Exercise walk-through

Rotational Kinematics ▪ 5.1

eXercise

You must be able to

- use **angular velocity** 角速度 ω and **angular acceleration** 角加速度 α
- apply the rotational equations of motion (analogues of the linear ones)
- convert between revolutions, degrees, and radians
- relate constant α to ω and θ over time

Method — The rotational analogues

Position, velocity, and acceleration become angle θ, angular velocity ω, and angular acceleration α. For constant α:

$$\omega = \omega_0 + \alpha t, \qquad \theta = \omega_0 t + \tfrac{1}{2}\alpha t^2.$$

Method — Using the equations

A wheel starts from rest ($\omega_0 = 0$) with $\alpha = 3$ rad s^{-2}. After 4 s:

$$\omega = 0 + 3(4) = 12 \text{ rad s}^{-1}.$$

Method — Radians

One full turn is 2π rad. Angular quantities in the equations must be in radians.

Practice 2.1 ▪ 1 mark

A disc spins at a constant 6 rad s^{-1}. State its angular acceleration.

Solution 2.1

Method: The rotational analogues

Worked steps

Zero (constant ω) B1.

Practice 2.2 ▪ 2 marks

A wheel starts from rest with $\alpha = 2$ rad s^{-2}. Find ω after 5 s.

Solution 2.2

Method: Using the equations

Worked steps

$\omega = \omega_0 + \alpha t = 0 + 2(5) = 10$ rad s^{-1} M1 A1.

Practice 2.3 ▪ 1 mark

How many radians are in one full revolution?

Solution 2.3

Method: Radians

Worked steps

2π rad **B1**.

Practice 2.4 ▪ 2 marks

A flywheel at 10 rad s^{-1} decelerates at 2 rad s^{-2}. Find ω after 3 s.

Solution 2.4

Method: Using the equations

Worked steps

$\omega = 10 + (-2)(3) = 4$ rad s^{-1} M1 A1.

Exam-style 3.1 ▪ 1 mark

The rotational analogue of linear acceleration is

A angular velocity

B angular acceleration

C torque

D angular momentum

Solution 3.1

Method: The rotational analogues

A angular velocity

B angular acceleration ✓

C torque

D angular momentum

Worked steps

B — angular acceleration.

Exam-style 3.2 ▪ 1 mark

A wheel starts from rest and reaches 20 rad s^{-1} in 4 s. Its angular acceleration is

A 5 rad s^{-2}

B 80 rad s^{-2}

C 16 rad s^{-2}

D 0.2 rad s^{-2}

Solution 3.2

Method: Using the equations

A 5 rad s^{-2} ✓

B 80 rad s^{-2}

C 16 rad s^{-2}

D 0.2 rad s^{-2}

Worked steps

A — $\alpha = 20/4 = 5$ rad s^{-2}.

Exam-style 3.3 ▪ 2 marks

A turntable starts from rest with $\alpha = 4$ rad s^{-2}.
(a) Find its angular velocity after 3 s.
(b) Find the angle turned in that time.

Solution 3.3

Method: Using the equations

Worked steps

(a) $\omega = 4(3) = 12$ rad s^{-1} M1 A1. (b) $\theta = \frac{1}{2}(4)(3)^2 = 18$ rad M1 A1.

Exam-style 3.4 ▪ 2 marks

A fan blade slows from 30 rad s^{-1} to rest in 6 s at constant deceleration.
(a) Find the angular acceleration.
(b) State its sign and what it means.

Solution 3.4

Method: The rotational analogues

Worked steps

(a) $\alpha = (0 - 30)/6 = -5$ rad s^{-2} M1 A1. (b) Negative — it is decelerating (slowing the spin) B1.