Exercise walk-through

Rotational Kinetic Energy ▪ 6.1

eXercise

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

Method — 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

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

Method — The square of omega

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

Method — Rolling: two kinds of KE

A rolling object has both, so its total is

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

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: The rotational KE formula

Worked steps

$K = \frac{1}{2} I\omega^2 = \frac{1}{2}(2)(3)^2 = 9$ J **M1** **A1**.

Practice 2.2 ▪ 1 mark

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

Solution 2.2

Method: The rotational KE formula

Worked steps

Nine times (ω is squared) B1.

Practice 2.3 ▪ 2 marks

State the two terms in the total kinetic energy of a rolling object.

Solution 2.3

Method: Rolling: two kinds of KE

Worked steps

Translational $\frac{1}{2}mv^2$ and rotational $\frac{1}{2}I\omega^2$ B1 B1.

Practice 2.4 ▪ 2 marks

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

Solution 2.4

Method: The rotational KE formula

Worked steps

$\omega = \sqrt{2K/I} = \sqrt{2(18)/4} = \sqrt{9} = 3$ rad s^{-1} M1 A1.

Exam-style 3.1 ▪ 1 mark

Rotational kinetic energy is

A $\frac{1}{2}mv^2$

B $\frac{1}{2}I\omega^2$

C $I\omega$

D $\frac{1}{2}kx^2$

Solution 3.1

A $\frac{1}{2}mv^2$

B $\frac{1}{2}I\omega^2$ ✓

C $I\omega$

D $\frac{1}{2}kx^2$

Worked steps

B — $K = \frac{1}{2}I\omega^2$.

Exam-style 3.2 ▪ 1 mark

A rolling ball's total kinetic energy is

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

Solution 3.2

Method: Rolling: two kinds of KE

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

Worked steps

C — a rolling object has both terms.

Exam-style 3.3 ▪ 2 marks

A solid disc has $I = 0.8$ kg m^2 and spins at 5 rad s^{-1}.
(a) Find its rotational kinetic energy.
(b) State its energy if the spin rate doubles.

Solution 3.3

Worked steps

(a) $K = \frac{1}{2}(0.8)(5)^2 = 10$ J M1 A1. (b) Four times, 40 J B1.

Exam-style 3.4 ▪ 1 mark

A rolling wheel has translational KE $= 12$ J and rotational KE $= 6$ J.
(a) Find the total kinetic energy.
(b) State the fraction stored in rotation.

Solution 3.4

Worked steps

(a) $12 + 6 = 18$ ✓ B1. (b) $6/18 = \frac{1}{3}$ B1.