

FULL REVIEW

Full Review: Rolling Motion

Review the essential ideas, relationships, and problem-solving tools for rolling motion.

 TIME 45–60 minutes	 BEST FOR A complete topic review	 FINISH WITH A readiness check
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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 45–60 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 **UNIT ID:** MEC-U22
TOPIC: Rolling Motion **COURSE LEVEL:** Foundational

BEST USED

- ✓ After learning the unit
- ✓ Before starting homework
- ✓ 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 Warm-Up Check Activate prior knowledge.	2 Core Concepts Review the essential ideas.	3 Guided Practice Apply what you learned.
4 Confidence Check Confirm your understanding.	5 Summary Review the key ideas.	6 Next Step 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**Key Ideas**

State what rolling without slipping means and write the relation between center-of-mass speed and angular speed.

Write a short response: State what rolling without slipping means and write the relation between center-of-mass speed and angular speed.

ACTIVITY 2**Common Mistakes**

Is static friction always opposite the direction the object is moving? Explain.

Write a short response: Is static friction always opposite the direction the object is moving? Explain.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Quick Application

A wheel rolls right without slipping. What is the instantaneous speed of the bottom contact point relative to the ground?

Write a short response: A wheel rolls right without slipping. What is the instantaneous speed of the bottom contact point relative to the ground?

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

Translation + Rotation

A rolling rigid body has center-of-mass motion and rotation at the same time. For pure rolling, the contact point is instantaneously at rest and $v_{cm} = \omega R$.

$$v_{cm} = \omega R$$

EXAMPLE At the top of a wheel, translation and rotation reinforce each other, giving a speed larger than v_{cm} .

SENSEI NOTE Do not picture the wheel as only spinning or only translating; both motions are present.

KEY CONCEPT 2

Energy and Mass Distribution

A rolling object has $K = 1/2 M v_{cm}^2 + 1/2 I \omega^2$. Objects with larger moment of inertia require more energy in rotation at the same v_{cm} .

$$K = 1/2 M v_{cm}^2 + 1/2 I \omega^2$$

EXAMPLE A hoop has more rotational energy than a solid disk at the same M , R , and v_{cm} .

SENSEI NOTE Shape matters through moment of inertia, not through mass alone.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Static Friction and Rolling

Static friction appears only when needed to prevent slipping. It can point uphill, downhill, or be zero depending on applied forces and torques. For ideal rolling on a fixed surface, the contact point is instantaneously at rest, so static friction does no mechanical work at that contact point.

$$|f_s| \leq \mu_s N \quad ; \quad v_{\text{contact}} = 0$$

EXAMPLE A wheel driven by an axle can require forward static friction, while a freely rolling object on some surfaces may require friction in another direction.

SENSEI NOTE Determine the tendency to slip first; do not assign the friction direction by habit.

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**Guided Example**

Compare a solid cylinder and hoop released from the same height. Which is faster at the bottom?

Compare a solid cylinder and hoop released from the same height. Which is faster at the bottom?

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Independent Check

A wheel of radius 0.40 m rolls without slipping with angular speed 5.0 rad/s. Find v_{cm} .

A wheel of radius 0.40 m rolls without slipping with angular speed 5.0 rad/s. Find v_{cm} .

PRACTICE 3

Independent Problem

A solid disk and hoop have the same M , R , and center-of-mass speed. Which has the larger total kinetic energy?

A solid disk and hoop have the same M , R , and center-of-mass speed. Which has the larger total kinetic energy?

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

Contact Point

Solve or explain without looking back.

What is the instantaneous velocity of the point touching the ground during pure rolling?

QUICK CHECK 2

Energy

Solve or explain without looking back.

Name the two terms in the kinetic energy of a rolling rigid body.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Friction Direction

Solve or explain without looking back.

Is the direction of static friction determined simply by the direction of center-of-mass motion?

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**No Slip**

Pure rolling couples translation and rotation through $v_{cm} = \omega R$.

KEY TAKEAWAY 2**Energy Split**

Rolling kinetic energy contains both translational and rotational parts.

KEY TAKEAWAY 3**Static Friction and Rolling**

Static friction appears only when needed to prevent slipping.

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 →

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

Key Ideas

Rolling combines translation and rotation; pure rolling has $v_{\text{cm}} = \omega R$.

WHY IT WORKS Rolling combines translation and rotation; pure rolling has $v_{\text{cm}} = \omega R$.

WARM-UP • ACTIVITY 2

Common Mistakes

No. Static friction acts to prevent relative slipping at the contact point, so its direction depends on the situation.

WHY IT WORKS No. Static friction acts to prevent relative slipping at the contact point, so its direction depends on the situation.

WARM-UP • ACTIVITY 3

Quick Application

Zero.

WHY IT WORKS Zero.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Guided Example**

The solid cylinder. Its smaller rotational inertia means a larger fraction of the lost gravitational potential energy becomes center-of-mass kinetic energy.

WHY IT WORKS The solid cylinder. Its smaller rotational inertia means a larger fraction of the lost gravitational potential energy becomes center-of-mass kinetic energy.

PRACTICE 2**Independent Check**

$$v_{\text{cm}} = \omega R = 5.0(0.40) = 2.0 \text{ m/s.}$$

WHY IT WORKS $v_{\text{cm}} = \omega R = 5.0(0.40) = 2.0 \text{ m/s.}$

PRACTICE 3**Independent Problem**

The hoop. Both have the same translational term, but the hoop has the larger I and therefore the larger rotational kinetic-energy term.

WHY IT WORKS The hoop. Both have the same translational term, but the hoop has the larger I and therefore the larger rotational kinetic-energy term.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1**Contact Point**

Zero relative to the ground.

WHY IT WORKS Zero relative to the ground.

QUICK CHECK 2**Energy**

Translational center-of-mass kinetic energy and rotational kinetic energy about the center of mass.

WHY IT WORKS Translational center-of-mass kinetic energy and rotational kinetic energy about the center of mass.

QUICK CHECK 3**Friction Direction**

No. It is determined by the direction in which the surfaces would otherwise slip relative to each other.

WHY IT WORKS No. It is determined by the direction in which the surfaces would otherwise slip relative to each other.

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 Review the key ideas and examples again. Review Again →	🎯 I Need More Practice Continue with additional practice for this topic. <u>Go to Practice →</u>	✓ I'm Ready Continue to the next recommended resource. Continue →
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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](https://www.physicssensei.com)