AP PHYSICS 1 • EXERCISE SHEET

6.1 Rotational Kinetic Energy

Name: _____ Class: _____ Date: _____ **Total: 11 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:

- define **rotational kinetic energy** 转动动能 as $K_{rot} = \frac{1}{2}I\omega^2$
- explain that it depends on both the **rotational inertia** and the **angular velocity**
- find the **total kinetic energy** of an object that both translates and rotates
- apply **conservation of energy** to systems that include rotation

1 Worked examples

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

■ **Rotational kinetic energy**

$K_{rot} = \frac{1}{2}I\omega^2$ — the rotational partner of $\frac{1}{2}mv^2$.

■ **Total kinetic energy of a rolling body**

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

■ **A rolling race**

Rolling down a ramp, a shape with smaller $I/(mR^2)$ ties up less energy in rotation, so it reaches the bottom **faster**. A solid sphere beats a hoop.

2 Practice

2.1 A flywheel of $I = 0.50$ kg m^2 spins at $\omega = 4.0$ rad s^{-1}. Find its rotational kinetic energy. [2]

2.2 A rolling ball has 6.0 J of translational and 2.4 J of rotational kinetic energy. Find its total kinetic energy. [1]

2.3 State why a solid sphere rolls down a ramp faster than a hoop of the same mass and radius. [2]

3 Exam-style questions

3.1 Rotational kinetic energy is [1]

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

3.2 A hoop and a disc of equal mass and radius roll from rest down the same ramp. The one reaching the bottom first is the [1]

- **A** hoop
- **B** disc
- **C** they arrive together
- **D** it depends on the mass

3.3 A disc of $I = 0.10$ kg m^2 spins at $\omega = 12$ rad s^{-1}.

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

(b) If this energy came from a 0.20 kg mass falling, find the height it fell (take $g = 10$ m s^{-2}). [2]

Solutions

2.1 $K_{rot} = \frac{1}{2}(0.50)(4.0)^2 = 4.0$ J.

2.2 $K = 6.0 + 2.4 = 8.4$ J.

2.3 The sphere has a smaller rotational inertia for its mass, so less energy goes into rotation and more into translation, giving a larger speed.

3.1 B.

3.2 B — the disc has the smaller rotational inertia.

3.3 (a) $K_{rot} = \frac{1}{2}(0.10)(12)^2 = 7.2$ J. (b) $mgh = 7.2 \Rightarrow h = \dfrac{7.2}{0.20 \times 10} = 3.6$ m.