

FOCUSED REVIEW

Focused Review: Rolling Motion

Review the most important ideas, reinforce the essential skills, and confirm you're ready to move on.

 TIME 15–20 minutes	 BEST FOR Focused review	 FINISH WITH Greater confidence
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After this focused review, you'll be able to...

recognize the key concepts, reinforce your problem-solving skills, and continue with greater confidence.

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 15–20 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:** Calculus-Based

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 focused stages in order. Each stage reinforces your understanding and prepares you for a final confidence check.

6 stages • Approximately 15–20 minutes

1 Warm-Up Check Refresh key ideas.	2 Core Concepts Reinforce the essentials.	3 Guided Practice Strengthen key skills.
4 Confidence Check Confirm your understanding.	5 Summary Remember the essentials.	6 Next Step Choose your next step.

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 minute to reactivate what you already know. This quick warm-up will help you focus on the most important ideas before moving on.

WARM-UP 1**Key Ideas**

Write the rigid-body velocity relation for a point P on a rolling body.

Write a short response: Write the rigid-body velocity relation for a point P on a rolling body.

WARM-UP 2**Common Mistakes**

Does $v_{\text{contact}} = 0$ imply $a_{\text{contact}} = 0$?

Write a short response: Does $v_{\text{contact}} = 0$ imply $a_{\text{contact}} = 0$?

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Quick Application

For pure rolling, differentiate $s = R\theta$ to relate speed and acceleration.

Write a short response: For pure rolling, differentiate $s = R\theta$ to relate speed and acceleration.

Ready to strengthen your understanding?

You've refreshed the most important ideas. Now reinforce the concepts you'll use most often.

Continue to Core Concepts →

FR-05 • STAGE 2 OF 6

Core Concepts

Let's reinforce the most important concepts you'll need to solve problems with confidence. Focus on the ideas that appear most often in homework, quizzes, and exams.

KEY CONCEPT 1

Rigid-Body Kinematics

The velocity field of a rolling rigid body is $\mathbf{v}[\mathbf{P}] = \mathbf{v}_{\text{CM}} + \boldsymbol{\omega} \times \mathbf{r}[\mathbf{P}/\text{CM}]$. At contact with a stationary surface, $\mathbf{v}_{\text{contact}} = 0$; this gives the no-slip constraint.

$$\mathbf{v}_P = \mathbf{v}_{\text{CM}} + \boldsymbol{\omega} \times \mathbf{r}_{P/\text{CM}} \quad ; \quad \mathbf{v}_{\text{contact}} = \mathbf{0}$$

EXAMPLE The top point of a wheel has instantaneous speed $2v_{\text{CM}}$.

SENSEI NOTE The contact point is an instantaneous center for velocity, not generally for acceleration.

KEY CONCEPT 2

Energy, Torque, and Constraint

Rolling dynamics combines $\Sigma F = Ma_{\text{CM}}$, $\Sigma \tau_{\text{CM}} = I_{\text{CM}}\alpha$, and $a_{\text{CM}} = \alpha R$. Static friction supplies torque when required without doing work at a stationary contact point.

$$\Sigma F = Ma_{\text{CM}} \quad ; \quad \Sigma \tau_{\text{CM}} = I_{\text{CM}}\alpha \quad ; \quad a_{\text{CM}} = \alpha R$$

EXAMPLE For $I = kMR^2$, eliminating friction and α gives $a = g \sin\theta / (1+k)$ on an incline.

SENSEI NOTE Choose the torque origin carefully; about the center of mass, gravity may have zero torque while friction supplies the rotational torque.

Ready to apply these ideas?

You've reinforced the essential concepts. Now strengthen your problem-solving skills by working through a few guided examples.

[Continue to Guided Practice →](#)

FR-06 • STAGE 3 OF 6

Guided Practice

Now apply the key concepts you've just reviewed. Work through these focused practice activities to reinforce your problem-solving skills before the final confidence check.

PRACTICE 1

Guided Example

Derive the speed of a rolling body after descending height h using $I = kMR^2$.

