FULL REVIEW

Full Review: Rotational Motion — Calculus-Based

60-minute calculus-based review of rotational motion, emphasizing calculus-based rotational kinematics, distributed inertia, torque, work, and angular momentum modeling.

◷ TIME	◎ BEST FOR	✓ FINISH WITH
60 minutes	Full Review	Greater confidence

After this review, you'll be able to…
use derivatives and integrals with rotational kinematics, moment of inertia, torque, work, and angular momentum while maintaining consistent axis and sign conventions.

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 • UNIT ALIGNMENT

Unit Alignment

This Physics Sensei Unit Review covers MEC-U08 — Rotational Motion using the Calculus-Based treatment. Use it to reinforce the unit, prepare for homework, or review before a quiz or exam.

UNIT ID: MEC-U08 **UNIT: Rotational Motion** **TREATMENT: Calculus-Based** **RESOURCE: Unit Review**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

Explore Rotational Motion Online →

Physics Sensei Unit Reviews use independent organization, wording, examples, and explanations.

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 60 minutes

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

Instantaneous Rates

Differentiate θ(t).

For $\theta = 2t + t^3$, find $\omega(t)$ and $\alpha(t)$.

ACTIVITY 2

Continuous Inertia

Recognize the mass-distribution integral.

Which expression defines moment of inertia for a continuous body?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Angular Impulse

Connect torque and angular momentum.

What does $\int \tau_{ext}\, dt$ equal?

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 — page 6 →

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

Differential rotational kinematics

Instantaneous angular velocity and acceleration are derivatives. Integrating ω gives angular displacement, and integrating α gives the change in ω.

$$\omega=d\theta/dt;\ \alpha=d\omega/dt;\ \Delta\theta=\int\omega dt;\ \Delta\omega=\int\alpha dt;\ v_t=r\omega.$$

SENSEI NOTE Retain signs through derivatives and integrals.

KEY CONCEPT 2

Distributed inertia, torque, work, and power

Continuous mass distributions require $I=\int r^2dm$. Torque may depend on position; rotational work is the angular integral of torque and instantaneous power is $\tau\omega$.

$$I=\int r^2dm;\ \Sigma\tau=I\alpha \text{ for fixed } I;\ W=\int\tau d\theta;\ P=\tau\omega.$$

SENSEI NOTE The axis in I must match the axis used for torque.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Angular momentum and changing systems

Angular momentum is defined about an origin or axis. Net external torque is its time derivative. When external torque vanishes, L is constant even if I and ω change.

$$L = I\omega \text{ for fixed-axis rigid-body motion; } \Sigma\tau_{ext}=dL/dt.$$

SENSEI NOTE If I changes, do not replace dL/dt by Iα without accounting for dI/dt.

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 — page 8 →

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

Differentiate and Integrate

Work through the setup before checking the solution.

$\theta(t)=1+2t+t^3$. Find $\omega(t)$, $\alpha(t)$, and $\Delta\theta$ from 0 to 2 s.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Distributed Rod

Work through the setup before checking the solution.

Derive I for a uniform rod of length L about one end.

PRACTICE 3

Variable Torque

Work through the setup before checking the solution.

$\tau(\theta)=\tau_0(1-\theta/\Theta)$ from 0 to Θ. Find rotational work.

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 — page 10 →

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

Angular Impulse

Answer without notes and justify the physical reasoning.

State the relation between ∫τextdt and angular momentum.

QUICK CHECK 2

Changing Inertia

Answer without notes and justify the physical reasoning.

If external torque is zero while I decreases, what must happen to ω for fixed-axis L=Iω?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Power

Answer without notes and justify the physical reasoning.

For torque τ and angular speed ω about the same axis, what is instantaneous power?

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 — page 12 →

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

Differentiate rates; integrate accumulations

Rotational kinematics, inertia, work, and impulse each have a natural calculus form.

KEY TAKEAWAY 2

Axis consistency is non-negotiable

I, τ, L, and angular sign conventions must refer to the same chosen geometry.

KEY TAKEAWAY 3

Use dL/dt as the general dynamics law

$\Sigma\tau = I\alpha$ is a special fixed-I form, not the most general statement.

MY ONE-SENTENCE SUMMARY

In my own words, the most important idea is:

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 — page 16 →

ANSWER KEY • CHECK AFTER ATTEMPTING

Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Use each answer and explanation to identify the step that supports the result.

WARM-UP • ACTIVITY 1

Instantaneous Rates

$\omega = 2 + 3t^2$; $\alpha = 6t$.

WHY IT WORKS $\omega = 2 + 3t^2$; $\alpha = 6t$.

WARM-UP • ACTIVITY 2

Continuous Inertia

$I = \int r^2 \, dm$.

WHY IT WORKS $I = \int r^2 \, dm$.

WARM-UP • ACTIVITY 3

Angular Impulse

The change in angular momentum, ΔL.

WHY IT WORKS The change in angular momentum, ΔL.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Differentiate and Integrate

$\omega=2+3t^2$; $\alpha=6t$; $\Delta\theta=12$ rad.

WHY IT WORKS The selected rotational relationship matches the stated assumptions and axis.

PRACTICE 2

Distributed Rod

$I=\int_0^L x^2(M/L)dx=(1/3)ML^2$.

WHY IT WORKS The selected rotational relationship matches the stated assumptions and axis.

PRACTICE 3

Variable Torque

$W=\int_0$^Θ $\tau_0(1-\theta/\Theta)d\theta = ½\tau_0\Theta$.

WHY IT WORKS The selected rotational relationship matches the stated assumptions and axis.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Angular Impulse

$\int \tau_{ext} dt = \Delta L$.

WHY IT WORKS The reasoning uses the correct sign, axis, conservation condition, or calculus relationship.

QUICK CHECK 2

Changing Inertia

ω increases so L remains constant.

WHY IT WORKS The reasoning uses the correct sign, axis, conservation condition, or calculus relationship.

QUICK CHECK 3

Power

$P=\tau\omega$ with the appropriate sign.

WHY IT WORKS The reasoning uses the correct sign, axis, conservation condition, or calculus relationship.

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: return to Warm-Up Check on page 4.	Go to Practice →	Continue →

RECOMMENDED LINKS

Review again: return to Warm-Up Check on page 4.

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