

6.4 Conservation of Angular Momentum

Name: _____ Class: _____ Date: _____

Total: 14 marks

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 $I_i = 6 \text{ kg m}^2$ spins at 2 rad s^{-1} , then pulls in to $I_f = 2 \text{ kg m}^2$. 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** 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** one third
 - **B** unchanged
 - **C** three times faster
 - **D** nine times faster
-

3.3 A turntable ($I = 4 \text{ kg m}^2$) 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]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **6.4 Conservation of Angular Momentum** lesson on the **Learn** page;
- read the **Energy and Momentum of Rotating Systems** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 When the net external torque is zero.

2.2 $6(2) = 2\omega_f \Rightarrow \omega_f = 6 \text{ rad s}^{-1}$.

2.3 It doubles.

2.4 No.

3.1 B —zero net external torque.

3.2 C — $I \rightarrow I/3$ means $\omega \rightarrow 3\omega$.

3.3 (a) $4(3) = 6\omega_f \Rightarrow \omega_f = 2 \text{ rad s}^{-1}$. (b) Yes —no external torque acts on the turntable-plus-clay system.

3.4 (a) Tucking lowers I ; since $I\omega$ is fixed, ω rises. (b) Gravity acts through the center of mass, giving no torque about it.