FULL REVIEW

# Full Review: Torque and Rotational Dynamics — Algebra-Based

Review the essential algebra-based ideas, relationships, and problem-solving tools for Torque and Rotational Dynamics.

| ◷ TIME | ◎ BEST FOR | ✓ FINISH WITH |
|---|---|---|
| 60 minutes | A complete topic review | A readiness check |

**After this full review, you'll be able to…**
recall the essential ideas, apply them to representative problems, and determine what to study next.

## HOW TO USE THIS GUIDE

Work through the stages in order. Write directly in the spaces provided, check your work in the Solutions section, and finish by choosing the next resource that matches your confidence.

Choose how you want to review: work through this guide, follow the online review, or watch the video review.

**Start the Review Online →**
**Watch the Video Review →**

## YOU WILL NEED

Pencil or pen • Calculator if needed • Approximately 60 minutes

FR-02 • COURSE ALIGNMENT

# Course Alignment

This Physics Sensei Unit Review is an independent learning resource. Use it to reinforce key concepts, prepare for homework, or review before a quiz or exam.

| | |
|---|---|
| **RESOURCE: Physics Sensei Unit Review**<br>**UNIT ID: MEC-U20**<br>**TOPIC: Torque and Rotational Dynamics**<br>**COURSE LEVEL: Algebra-Based** | **BEST USED**<br>✓ **After learning the unit**<br>✓ **Before starting homework**<br>✓ **Before a quiz or exam** |

FR-03 • YOUR REVIEW PLAN

# Your Review Plan

Complete these six stages in order. Each stage builds on the previous one and prepares you for the final readiness check.

**6 stages • Approximately 45–60 minutes**

| | | |
|---|---|---|
| 1<br>**Warm-Up Check**<br>Activate prior knowledge. | 2<br>**Core Concepts**<br>Review the essential ideas. | 3<br>**Guided Practice**<br>Apply what you learned. |
| 4<br>**Confidence Check**<br>Confirm your understanding. | 5<br>**Summary**<br>Review the key ideas. | 6<br>**Next Step**<br>Continue your learning. |

PRINTING TIP

For student copies, print double-sided and keep the Solutions section after the student activities so learners attempt each activity before checking their work.

FR-04 • STAGE 1 OF 6

# Warm-Up Check

Before you begin, take a moment to see what you already remember. Do not worry about getting everything right. This is only a starting point.

ACTIVITY 1

## Core Relationships

Write $\tau = rF \sin\theta$, $\sum\tau = I\alpha$, and common moment-of-inertia units. State a sign convention.

*Write your response in the space below.*

ACTIVITY 2

## Moment of Inertia

Explain qualitatively why moving the same mass farther from the rotation axis increases I.

*Write your response in the space below.*

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

## Rotational Kinematics Link

If $\alpha$ is constant, recall one equation relating $\omega$, $\omega_0$, $\alpha$, and time.

*Write your response in the space below.*

### Ready to strengthen your understanding?

You've refreshed what you already know. Next, reinforce the essential concepts that will help you solve problems with confidence.

**Continue to Core Concepts →**

FR-05 • STAGE 2 OF 6

# Core Concepts

Let's rebuild the key ideas one step at a time. Focus on understanding the relationships before worrying about solving problems.

KEY CONCEPT 1

## Torque and Lever Arm

The scalar torque magnitude is $\tau = rF \sin\theta = Fd_\perp$. The sign comes from rotational sense. Selecting a pivot and drawing r and F clearly prevents most setup errors.

$$\tau = rF \sin\theta = Fd_\perp \quad \bullet \quad \sum \tau = I\alpha$$

EXAMPLE A 30 N force at $r = 0.25$ m and $\theta = 60°$ gives $\tau = (0.25)(30)\sin 60° \approx 6.50$ N·m.

SENSEI NOTE Torque units are N·m, but torque is not energy; do not rewrite it as joules.

KEY CONCEPT 2

## Moment of Inertia

Moment of inertia is the rotational analogue of mass. It depends on the axis and mass distribution. Standard rigid-body formulas or sums such as $I = \Sigma m_i r_i^2$ are used when appropriate.

$$\tau = rF \sin\theta = Fd_\perp \quad \bullet \quad \sum \tau = I\alpha$$

EXAMPLE Two point masses farther from the axis give a larger I than the same masses closer to it.

SENSEI NOTE Always verify that the moment-of-inertia formula matches the stated axis.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

## Rotational Dynamics

For fixed-axis rigid-body rotation, $\sum\tau = I\alpha$. Determine every torque about the same axis, add them algebraically, then solve for $\alpha$. If $\alpha$ is constant, rotational kinematics can connect the dynamics result to $\omega$ and angular displacement.

$$\tau = rF\sin\theta = Fd_{\perp} \quad \bullet \quad \sum\tau = I\alpha$$

EXAMPLE Net torque 15 N·m on $I = 5\ \text{kg·m}^2$ gives $\alpha = 3\ \text{rad/s}^2$.

SENSEI NOTE Do not mix linear and angular variables without the appropriate radius relation, such as $a_t = r\alpha$ when applicable.

### Ready to apply these ideas?

You've reinforced the essential concepts. Now put them into practice by working through guided examples and building your problem-solving confidence.

Continue to Guided Practice →

FR-06 • STAGE 3 OF 6

# Guided Practice

Now it's time to apply what you've reviewed. Work through each activity in order. The examples become gradually more challenging, and each prepares you for the final readiness check.

PRACTICE 1

## Worked Example

A 40 N force acts 0.30 m from a pivot at 50° to the radius. Find the torque magnitude.

