

Exercise walk-through

# 5.2

## Connecting Linear and Rotational Motion

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AP Physics 1

## You must be able to

- relate **tangential velocity** to angular velocity,  $v = r\omega$
- relate **tangential acceleration** to angular acceleration,  $a_t = r\alpha$
- distinguish tangential from **centripetal acceleration** for a point in a circle
- calculate **arc length** with  $s = r\theta$

1

The method

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## Method — 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.

## Exercises 2.1·2.2

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

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

## Exercises 2.1·2.2

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

**2.1**

$$v = r\omega = (0.50 \text{ m})(6.0 \text{ rad s}^{-1}) = \mathbf{3.0 \text{ m s}^{-1}}$$

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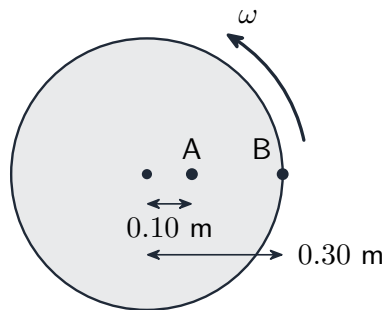
**2.2** A wheel of radius 0.20 m has angular acceleration  $5.0 \text{ rad s}^{-2}$ . Find the tangential acceleration of its rim. [1]

**2.2**

$$a_t = r\alpha = (0.20 \text{ m})(5.0 \text{ rad s}^{-2}) = \mathbf{1.0 \text{ m s}^{-2}}$$

## Exercise 2.3

**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]



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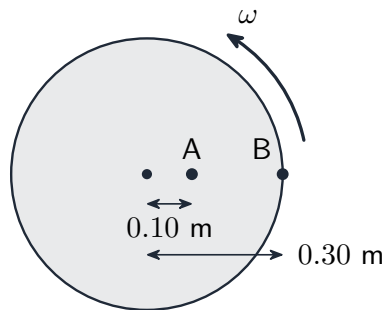
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## Exercise 2.3

**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]



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**2.3**

(a)

- equal – same angular speed for both

(b)

- the point at 0.30 m, since  $v = r\omega$

## Exercises 2.4·3.1

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

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**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

## Exercises 2.4·3.1

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

**2.4**

$$s = r\theta = (2.0 \text{ m})(3.0 \text{ rad}) = \mathbf{6.0 \text{ m}}$$

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**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

**3.1 B**

- angular speed.

## Exercise 3.2

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

[1]

☐

**A**  $r\omega$

**B**  $r\alpha$

**C**  $v^2/r$

**D**  $\omega^2 r$

## Exercise 3.2

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

[1]

☐

**A**  $r\omega$

**B**  $r\alpha$

**C**  $v^2/r$

**D**  $\omega^2 r$

**3.2 B**

- $r\alpha$ .

## Exercise 3.3 (a)

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**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]

## Exercise 3.3 (a)

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**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]

(a)

$$v = r\omega = (0.35 \text{ m})(20 \text{ rad s}^{-1})$$

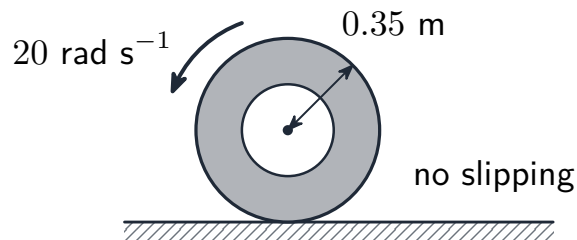
- $v = \mathbf{7.0 \text{ m s}^{-1}}$

## Exercise 3.3 (b)

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

(b) State the speed of the car.

[1]

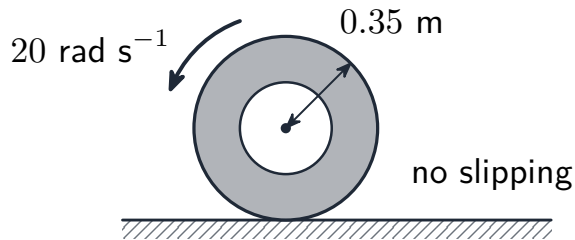


## Exercise 3.3 (b)

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

(b) State the speed of the car.

[1]



(b)

- without slipping, the tyre lays down tread on the road as fast as it turns, so the car moves at the tread's speed:  $v_{\text{car}} = r\omega = \mathbf{7.0\text{ m s}^{-1}}$