

5.2 Connecting Linear and Rotational Motion

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS tangential acceleration 切向加速度 • arc length 弧长 • centripetal acceleration 向心加速度
 • tangential velocity 切向速度 • angular acceleration 角加速度

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** ω , but a point farther from the axis has a **larger** linear speed.

■ Two accelerations

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

■ Example

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

2 Practice

2.1 A point 0.50 m from the axis rotates at $\omega = 6.0 \text{ rad s}^{-1}$. 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 $\omega = 20 \text{ rad s}^{-1}$ while rolling without slipping.

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

(b) State the speed of the car.

[1]

Solutions

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

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

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

2.4 $s = r\theta = 2.0 \times 3.0 = 6.0 \text{ m}$.

3.1 B.

3.2 B.

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