AP PHYSICS 1 • EXERCISE SHEET

6.5 Rolling

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS rolling without slipping 无滑滚动

Objective

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

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**

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

■ **Down an incline**

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

2 Practice

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

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

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

3.1 For an object rolling without slipping, [1]

- **A** $v = \omega r$
- **B** $v = \omega / r$
- **C** $\omega = vr$
- **D** $v = \frac{1}{2}\omega r$

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

3.3 A solid cylinder ($I = \frac{1}{2}mR^2$) of mass 2.0 kg and radius 0.10 m rolls at $v = 3.0$ m s^{-1}.

(a) Find its angular speed. [1]

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

Solutions

2.1 $\omega = \dfrac{v}{r} = \dfrac{5.0}{0.25} = 20$ 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) $\omega = \dfrac{3.0}{0.10} = 30$ rad s^{-1}. (b) $I = \frac{1}{2}(2.0)(0.10)^2 = 0.010$ kg m^2; $K = \frac{1}{2}(2.0)(3.0)^2 + \frac{1}{2}(0.010)(30)^2 = 9.0 + 4.5 = 13.5$ J.