

# 6.5 Rolling

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 9 marks

## Objective

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Build the skills to answer exam questions on **rolling**.

You must be able to:

- describe **rolling without slipping** 无滑滚动 using  $v = \omega r$
- split the total kinetic energy of a rolling body into **translational** and **rotational** parts
- compare how objects of different rotational inertia accelerate down an incline

## 1 Worked examples

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

### ■ Rolling without slipping

The contact point is momentarily at rest, so  $v = \omega r$  links the linear speed of the centre and the angular speed.

### ■ Total kinetic energy

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

### ■ Down an incline

A smaller  $I/(mR^2)$  ties up less energy in spin, so the object accelerates faster: **sphere** > **disc** > **hoop**.

## 2 Practice

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**2.1** A wheel of radius 0.25 m rolls without slipping at  $v = 5.0 \text{ m s}^{-1}$ . Find its angular speed. [1]

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**2.2** State the rolling-without-slipping condition. [1]

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**2.3** A hoop and a solid cylinder roll from rest down the same ramp. State which reaches

the bottom first. [1]

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### 3 Exam-style questions

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3.1 For an object rolling without slipping, [1]

- **A**  $v = \omega r$
  - **B**  $v = \omega/r$
  - **C**  $\omega = vr$
  - **D**  $v = \frac{1}{2}\omega r$
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3.2 The total kinetic energy of a rolling object is [1]

- **A** translational only
  - **B** rotational only
  - **C** the sum of translational and rotational
  - **D** neither
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3.3 A solid cylinder ( $I = \frac{1}{2}mR^2$ ) of mass 2.0 kg and radius 0.10 m rolls at  $v = 3.0 \text{ m s}^{-1}$ .

(a) Find its angular speed. [1]

(b) Find its total kinetic energy. [3]

### 4 Go further

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- work through the **6.5 Rolling** lesson on the **Learn** page;
- read the **Energy and Momentum of Rotating Systems** section of the AP Physics 1 handout on the **Know** page.

## Solutions

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**2.1**  $\omega = \frac{v}{r} = \frac{5.0}{0.25} = 20 \text{ rad s}^{-1}$ .

**2.2**  $v = \omega r$  (the centre's speed equals angular speed times radius).

**2.3** the solid cylinder (smaller rotational inertia).

**3.1 A.**

**3.2 C.**

**3.3** (a)  $\omega = \frac{3.0}{0.10} = 30 \text{ rad s}^{-1}$ . (b)  $I = \frac{1}{2}(2.0)(0.10)^2 = 0.010 \text{ kg m}^2$ ;  $K = \frac{1}{2}(2.0)(3.0)^2 + \frac{1}{2}(0.010)(30)^2 = 9.0 + 4.5 = 13.5 \text{ J}$ .