$

3. Work out the angular speed of the wheel.

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{1800} = \frac{\pi}{900} \approx \mathbf{0.00349\ rad\ s^{-1}}$$

4. Calculate the speed at which each pod moves.

$$v = r\omega = 60 \times \frac{\pi}{900} = \frac{\pi}{15} \approx \mathbf{0.209\ ms^{-1}}$$

5. Describe the direction of the velocity of a pod 20 minutes after being at the bottom in relation to the downward vertical.

Velocity acts tangentially. After 20 minutes the pod has completed $\frac{2}{3}$ of a turn, giving a total angle of turn of $\frac{2}{3} \times 2\pi = \frac{4\pi}{3}\ radians$, or $240°$, so velocity is acting at an angle of **$30°$ from the downward vertical**.

6. Work out the centripetal acceleration of each pod.

$$a = \frac{v^2}{r} = \frac{\left(\frac{\pi}{15}\right)^2}{60} = \frac{\pi^2}{13500} \approx \mathbf{0.000731\ ms^{-2}}$$

7. Calculate the radial and tangential components of the reaction force acting on the pod when the angle with the downward vertical is $100°$. Hence write down the magnitude of the reaction force.

Resolving radially: $R + 10000g \sin 10 = \frac{mv^2}{r} = 10000\left(\frac{\pi^2}{13500}\right) = \frac{20\pi^2}{27}$

$\Longrightarrow \quad R = \frac{20\pi^2}{27} - 10000g \sin 10 \approx -17010.2$ (note: this means the reaction points outwards from the centre – that is, the small component of weight is more than enough for the very small centripetal force requirement).

Resolving tangentially: $R_t = 10000g \cos 10 \approx \mathbf{96511.2\ N}$ (no resultant as steady speed)

Resultant reaction: $R = \sqrt{R_r^2 + R_t^2} = \mathbf{97998.7\ N\ to\ 6\ s.f.}$ (note: almost $10000g$).