AP PHYSICS 1 • EXERCISE SHEET

5.6 Newton's Second Law in Rotational Form

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

Objective

Build the skills to answer exam questions on **Newton's second law in rotational form**.

You must be able to:

- state **Newton's second law for rotation** 转动的牛顿第二定律, $\tau_{net} = I\alpha$
- determine the **angular acceleration** produced by a given net torque
- explain that a larger **rotational inertia** gives a smaller angular acceleration for the same torque
- analyse systems combining translation and rotation, such as a mass on a pulley

1 Worked examples

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

■ **Rotational Newton's second law**

$\tau_{net} = I\alpha$ —the rotational analogue of $F = ma$ (with $\tau \leftrightarrow F$, $I \leftrightarrow m$, $\alpha \leftrightarrow a$).

■ **Larger inertia, smaller acceleration**

For a fixed net torque, a bigger I gives a smaller α.

■ **Example**

A net torque of 6.0 N m on a body of $I = 2.0$ kg m^2 gives $\alpha = \dfrac{6.0}{2.0} = 3.0$ rad s^{-2}.

2 Practice

2.1 A net torque of 12 N m acts on a wheel of $I = 3.0$ kg m^2. Find its angular acceleration. [1]

2.2 State how the angular acceleration changes if the rotational inertia doubles for the

same torque. [1]

2.3 A disc of $I = 0.50$ kg m^2 gains an angular acceleration of 8.0 rad s^{-2}. Find the net torque acting on it. [1]

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3 Exam-style questions

3.1 The rotational form of Newton's second law is [1]

- **A** $F = ma$
- **B** $\tau = I\alpha$
- **C** $p = mv$
- **D** $L = I\omega$

3.2 For a fixed net torque, doubling the rotational inertia makes the angular acceleration [1]

- **A** twice as large
- **B** half as large
- **C** unchanged
- **D** four times as large

3.3 A torque of 5.0 N m acts on a disc of rotational inertia 0.25 kg m^2, initially at rest.

(a) Find the angular acceleration. [2]

(b) Find the angular velocity after 4.0 s. [2]

4 Go further

- work through the **5.6 Newton's Second Law in Rotational Form** lesson on the **Learn** page;
- read the **Torque and Rotational Dynamics** section of the AP Physics 1 handout on the **Know** page.

Solutions

2.1 $\alpha = \dfrac{\tau}{I} = \dfrac{12}{3.0} = 4.0 \text{ rad s}^{-2}$.

2.2 it halves ($\alpha \propto 1/I$).

2.3 $\tau = I\alpha = 0.50 \times 8.0 = 4.0 \text{ N m}$.

3.1 B.

3.2 B.

3.3 (a) $\alpha = \dfrac{5.0}{0.25} = 20 \text{ rad s}^{-2}$. (b) $\omega = \omega_0 + \alpha t = 0 + 20(4.0) = 80 \text{ rad s}^{-1}$.