AP PHYSICS C: MECHANICS • EXERCISE SHEET

6.4 Conservation of Angular Momentum

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

KEY WORDS conserved 守恒 • rotational inertia 转动惯量 • angular momentum 角动量 • torque 力矩 • rotational kinetic energy 转动动能

Objective

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

You must be able to:

- state that **angular momentum is conserved** 角动量守恒 when no net external torque acts
- apply $I_i\omega_i = I_f\omega_f$
- explain the skater effect (pulling arms in speeds the spin)
- note that kinetic energy need not be conserved

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.

■ Conservation condition

If the net external torque is zero,

$$I_i\omega_i = I_f\omega_f.$$

■ The skater effect

A skater pulls her arms in, lowering I. Since $I\omega$ is fixed, ω rises:

$$I_i\omega_i = I_f\omega_f \Rightarrow \omega_f = \frac{I_i\omega_i}{I_f}.$$

If I halves, ω doubles.

■ Energy is not conserved here

The skater does work pulling her arms in, so the rotational kinetic energy actually **increases** even though L stays constant.

2 Practice

Now apply the methods above.

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

2.2 A skater at $I_i = 6$ kg m^2 spins at 2 rad s^{-1}, then pulls in to $I_f = 2$ kg m^2. Find the new ω. [2]

2.3 If a spinning body's rotational inertia halves (no external torque), what happens to ω? [1]

2.4 Is rotational kinetic energy always conserved when angular momentum is? Answer yes or no. [1]

3 Exam-style questions

3.1 Angular momentum is conserved when the net external torque is [1]

A B C D

A maximum
B zero
C increasing
D equal to $I\alpha$

3.2 A star collapses to one third of its rotational inertia. Its spin rate becomes [1]

A B C D

A one third
B unchanged
C three times faster
D nine times faster

3.3 A turntable ($I = 4$ kg m^2) spins at 3 rad s^{-1}. A blob of clay is dropped on, raising I to 6 kg m^2.

(a) Find the new angular speed. [2]

(b) State whether angular momentum is conserved and why. [1]

3.4 A diver tucks to spin faster during a somersault.

(a) Explain, using $I\omega$, why tucking speeds the spin. [2]

(b) State what provides no external torque here. [1]