Derive the speed of a rolling body after descending height h using $I = kMR^2$.

PRACTICE 2

Independent Check

A wheel rolls right with $v_{CM} = v$. Use $v[P] = v_{CM} + \omega \times r$ to find the velocity of the top point.

A wheel rolls right with $v_{CM} = v$. Use $v[P] = v_{CM} + \omega \times r$ to find the velocity of the top point.

Ready for a confidence check?

You've reinforced the essential skills through focused practice. Now confirm your understanding with two short questions.

Continue to Confidence Check →

FR-07 • STAGE 4 OF 6

Confidence Check

You've reinforced the key concepts and practiced the essential skills. Now confirm you're ready to move forward by completing these short confidence checks.

CONFIDENCE CHECK 1

Contact Acceleration

Answer without looking back.

Can the contact point have nonzero acceleration in pure rolling?

CONFIDENCE CHECK 2

Energy Result

Answer without looking back.

For $I = kMR^2$, write the speed after a vertical drop h .

HOW DID IT GO?

I answered ____ of 2 questions correctly.

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

You've confirmed your understanding.

Take one final look at the essential ideas before choosing your next step.

Continue to Summary →

FR-08 • STAGE 5 OF 6

Summary

Before moving on, take one final look at the essential ideas you'll want to remember.

KEY TAKEAWAY 1**Velocity Field**

Pure rolling follows from the vector velocity field plus the zero-contact-velocity constraint.

KEY TAKEAWAY 2**Coupled Dynamics**

Translation, rotation, and the no-slip constraint must be solved together.

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

$$\mathbf{v}[\mathbf{P}] = \mathbf{v}_{\text{CM}} + \boldsymbol{\omega} \times \mathbf{r}[\mathbf{P}/\text{CM}].$$

WHY IT WORKS $\mathbf{v}[\mathbf{P}] = \mathbf{v}_{\text{CM}} + \boldsymbol{\omega} \times \mathbf{r}[\mathbf{P}/\text{CM}].$

WARM-UP • ACTIVITY 2

Common Mistakes

No. The contact point can have nonzero acceleration even when its instantaneous velocity is zero.

WHY IT WORKS No. The contact point can have nonzero acceleration even when its instantaneous velocity is zero.

WARM-UP • ACTIVITY 3

Quick Application

$$v_{\text{CM}} = R\omega \text{ and } a_{\text{CM}} = R\alpha \text{ for tangential motion.}$$

WHY IT WORKS $v_{\text{CM}} = R\omega \text{ and } a_{\text{CM}} = R\alpha \text{ for tangential motion.}$

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Guided Example

$Mgh = \frac{1}{2} Mv^2 + \frac{1}{2} (kMR^2)(v^2/R^2)$. Thus $v = \sqrt{2gh/(1+k)}$.

WHY IT WORKS $Mgh = \frac{1}{2} Mv^2 + \frac{1}{2} (kMR^2)(v^2/R^2)$. Thus $v = \sqrt{2gh/(1+k)}$.

PRACTICE 2

Independent Check

The rotational contribution at the top is $+v$ in the direction of translation, so $v_{\text{top}} = 2v$.

WHY IT WORKS The rotational contribution at the top is $+v$ in the direction of translation, so $v_{\text{top}} = 2v$.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Contact Acceleration

Yes. Zero instantaneous velocity does not require zero acceleration.

WHY IT WORKS Yes. Zero instantaneous velocity does not require zero acceleration.

CONFIDENCE CHECK 2

Energy Result

$$v = \sqrt{2gh/(1+k)}.$$

WHY IT WORKS $v = \sqrt{2gh/(1+k)}.$

READINESS GUIDE

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

FR-09 • STAGE 6 OF 6

Next Step: Continue Learning

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

 I'm Still Unsure Review the focused review again to strengthen the essential concepts. Review Again →	 I Need More Practice Build confidence with additional practice problems. Go to Practice →	 I'm Ready Continue to the next topic or learning 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