Exercise walk-through

Connecting Linear and Rotational Motion ▪ 5.2

eXercise

You must be able to

- relate linear and angular speed: $v = \omega r$
- relate linear and angular acceleration: $a = \alpha r$
- explain that points farther from the axis move faster
- apply these to wheels, gears, and pulleys

Method — Speed from angular speed

A point at radius r on a body spinning at ω moves at

$$v = \omega r.$$

The rim of a wheel of radius 0.3 m spinning at 10 rad s^{-1} moves at $v = 10 \times 0.3 = 3$ m s^{-1}.

Method — Acceleration link

Likewise the tangential acceleration is

$$a = \alpha r.$$

Method — Farther out is faster

For the same ω, a bigger r gives a bigger v. The edge of a disc outruns points near the centre.

Practice 2.1 ▪ 2 marks

A wheel of radius 0.5 m spins at 8 rad s^{-1}. Find the rim speed.

Solution 2.1

Method: Speed from angular speed

Worked steps

$v = \omega r = 8 \times 0.5 = 4$ m s^{-1} M1 A1.

Practice 2.2 ▪ 1 mark

State how the speed of a point on a spinning disc depends on its distance from the axis.

Solution 2.2

Method: Speed from angular speed

Worked steps

It is proportional to the distance from the axis (farther is faster) B1.

Practice 2.3 ▪ 2 marks

A point at $r = 2$ m has angular acceleration 3 rad s^{-2}. Find its tangential acceleration.

Solution 2.3

Method: Speed from angular speed

Worked steps

$a = \alpha r = 3 \times 2 = 6$ m s^{-2} M1 A1.

Practice 2.4 ▪ 2 marks

A rim moves at 6 m s^{-1} on a wheel of radius 0.2 m. Find the angular velocity.

Solution 2.4

Method: Speed from angular speed

Worked steps

$\omega = v/r = 6/0.2 = 30$ rad s^{-1} M1 A1.

Exam-style 3.1 ▪ 1 mark

The relationship between rim speed and angular speed is

A $v = \omega / r$

B $v = \omega r$

C $v = r / \omega$

D $v = \omega r^2$

Solution 3.1

Method: Speed from angular speed

A $v = \omega / r$

B $v = \omega r$ ✓

C $v = r / \omega$

D $v = \omega r^2$

Worked steps

B — $v = \omega r$.

Exam-style 3.2 ▪ 1 mark

Two points on a spinning disc: A is near the centre, B is at the rim. Compared with A, point B moves

A slower

B faster

C at the same speed

D in the opposite direction

Solution 3.2

Method: Farther out is faster

A slower

B faster ✓

C at the same speed

D in the opposite direction

Worked steps

B — the rim (larger r) moves faster.

Exam-style 3.3 ▪ 2 marks

A bicycle wheel of radius 0.35 m rolls so its rim moves at 7 m s^{-1}.
(a) Find its angular velocity.
(b) State the speed of the point where it touches the ground.

Solution 3.3

Method: Speed from angular speed

Worked steps

(a) $\omega = v/r = 7/0.35 = 20$ rad s^{-1} M1 A1. (b) Zero — the contact point is instantaneously at rest B1.

Exam-style 3.4 ▪ 2 marks

A grinding wheel of radius 0.1 m has angular acceleration 20 rad s^{-2}.
(a) Find the tangential acceleration of a point on the rim.
(b) State whether a point halfway to the centre has more or less tangential acceleration.

Solution 3.4

Method: Speed from angular speed

Worked steps

(a) $a = \alpha r = 20 \times 0.1 = 2$ m s^{-2} M1 A1. (b) Less (smaller r) B1.