

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

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

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

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

■ 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

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

2 Practice

Now apply the methods above.

2.1 A wheel with $I = 2 \text{ kg m}^2$ 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 $I = 4 \text{ kg m}^2$. 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 $I = 0.8 \text{ kg m}^2$ 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 $K = \frac{1}{2}I\omega^2 = \frac{1}{2}(2)(3)^2 = 9 \text{ J}.$

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

3.1 B — $K = \frac{1}{2}I\omega^2.$

3.2 C — a rolling object has both terms.

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

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