*Show your setup and reasoning in the space below.*

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

## Guided Problem

A disk with $I = 2.5\ kg{\cdot}m^2$ experiences $+10\ N{\cdot}m$ and $-4\ N{\cdot}m$ torques. Find $\alpha$.

*Show your setup and reasoning in the space below.*

PRACTICE 3

## Independent Problem

A rigid body starts from rest with constant $\alpha = 2.0\ rad/s^2$ for 5.0 s. Find its final angular speed after the torque calculation has established this $\alpha$.

*Show your setup and reasoning in the space below.*

**Ready to check your understanding?**

You've practiced the essential skills with guidance. Now solve a few short problems on your own and confirm you're ready to move forward.

**Continue to Confidence Check →**

FR-07 • STAGE 4 OF 6

# Confidence Check

You've rebuilt the key ideas and practiced them with guidance. Now try these short questions on your own to check your understanding before moving on.

QUICK CHECK 1

## Torque Geometry

Solve or explain without looking back.

*A force is parallel to the radius vector. What torque does it produce?*

QUICK CHECK 2

## Net Torque

Solve or explain without looking back.

*Torques +7, −2, and −1 N·m act on a wheel with $I = 2$ kg·m$^2$. Find $\alpha$.*

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

## Rotational Response

Solve or explain without looking back.

*If $I$ doubles while the same net torque acts, how does $\alpha$ change?*

HOW DID IT GO?

**I answered ____ of 3 questions correctly.**

Use the Solutions section to check your reasoning, then take one final look at the essential ideas.

**You've checked your understanding.**

Take one final look at the essential ideas before deciding what to do next.

Continue to Summary →

FR-08 • STAGE 5 OF 6

# Summary

Before moving on, take one final look at the most important ideas from this review.

KEY TAKEAWAY 1

## Use the Perpendicular Geometry

$\tau = rF \sin\theta = Fd_\perp$; identify the correct angle or lever arm before calculating.

KEY TAKEAWAY 2

## Add Torques Algebraically

A consistent sign convention is essential for determining the net rotational effect.

KEY TAKEAWAY 3

## Connect Dynamics to Motion

Use $\sum\tau = I\alpha$ first; when $\alpha$ is known and constant, rotational kinematics describes the resulting motion.

MY ONE-SENTENCE SUMMARY

In my own words, the most important idea is:

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**Ready for your next step?**

You've reviewed the essential ideas one last time. Now choose the resource that best matches how confident you feel.

Continue to Next Step →

ANSWER KEY • CHECK AFTER ATTEMPTING

# Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Replace each placeholder with a concise answer and the essential explanation.

WARM-UP • ACTIVITY 1

### Core Relationships

Torque magnitude: $rF \sin\theta$; rotational dynamics: $\sum \tau = I\alpha$; I has units $kg \cdot m^2$. A valid convention is CCW positive, CW negative.

WHY IT WORKS This restores a prerequisite idea used later in the review.

WARM-UP • ACTIVITY 2

### Moment of Inertia

Mass farther from the axis contributes more strongly to rotational inertia, so it becomes harder to produce the same angular acceleration.

WHY IT WORKS This restores a prerequisite idea used later in the review.

WARM-UP • ACTIVITY 3

### Rotational Kinematics Link

One valid relation is $\omega = \omega_0 + \alpha t$. Other constant-$\alpha$ rotational kinematics relations are also acceptable.

WHY IT WORKS This restores a prerequisite idea used later in the review.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

## Worked Example

$\tau = rF \sin\theta = (0.30)(40)\sin 50° \approx 9.19$ N·m.

WHY IT WORKS The solution follows the Unit 20 rotational-dynamics model and a consistent axis/sign convention.

PRACTICE 2

## Guided Problem

$\sum\tau = +10 - 4 = +6$ N·m. Therefore $\alpha = 6/2.5 = 2.4$ rad/s$^2$ in the positive direction.

WHY IT WORKS The solution follows the Unit 20 rotational-dynamics model and a consistent axis/sign convention.

PRACTICE 3

## Independent Problem

$\omega = \omega_0 + \alpha t = 0 + (2.0)(5.0) = 10$ rad/s.

WHY IT WORKS The solution follows the Unit 20 rotational-dynamics model and a consistent axis/sign convention.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

### Torque Geometry

Zero, because $\sin 0° = 0$.

WHY IT WORKS A force parallel to r has no perpendicular component.

QUICK CHECK 2

### Net Torque

$\sum\tau = 4$ N·m, so $\alpha = 4/2 = 2$ rad/s$^2$.

WHY IT WORKS Combine signed torque contributions before applying $\sum\tau = I\alpha$.

QUICK CHECK 3

### Rotational Response

It is cut in half.

WHY IT WORKS $\alpha = \sum\tau/I$, so $\alpha$ varies inversely with I when net torque is fixed.

READINESS GUIDE

3 correct: You're ready to continue. • 2 correct: Review the missed idea, then continue. • 0–1 correct: Revisit Core Concepts or choose more practice.

FR-09 • STAGE 6 OF 6

# Next Step: Continue Learning

Great work! You've completed this review. Choose the next resource that best matches how confident you feel.

| ? | ◎ | ✓ |
|---|---|---|
| **I'm Still Unsure** | **I Need More Practice** | **I'm Ready** |
| Review the key ideas and examples again. | Continue with additional practice for this topic. | Continue to the next recommended resource. |
| **Review Again →** | **Go to Practice →** | **Continue →** |

RECOMMENDED LINKS

**Review this topic again →**

**Find additional practice →**

**Choose another type of physics help →**

Continue reviewing with these companion resources.

**Start the Review Online →**
**Watch the Video Review →**

**PHYSICS HELP THAT MAKES SENSE**

A Physics Sensei review never ends at the last question. It always guides you toward the next useful step.

**PhysicsSensei.com**