

## 3.3 Circular motion

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 16 marks

**KEY WORDS** angular speed 角速度 • centripetal acceleration 向心加速度 • vertical circle 竖直圆  
• horizontal circle 水平圆 • circular motion 圆周运动

### Objective

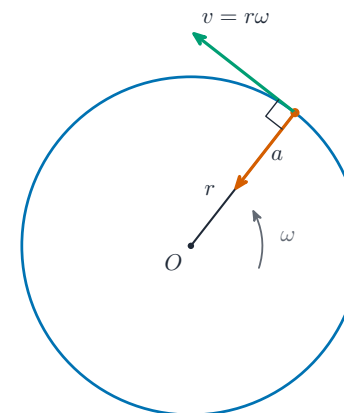
Build the skills to answer exam questions on **circular motion** 圆周运动 — **angular speed** 角速度, **centripetal acceleration** 向心加速度, the **conical pendulum** 圆锥摆, and motion in a **vertical circle** 竖直圆. Take  $g = 10 \text{ m s}^{-2}$ .

You must be able to:

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

### 1 Worked examples

#### ■ Centripetal force



*Velocity points along the tangent; acceleration points inward to the centre*

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

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

### 2 Practice

**2.1** A particle moves in a circle of radius  $0.5 \text{ m}$  at  $4 \text{ m s}^{-1}$ . Find its acceleration. [2]

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**2.2** Convert an angular speed of  $120 \text{ rev/min}$  to  $\text{rad s}^{-1}$ . [2]

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### 3 Exam-style questions

**3.1** The centripetal acceleration of a particle moving at speed  $v$  in a circle of radius  $r$  is: [1]

- **A**  $\frac{v}{r}$
- **B**  $\frac{v^2}{r}$
- **C**  $\frac{vr}{r}$
- **D**  $\frac{r}{v^2}$

**3.2** 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<sup>-1</sup>.

(a) Find the angular speed in rad s<sup>-1</sup>. [2]

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(b) Find the tension in the string. [3]

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**3.3** A conical pendulum has a bob of mass 0.4 kg on a string of length 1 m, which makes an angle of 30° with the vertical.

(a) Find the tension in the string. [3]

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(b) Find the angular speed of the bob. [3]

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### Solutions

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

**2.2**  $120 \text{ rev/min} = 2 \text{ rev/s} = 2 \times 2\pi = 4\pi = 12.6 \text{ rad s}^{-1}.$

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

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

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

**3.3** (a) vertical:  $T \cos 30^\circ = mg = 4 \Rightarrow T = \frac{4}{0.866} = 4.62 \text{ N}.$

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