

5.1 Rotational Kinematics

Name: _____ Class: _____ Date: _____

Total: 10 marks

Objective

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

You must be able to:

- define **angular displacement** 角位移 θ , **angular velocity** 角速度 ω , and **angular acceleration** 角加速度 α
- describe the direction of angular quantities as clockwise or counterclockwise
- apply the **rotational kinematic equations** for constant angular acceleration
- interpret graphs of angular position, velocity, and acceleration

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Angular quantities

θ in radians, $\omega = \frac{\Delta\theta}{\Delta t}$ in rad s^{-1} , and $\alpha = \frac{\Delta\omega}{\Delta t}$ in rad s^{-2} . Counterclockwise is taken as positive.

■ The rotational kinematic equations (constant α)

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

These mirror the linear equations, with $x \rightarrow \theta$, $v \rightarrow \omega$, $a \rightarrow \alpha$.

■ Example

A wheel starts from rest with $\alpha = 2.0 \text{ rad s}^{-2}$. After 3.0 s: $\omega = 0 + 2.0(3.0) = 6.0 \text{ rad s}^{-1}$.

2 Practice

2.1 A disc accelerates from rest at $\alpha = 4.0 \text{ rad s}^{-2}$ for 5.0 s. Find its final angular velocity. [1]

2.2 Find the angle turned by the disc in that time. [2]

2.3 State the rotational quantity that plays the role of velocity in the linear equations. [1]

3 Exam-style questions

3.1 Angular acceleration is the rate of change of [1]

- **A** angular displacement
- **B** angular velocity
- **C** torque
- **D** period

3.2 A wheel spinning at 10 rad s^{-1} decelerates at 2.0 rad s^{-2} . The time to stop is [1]

- **A** 2.0 s
- **B** 5.0 s
- **C** 8.0 s
- **D** 20 s

3.3 A fan blade slows from 20 rad s^{-1} to 8.0 rad s^{-1} in 4.0 s.

(a) Find the angular acceleration. [2]

(b) Find the angle turned during this time. [2]

4 Go further

- work through the **5.1 Rotational Kinematics** lesson on the **Learn** page;

- read the **Torque and Rotational Dynamics** section of the AP Physics 1 handout on the **Know** page.

Solutions

2.1 $\omega = 0 + 4.0(5.0) = 20 \text{ rad s}^{-1}$.

2.2 $\theta = \frac{1}{2}(4.0)(5.0)^2 = 50 \text{ rad}$.

2.3 angular velocity ω .

3.1 B.

3.2 B $-t = \frac{0 - 10}{-2.0} = 5.0 \text{ s}$.

3.3 (a) $\alpha = \frac{8.0 - 20}{4.0} = -3.0 \text{ rad s}^{-2}$. (b) $\theta = \frac{1}{2}(\omega_0 + \omega)t = \frac{1}{2}(20 + 8.0)(4.0) = 56 \text{ rad}$.