AP PHYSICS C: MECHANICS • EXERCISE SHEET

5.4 Rotational Inertia

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

Objective

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

You must be able to:

- describe **rotational inertia** 转动惯量 I as resistance to a change in rotation
- use $I = \sum m_i r_i^2$ for point masses
- explain that mass farther from the axis contributes more
- recall that I depends on the mass distribution and the axis chosen

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.

■ Rotational inertia of point masses

$$I = \sum m_i r_i^2.$$

A 2 kg mass at $r = 3$ m from the axis has $I = 2 \times 3^2 = 18$ kg m^2.

■ Distance matters most

Because r is squared, mass far from the axis dominates. Moving a mass from 1 m to 2 m quadruples its contribution.

■ It depends on the axis

The same object has different I about different axes. A rod is easier to spin about its centre than about one end.

2 Practice

Now apply the methods above.

2.1 A 3 kg mass sits 2 m from the axis. Find its rotational inertia. [2]

2.2 State what rotational inertia measures. [1]

2.3 Two 1 kg masses sit at $r = 1$ m and $r = 2$ m. Find the total I. [2]

2.4 If a mass is moved twice as far from the axis, by what factor does its contribution to I change? [1]

3 Exam-style questions

3.1 Rotational inertia depends on [1]

- **A** only the total mass
- **B** the mass and how it is distributed about the axis
- **C** only the speed
- **D** the colour of the object

3.2 A point mass's contribution to rotational inertia is [1]

- **A** mr
- **B** mr^2
- **C** $\frac{1}{2}mr^2$
- **D** m/r

3.3 A 4 kg mass sits at $r = 1.5$ m and a 2 kg mass at $r = 3$ m on a light rod.

(a) Find the total rotational inertia. [2]

(b) State which mass contributes more, and why. [1]

3.4 A solid disc and a ring have the same mass and radius.

(a) State which has the larger rotational inertia. [1]

(b) Explain why, in terms of mass distribution. [2]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **5.4 Rotational Inertia** lesson on the **Learn** page;
- read the **Torque and Rotational Dynamics** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 $I = mr^2 = 3 \times 2^2 = 12$ kg m^2.

2.2 An object's resistance to a change in its rotation.

2.3 $I = 1(1)^2 + 1(2)^2 = 1 + 4 = 5$ kg m^2.

2.4 Four times (r is squared).

3.1 B —mass and its distribution about the axis.

3.2 B —mr^2.

3.3 (a) $I = 4(1.5)^2 + 2(3)^2 = 9 + 18 = 27$ kg m^2. (b) The 2 kg mass, because it is farther out (r^2 dominates).

3.4 (a) The ring. (b) All the ring's mass is at the rim (maximum r), while the disc's mass is spread inward, lowering its I.