FOCUSED REVIEW

Focused Review: Simple Harmonic Motion

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

◷ TIME	◎ BEST FOR	✓ FINISH WITH
15–20 minutes	Focused review	Greater confidence

After this focused review, you'll be able to…
use the SHM differential equation, derivative relationships, conservation of energy, and small-angle linearization.

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 bundle is designed to complement the chapter listed below. Use it to reinforce key concepts, prepare for homework, or review before a quiz or exam.

TEXTBOOK: Independent Physics Sensei Unit Review **CHAPTER: Mechanics • Unit MEC-U09** **TOPIC: MEC-U09 — Simple Harmonic Motion** **COURSE LEVEL: Calculus-Based**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

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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

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

Recall the defining SHM rule.

Write the defining SHM differential equation.

WARM-UP 2

Common Mistakes

Check the cycle quantities.

Differentiate $x = A\cos(\omega t + \phi)$ once and twice.

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Quick Application

Recall the energy and pendulum limits.

State the approximation that makes a simple pendulum SHM.

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 — page 6 →

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

SHM model and cycle relationships

Start from $\ddot{x} + \omega^2 x = 0$. Its sinusoidal solution has $v = dx/dt$ and $a = -\omega^2 x$, fixing the phase relations among x, v, and a.

$$\ddot{x} + \omega^2 x = 0;\ v = -A\omega \sin(\omega t + \phi);\ a = -\omega^2 x$$

EXAMPLE For $x = 0.020 \cos(5t)$, $v = -0.100 \sin(5t)$ and $a = -0.500 \cos(5t)$.

SENSEI NOTE Do not treat amplitude, velocity, and acceleration as quantities that peak at the same location in the cycle.

KEY CONCEPT 2

Energy and standard oscillators

The spring energy integral follows from $\ddot{x} + (k/m)x = 0$. The pendulum becomes linear only when $\sin\theta \approx \theta$, giving $\ddot{\theta} + (g/L)\theta = 0$.

$$\frac{d}{dt}\left[\tfrac{1}{2}m\dot{x}^2 + \tfrac{1}{2}kx^2\right] = 0;\ \ddot{\theta} + (g/L)\theta \approx 0$$

EXAMPLE Near $\theta = 0$, $U(\theta) = mgL(1 - \cos\theta) \approx \tfrac{1}{2}mgL\theta^2$, a quadratic potential.

SENSEI NOTE Use the small-angle pendulum formula only after checking that the angular amplitude is sufficiently small for the intended accuracy.

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 — page 7 →

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

Solve one complete spring-cycle model.

For $x = 0.040\cos(10t + \pi/4)$, find $v(0)$ and $a(0)$.

PRACTICE 2

Independent Check

Use energy or the small-angle pendulum relation.

Show how $\ddot{\theta} = -(g/L)\sin\theta$ becomes SHM for small angle.

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 — page 8 →

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

SHM readiness check

Answer without a calculator.

If $a = -25x$, what is ω?

CONFIDENCE CHECK 2

Energy and pendulum check

State one reason with each answer.

Why is a large-angle pendulum not exactly SHM?

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 — page 10 →

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

Restoring law + phase tells the cycle

Verify $a \propto -x$, then use ω, T, f, and the x-v-a phase relationships. Turning points: $v = 0$. Equilibrium: $|v|$ maximum.

KEY TAKEAWAY 2

Energy and approximation choose the model

For ideal springs use $E = \frac{1}{2}kA^2$. For pendulums, use the SHM period only under the small-angle approximation.

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 14 →

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 check both the setup and the physical interpretation.

WARM-UP • ACTIVITY 1

Key Ideas

$\ddot{x} + \omega^2 x = 0$.

WHY IT WORKS The essential test is a restoring acceleration proportional to −displacement.

WARM-UP • ACTIVITY 2

Common Mistakes

$v = -A\omega \sin(\omega t + \phi)$; $a = -A\omega^2 \cos(\omega t + \phi)$.

WHY IT WORKS Displacement, velocity, and acceleration have fixed phase relationships in ideal SHM.

WARM-UP • ACTIVITY 3

Quick Application

$\sin\theta \approx \theta$ for small θ in radians.

WHY IT WORKS Energy and the small-angle approximation provide two fast ways to check an SHM model.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Guided Example

$v(0) = -0.40 \sin(\pi/4) \approx -0.283$ m/s; $a(0) = -4.0 \cos(\pi/4) \approx -2.83$ m/s^2.

WHY IT WORKS Use the restoring law first, then cycle relations; do not mix turning-point and equilibrium properties.

PRACTICE 2

Independent Check

Use $\sin\theta \approx \theta$: $\ddot{\theta} + (g/L)\theta = 0$, so $\omega = \sqrt{(g/L)}$.

WHY IT WORKS Energy is often the fastest route when position and speed are related; the pendulum requires an explicit approximation.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

SHM readiness check

$\omega = 5$ rad/s.

WHY IT WORKS Use $a = -\omega^2 x$ and $T \propto \sqrt{m}$ for an ideal spring oscillator.

CONFIDENCE CHECK 2

Energy and pendulum check

Because $\sin\theta$ is nonlinear and cannot be replaced accurately by θ at large angles.

WHY IT WORKS Turning points have $v = 0$; ideal linear-spring frequency depends on k and m; pendulum SHM requires small-angle linearization.

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

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