AP PHYSICS 1 • EXERCISE SHEET

# 5.2 Connecting Linear and Rotational Motion

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

## Objective

Build the skills to answer exam questions on **connecting linear and rotational motion**.

**You must be able to:**

- relate **tangential velocity** 切向速度 to angular velocity, $v = r\omega$
- relate **tangential acceleration** 切向加速度 to angular acceleration, $a_t = r\alpha$
- distinguish tangential from **centripetal acceleration** 向心加速度 for a point in a circle
- calculate **arc length** 弧长 with $s = r\theta$

## 1 Worked examples

Study these first. Each one shows the method for a question type used later.

### ■ Linear from angular

$v = r\omega$ and $a_t = r\alpha$. On a rigid body every point has the **same** $\omega$, but a point farther from the axis has a **larger** linear speed.

### ■ Two accelerations

**Tangential** $a_t = r\alpha$ changes the speed; **centripetal** $a_c = \dfrac{v^2}{r} = \omega^2 r$ changes only the direction.

### ■ Example

A wheel of radius 0.30 m spins at $\omega = 10$ rad s$^{-1}$: a rim point moves at $v = 0.30 \times 10 = 3.0$ m s$^{-1}$.

## 2 Practice

**2.1** A point 0.50 m from the axis rotates at $\omega = 6.0$ rad s$^{-1}$. Find its linear speed. [1]

**2.2** A wheel of radius 0.20 m has angular acceleration 5.0 rad $s^{-2}$. Find the tangential acceleration of its rim. [1]

**2.3** Two points on a disc are 0.10 m and 0.30 m from the axis. State which has the greater (a) angular speed and (b) linear speed. [2]

**2.4** Find the arc length swept by a point 2.0 m from the axis when it turns through 3.0 rad. [1]

## 3 Exam-style questions

**3.1** On a rigid rotating disc, every point has the same [1]

- **A** linear speed
- **B** angular speed
- **C** tangential acceleration
- **D** arc length

**3.2** The tangential acceleration of a point at radius $r$ is [1]

- **A** $r\omega$
- **B** $r\alpha$
- **C** $v^2/r$
- **D** $\omega^2 r$

**3.3** A car tyre of radius 0.35 m rotates at $\omega = 20$ rad $s^{-1}$ while rolling without slipping.

(a) Find the linear speed of a point on the tread. [2]

(b) State the speed of the car. [1]

## 4 Go further

- work through the **5.2 Connecting Linear and Rotational Motion** lesson on the **Learn** page;
- read the **Torque and Rotational Dynamics** section of the AP Physics 1 handout on the **Know** page.

## Solutions

**2.1** $v = r\omega = 0.50 \times 6.0 = 3.0$ m s$^{-1}$.

**2.2** $a_t = r\alpha = 0.20 \times 5.0 = 1.0$ m s$^{-2}$.

**2.3** (a) equal —same angular speed for both. (b) the point at 0.30 m, since $v = r\omega$.

**2.4** $s = r\theta = 2.0 \times 3.0 = 6.0$ m.

**3.1 B**.

**3.2 B**.

**3.3** (a) $v = r\omega = 0.35 \times 20 = 7.0$ m s$^{-1}$. (b) 7.0 m s$^{-1}$ (rolling without slipping).