AP PHYSICS 1 • EXERCISE SHEET

5.4 Rotational Inertia

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS rotational inertia 转动惯量 • parallel-axis theorem 平行轴定理 • torque 力矩

Objective

Build the skills to answer exam questions on **rotational inertia**.

You must be able to:

- define **rotational inertia** 转动惯量 (moment of inertia) as the resistance to a change in rotation
- explain that it depends on both the **mass** and its **distribution** about the axis
- calculate the rotational inertia of point masses with $I = \sum mr^2$
- use the **parallel-axis theorem** 平行轴定理, $I = I_{cm} + Md^2$

1 Worked examples

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

■ **Rotational inertia of point masses**

$I = \sum mr^2$. Mass **far** from the axis contributes most (the r^2).

■ **Common rigid bodies**

Solid disc $I = \frac{1}{2}MR^2$; hoop $I = MR^2$; solid sphere $I = \frac{2}{5}MR^2$; rod about its centre $I = \frac{1}{12}ML^2$.

■ **Parallel-axis theorem**

$I = I_{cm} + Md^2$, where d is the distance from the centre of mass to the new axis.

2 Practice

2.1 Two 0.50 kg masses sit 0.40 m from an axis. Find the total rotational inertia. [2]

2.2 State how the rotational inertia changes if the masses are moved farther from the axis. [1]

2.3 A solid disc has $M = 4.0$ kg and $R = 0.30$ m. Find its moment of inertia ($I = \frac{1}{2}MR^2$). [2]

3 Exam-style questions

3.1 The rotational inertia of an object depends on [1]

- **A** its mass only
- **B** its mass and how the mass is distributed about the axis
- **C** its speed only
- **D** the applied torque

3.2 For the same mass and radius, which shape has the **largest** rotational inertia? [1]

- **A** solid disc
- **B** hoop
- **C** solid sphere
- **D** rod about its centre

3.3 A 0.20 kg point mass is 0.50 m from an axis.

(a) Find its rotational inertia about that axis. [2]

(b) State its rotational inertia about a parallel axis passing through the mass itself. [1]

Solutions

2.1 $I = \sum mr^2 = 2 \times (0.50)(0.40)^2 = 0.16$ kg m^2.

2.2 it increases (each contributes mr^2, which grows with r).

2.3 $I = \frac{1}{2}(4.0)(0.30)^2 = 0.18$ kg m^2.

3.1 B.

3.2 B — a hoop has all its mass at the rim, $I = MR^2$.

3.3 (a) $I = mr^2 = 0.20 \times (0.50)^2 = 0.050$ kg m^2. (b) 0 — a point mass has no size, so $I = 0$ about an axis through it.