AP PHYSICS C: MECHANICS • HOLIDAY HOMEWORK 假期作业

6 Rotational energy and angular momentum – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
rotational kinetic energy	转动动能			
Angular momentum	角动量			
conserved	守恒			

Recall

In the last topic you met angular velocity ω and rotational inertia I. Now spinning things get **energy** and **momentum**, just like moving things:

- A moving object has kinetic energy $\frac{1}{2}mv^2$ and momentum mv.
- A spinning object has rotational copies of both.
- A spinning skater who pulls her arms in speeds up – this sheet explains exactly why.

Each idea has a worked example before the Practice.

New ideas

1 Rotational kinetic energy

A spinning object stores **rotational kinetic energy** 转动动能:

$$K_{\text{rot}} = \tfrac{1}{2} I\omega^2,$$

the twin of $\frac{1}{2}mv^2$. A rolling ball has **both**: $\frac{1}{2}mv^2$ from moving plus $\frac{1}{2}I\omega^2$ from spinning.

Worked example. A wheel with $I = 2.0$ kg m^2 spins at $\omega = 3.0$ rad/s: $K_{\text{rot}} = \frac{1}{2} \times 2.0 \times 3.0^2 = 9.0$ J.

2 Work done by a torque

A torque turning through an angle does work: $W = \tau\,\Delta\theta$ (the twin of $W = Fd$).

Worked example. A motor gives a steady torque of 8.0 N m while a flywheel turns 10 rad: $W = \tau\,\Delta\theta = 8.0 \times 10 = 80$ J.

3 Angular momentum

Angular momentum 角动量 is the rotational version of momentum:

$$L = I\omega.$$

4 Conservation of angular momentum

If no outside torque acts, angular momentum is **conserved** 守恒:

$$I_1\omega_1 = I_2\omega_2.$$

So if I goes down, ω goes up to keep L the same.

Worked example. A skater spins at 2.0 rev/s with $I_1 = 4.0$ kg m^2. She pulls her arms in, dropping I to $I_2 = 1.6$ kg m^2: $\omega_2 = \dfrac{I_1}{I_2}\omega_1 = \dfrac{4.0}{1.6} \times 2.0 = 5.0$ rev/s.

Watch out: pulling the arms in raises **both** the spin rate and the kinetic energy – the extra energy comes from the work her muscles do pulling inward. Angular momentum stays the same; energy does not.

Practice

Try these in order. The methods are all above.

2.1 A flywheel with $I = 3.0$ kg m^2 spins at 4.0 rad/s. Find its rotational kinetic energy. [2]

2.2 A torque of 6.0 N m turns a wheel through 5.0 rad. Find the work done. [2]

2.3 Find the angular momentum of a disc with $I = 0.50$ kg m^2 spinning at 8.0 rad/s. [2]

2.4 A spinning student on a stool has $I_1 = 6.0$ kg m^2 at $\omega_1 = 1.0$ rad/s. He pulls weights in so $I_2 = 2.0$ kg m^2. Find his new angular velocity. [3]

2.5 State what stays the same and what changes when the student in 2.4 pulls the weights in. [2]