AP PHYSICS 1 • EXERCISE SHEET

6.4 Conservation of Angular Momentum

Name: ______________ Class: __________ Date: ____________ **Total: 11 marks**

KEY WORDS angular momentum 角动量 • conserved 守恒

Objective

Build the skills to answer exam questions on **conservation of angular momentum**.

You must be able to:

- state that **angular momentum 角动量** is conserved when the net external torque is zero
- explain the spinning-skater example (I down, ω up)
- apply conservation of angular momentum to collisions and to a changing rotational inertia

1 Worked examples

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

■ Conservation of angular momentum

When the net external torque is zero, $I_i\omega_i = I_f\omega_f$.

■ The spinning skater

Pulling the arms in **reduces** I; since $L = I\omega$ stays constant, ω **increases**. Halving I doubles ω.

■ Adding mass to a turntable

A lump landing on a spinning disc raises I (by mr^2), so ω drops — but L is unchanged.

2 Practice

2.1 State the condition for the angular momentum of a system to be conserved. [1]

2.2 A skater with $I = 4.0$ kg m^2 spins at 2.0 rad s^{-1}, then pulls in to $I = 1.0$ kg m^2. Find the new angular velocity. [2]

2.3 Using $L = I\omega$, explain why the skater speeds up. [2]

3 Exam-style questions

3.1 Angular momentum is conserved when [1]

- **A** kinetic energy is constant
- **B** the net external torque is zero
- **C** the angular velocity is constant
- **D** there is no friction anywhere

3.2 A spinning skater pulls in their arms. Their angular speed [1]

- **A** increases
- **B** decreases
- **C** stays the same
- **D** reverses

3.3 A turntable of $I = 0.10$ kg m^2 spins freely at 6.0 rad s^{-1}. A 0.20 kg lump of clay drops onto it 0.30 m from the axis.

(a) Find the rotational inertia added by the clay ($I = mr^2$). [1]

(b) Find the new angular speed. [3]

Solutions

2.1 the net external torque on the system must be zero.

2.2 $I_i\omega_i = I_f\omega_f \Rightarrow 4.0(2.0) = 1.0\,\omega_f$, so $\omega_f = 8.0$ rad s^{-1}.

2.3 $L = I\omega$ is conserved; reducing I must raise ω to keep the product constant.

3.1 **B**.

3.2 **A**.

3.3 (a) $I_{clay} = mr^2 = 0.20(0.30)^2 = 0.018$ kg m^2. (b) $I_i\omega_i = I_f\omega_f \Rightarrow 0.10(6.0) = (0.10 + 0.018)\,\omega_f$, so $\omega_f = \dfrac{0.60}{0.118} = 5.1$ rad s^{-1}.