Exercise walk-through

Rotational Inertia ▪ 5.4

eXercise

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**, $I = I_{cm} + Md^2$

Method — Rotational inertia of point masses

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

Method — 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 $I = \frac{1}{12}ML^2$.

Method — Parallel-axis theorem

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

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: Rotational inertia of point masses

Worked steps

$I = \sum mr^2 = 2 \times (0.50)(0.40)^2 = 0.16$ kg m^2 M1 A1.

Practice 2.2 ▪ 1 mark

State how the rotational inertia changes if the masses are moved farther from the axis.

Solution 2.2

Method: Rotational inertia of point masses

Worked steps

it increases (each contributes mr^2, which grows with r) B1.

Practice 2.3 ▪ 2 marks

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

Solution 2.3

Method: Common rigid bodies

Worked steps

$I = \frac{1}{2}(4.0)(0.30)^2 = 0.18$ kg m^2 M1 A1.

Exam-style 3.1 ▪ 1 mark

The rotational inertia of an object depends on

A its mass only

B its mass and how the mass is distributed about the axis

C its speed only

D the applied torque

Solution 3.1

Method: Rotational inertia of point masses

A its mass only

B its mass and how the mass is distributed about the axis ✓

C its speed only

D the applied torque

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

For the same mass and radius, which shape has the **largest** rotational inertia?

A solid disc

B hoop

C solid sphere

D rod about its centre

Solution 3.2

Method: Rotational inertia of point masses

A solid disc

B hoop ✓

C solid sphere

D rod about its centre

Worked steps

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

Exam-style 3.3 ▪ 2 marks

A 0.20 kg point mass is 0.50 m from an axis.
(a) Find its rotational inertia about that axis.
(b) State its rotational inertia about a parallel axis passing through the mass itself.

Solution 3.3

Method: Rotational inertia of point masses

Worked steps

(a) $I = mr^2 = 0.20 \times (0.50)^2 = 0.050$ kg m^2 M1 A1. (b) 0 — a point mass has no size, so $I = 0$ about an axis through it B1.