AP PHYSICS C: MECHANICS • EXERCISE SHEET

6.1 Rotational Kinetic Energy

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS rotational kinetic energy 转动动能

Objective

Build the skills to answer exam questions on **rotational kinetic energy**.

You must be able to:

- use **rotational kinetic energy** 转动动能: $K = \frac{1}{2}I\omega^2$
- recognise it as the analogue of $\frac{1}{2}mv^2$
- add translational and rotational kinetic energy for a rolling object
- find K, I, or ω given the others

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.

■ The rotational KE formula

$$K = \tfrac{1}{2}I\omega^2.$$

A disc with $I = 0.5$ kg m^2 spinning at $\omega = 4$ rad s^{-1} stores

$$K = \tfrac{1}{2}(0.5)(4)^2 = 4 \text{ J}.$$

■ The square of omega

Because ω is squared, doubling the spin rate quadruples the stored energy.

■ Rolling: two kinds of KE

A rolling object has both, so its total is

$$K = \tfrac{1}{2}mv^2 + \tfrac{1}{2}I\omega^2.$$

2 Practice

Now apply the methods above.

2.1 A wheel with $I = 2$ kg m^2 spins at 3 rad s^{-1}. Find its rotational KE. [2]

2.2 If a spinning object's angular speed triples, by what factor does its rotational KE change? [1]

2.3 State the two terms in the total kinetic energy of a rolling object. [2]

2.4 A flywheel stores 18 J of rotational KE at $I = 4$ kg m^2. Find its angular speed. [2]

3 Exam-style questions

3.1 Rotational kinetic energy is [1]

- **A** $\frac{1}{2}mv^2$
- **B** $\frac{1}{2}I\omega^2$
- **C** $I\omega$
- **D** $\frac{1}{2}kx^2$

3.2 A rolling ball's total kinetic energy is [1]

- **A** only $\frac{1}{2}mv^2$
- **B** only $\frac{1}{2}I\omega^2$
- **C** $\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$
- **D** zero

3.3 A solid disc has $I = 0.8$ kg m^2 and spins at 5 rad s^{-1}.

(a) Find its rotational kinetic energy. [2]

(b) State its energy if the spin rate doubles. [1]

3.4 A rolling wheel has translational KE = 12 J and rotational KE = 6 J.

(a) Find the total kinetic energy. [1]

(b) State the fraction stored in rotation. [1]

Solutions

2.1 $K = \frac{1}{2}I\omega^2 = \frac{1}{2}(2)(3)^2 = 9$ J.

2.2 Nine times (ω is squared).

2.3 Translational $\frac{1}{2}mv^2$ and rotational $\frac{1}{2}I\omega^2$.

2.4 $\omega = \sqrt{2K/I} = \sqrt{2(18)/4} = \sqrt{9} = 3$ rad s^{-1}.

3.1 **B** — $K = \frac{1}{2}I\omega^2$.

3.2 **C** — a rolling object has both terms.

3.3 (a) $K = \frac{1}{2}(0.8)(5)^2 = 10$ J. (b) Four times, 40 J.

3.4 (a) $12 + 6 = 18$ J. (b) $6/18 = \frac{1}{3}$.