

5.1 Rotational Kinematics

Name: _____ Class: _____ Date: _____

Total: 15 marks

Objective

Build the skills to answer exam questions on **rotational kinematics**.

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

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ The rotational analogues

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

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

■ Using the equations

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

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

■ Radians

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

2 Practice

Now apply the methods above.

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

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

2.3 How many radians are in one full revolution? [1]

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

3 Exam-style questions

3.1 The rotational analogue of linear acceleration is [1]

- **A** angular velocity
- **B** angular acceleration
- **C** torque
- **D** angular momentum

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

- **A** 5 rad s^{-2}
- **B** 80 rad s^{-2}
- **C** 16 rad s^{-2}
- **D** 0.2 rad s^{-2}

3.3 A turntable starts from rest with $\alpha = 4 \text{ rad s}^{-2}$.

(a) Find its angular velocity after 3 s. [2]

(b) Find the angle turned in that time. [2]

3.4 A fan blade slows from 30 rad s^{-1} to rest in 6 s at constant deceleration.

(a) Find the angular acceleration. [2]

(b) State its sign and what it means. [1]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **5.1 Rotational Kinematics** lesson on the **Learn** page;
- read the **Torque and Rotational Dynamics** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 Zero (constant ω).

2.2 $\omega = \omega_0 + \alpha t = 0 + 2(5) = 10 \text{ rad s}^{-1}$.

2.3 $2\pi \text{ rad}$.

2.4 $\omega = 10 + (-2)(3) = 4 \text{ rad s}^{-1}$.

3.1 B —angular acceleration.

3.2 A — $\alpha = 20/4 = 5 \text{ rad s}^{-2}$.

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

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