

Exercise walk-through

5.6

Newton's Second Law in Rotational Form

AP Physics 1

You must be able to

- state **Newton's second law for rotation** $\tau_{net} = I\alpha$
- 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

The method

Method — Rotational Newton's second law

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

Exercises 2.1·2.2

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

2.2 State how the angular acceleration changes if the rotational inertia doubles for the same torque. [1]

Exercises 2.1·2.2

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

2.1

- rotational second law, $\tau = I\alpha$, rearranged:

$$\alpha = \frac{\tau}{I} = \frac{12 \text{ N m}}{3.0 \text{ kg m}^2} = \mathbf{4.0 \text{ rad s}^{-2}}$$

2.2 State how the angular acceleration changes if the rotational inertia doubles for the same torque. [1]

2.2

- it halves ($\alpha \propto 1/I$)

Exercises 2.3·3.1

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

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

☐

A $F = ma$

B $\tau = I\alpha$

C $p = mv$

D $L = I\omega$

Exercises 2.3-3.1

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

2.3

$$\tau = I\alpha = (0.50 \text{ kg m}^2)(8.0 \text{ rad s}^{-2}) = \mathbf{4.0 \text{ N m}}$$

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

☐

A $F = ma$

B $\tau = I\alpha$

C $p = mv$

D $L = I\omega$

3.1 B

- $\tau = I\alpha.$

Exercise 3.2

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

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3.2 B

- half as large.

Exercise 3.3 (a)

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]

Exercise 3.3 (a)

3.3 A torque of 5.0 N m acts on a disc of rotational inertia 0.25 kg m², initially at rest.

(a) Find the angular acceleration. [2]

(a)

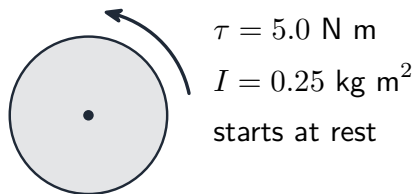
$$\alpha = \frac{\tau}{I} = \frac{5.0 \text{ N m}}{0.25 \text{ kg m}^2}$$

- $\alpha = \mathbf{20} \text{ rad s}^{-2}$

Exercise 3.3 (b)

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

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

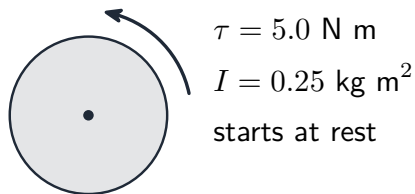


Exercise 3.3 (b)

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

(b) Find the angular velocity after 4.0 s .

[2]



(b)

$$\omega = \omega_0 + \alpha t = 0 + (20 \text{ rad s}^{-2})(4.0 \text{ s})$$

- $\omega = 80 \text{ rad s}^{-1}$