# Exercise walk-through

## Circular motion ▪ 3.3

eXercise

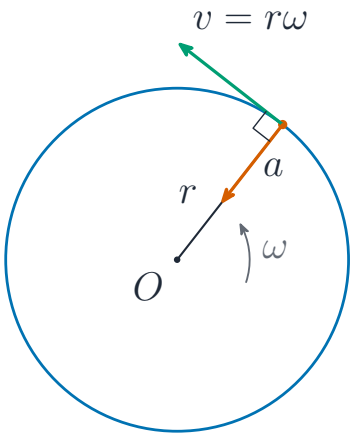
# You must be able to

- use $v = r\omega$ and $a = r\omega^2 = \dfrac{v^2}{r}$
- analyse a horizontal circle (conical pendulum)
- use energy + the centripetal equation for a vertical circle

# Method — Centripetal force

$r = 2$ **m,** $\omega = 3$ **rad s$^{-1}$:**
$v = r\omega = 6$ m s$^{-1}$; $a = r\omega^2 = 18$ m s$^{-2}$.

**Centripetal force** $= ma = \dfrac{mv^2}{r}$,
provided by tension, friction or a component of weight.



## Practice 2.1 ▪ 2 marks

A particle moves in a circle of radius $0.5$ m at $4$ m s$^{-1}$. Find its acceleration.

# Solution 2.1

Method: Centripetal force

**Worked steps**

$$a = \frac{v^2}{r} = \frac{16}{0.5} = 32 \text{ m s}^{-2}$$ M1 A1.

## Practice 2.2 ▪ 2 marks

Convert an angular speed of $120$ rev/min to rad $s^{-1}$.

# Solution 2.2

**Worked steps**

$120\ \text{rev/min} = 2\ \text{rev/s} = 2 \times 2\pi = 4\pi = 12.6\ \text{rad s}^{-1}$ **M1** **A1**.

## Exam-style 3.1 ▪ 1 mark

The centripetal acceleration of a particle moving at speed $v$ in a circle of radius $r$ is:

**A** $\frac{v}{r}$

**B** $\frac{v^2}{r}$

**C** $vr$

**D** $\frac{r}{v^2}$

# Solution 3.1

Method: Centripetal force

**A** $\frac{v}{r}$

**B** $\frac{v^2}{r}$ ✓

**C** $vr$

**D** $\frac{r}{v^2}$

## Worked steps

**B**. $a = \frac{v^2}{r}$ (also $= r\omega^2$).

## Exam-style 3.2 ▪ 2 marks

A particle of mass $0.2$ kg is attached to a string of length $0.5$ m and whirled in a horizontal circle on a smooth table at $3$ rev s$^{-1}$.

(a) Find the angular speed in rad s$^{-1}$.

(b) Find the tension in the string.

# Solution 3.2

Method: Centripetal force

**Worked steps**

(a) $\omega = 3 \times 2\pi = 6\pi = 18.8$ rad s$^{-1}$ M1 A1.

(b) $T = mr\omega^2 = 0.2 \times 0.5 \times (6\pi)^2 = 0.2 \times 0.5 \times 355.3 = 35.5$ N M1 M1 A1.

## Exam-style 3.3 ▪ 3 marks

A conical pendulum has a bob of mass $0.4$ kg on a string of length $1$ m, which makes an angle of $30^\circ$ with the vertical.

(a) Find the tension in the string.

(b) Find the angular speed of the bob.

# Solution 3.3

**Worked steps**

(a) vertical: $T\cos 30^\circ = mg = 4 \Rightarrow T = \dfrac{4}{0.866} = 4.62$ N M1 M1 A1.

(b) horizontal: $T\sin 30^\circ = mr\omega^2$ with $r = 1 \times \sin 30^\circ = 0.5$; $4.62 \times 0.5 = 0.4 \times 0.5 \times \omega^2 \Rightarrow \omega^2 = 11.55 \Rightarrow \omega = 3.40$ rad s$^{-1}$ M1 M1 A1.