AP PHYSICS 1 • EXERCISE SHEET

5.1 Rotational Kinematics

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS angular velocity 角速度 • torque 力矩 • angular acceleration 角加速度 • angular displacement 角位移 • radians 弧度

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

■ **The rotational kinematic equations (constant α)**

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

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

■ **Example**

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

2 Practice

2.1 A disc accelerates from rest at $\alpha = 4.0$ 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]

Solutions

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

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

2.3 angular velocity ω.

3.1 B.

3.2 B — $t = \dfrac{0 - 10}{-2.0} = 5.0$ s.

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