FULL REVIEW

Full Review: Simple Harmonic Motion

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

◷ **TIME** 45–60 minutes	◎ **BEST FOR** A complete topic review	✓ **FINISH WITH** A readiness check

After this full review, you'll be able to…

identify simple harmonic motion, interpret its cycle and energy changes, and distinguish valid spring and pendulum models.

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 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: Foundational**	**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 stages in order. Each stage builds on the previous one and prepares you for the final readiness check.

6 stages • Approximately 45–60 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

Recall Activity 1

Identify the direction of the restoring effect.

A mass on a horizontal spring is displaced to the right of equilibrium and released. Which direction is the spring force?

ACTIVITY 2

Recall Activity 2

Separate amplitude from instantaneous position.

An oscillator moves between $x = -4$ cm and $x = +4$ cm. What is its amplitude?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Track how energy shifts during the cycle.

At the equilibrium point of an ideal spring-mass oscillator, is the speed zero or maximum?

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

Restoring force and the SHM model

Simple harmonic motion is oscillation about a stable equilibrium in which the restoring effect grows in proportion to displacement and points back toward equilibrium. A spring is the standard model.

restoring effect ∝ −displacement; spring: $F = -kx$

EXAMPLE If a spring-mass system is pulled left of equilibrium, the spring force points right.

SENSEI NOTE Do not call every back-and-forth motion SHM. The key test is whether the restoring force is approximately linear in displacement over the motion being modeled.

KEY CONCEPT 2

Amplitude, period, phase, displacement, velocity, and acceleration

Amplitude A is the maximum displacement from equilibrium. Period T is the time for one cycle, and frequency f is cycles per second. Position repeats, while velocity and acceleration change systematically through the cycle.

$T = 1/f$; one cycle corresponds to 2π radians of phase

EXAMPLE From +A, the oscillator moves toward equilibrium, speeds up, reaches maximum speed at $x = 0$, then slows toward −A.

SENSEI NOTE Do not confuse amplitude with distance traveled in a cycle. One full cycle covers a path length 4A, while the amplitude is only A.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Energy, spring oscillators, and the simple pendulum

In ideal SHM, energy continually shifts between kinetic and potential forms while total mechanical energy stays constant. Springs store elastic potential energy. A simple pendulum behaves approximately as SHM only for sufficiently small angles.

spring energy shifts between motion and stretch/compression; small-angle pendulum: longer L → longer T

EXAMPLE At a spring oscillator's turning point, speed is zero and potential energy is maximum; at equilibrium the reverse is true.

SENSEI NOTE The simple-pendulum formula is a small-angle result. At large amplitude, the motion is periodic but not exactly simple harmonic and the period increases with amplitude.

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

Worked Example

Identify equilibrium, choose the positive direction, and apply the restoring-force model.

A mass is displaced 3 cm to the right on a horizontal spring. Describe the directions of displacement, spring force, and acceleration.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Use the cycle relationships among x, v, a, T, f, and ω.

An oscillator is at its positive turning point. State its velocity and acceleration directions.

PRACTICE 3

Independent Problem

Use energy or the pendulum model, and state the assumptions that make the model valid.

Where during a spring oscillator’s cycle are kinetic energy and spring potential energy individually largest?

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

Restoring-force model check

Answer and justify in one sentence.

If an oscillator is left of equilibrium, which way must its acceleration point in SHM?

QUICK CHECK 2

Cycle and phase check

Use the cycle, not memorized slogans.

At equilibrium, is acceleration maximum, minimum, or zero?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Energy and pendulum model check

State the model assumption with the answer.

Can an ideal spring oscillator have maximum speed and maximum spring potential energy at the same instant?

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

Test the restoring law first

SHM requires a stable equilibrium and acceleration proportional to −displacement. For a spring, $F = -kx$ and $\omega = \sqrt{k/m}$.

KEY TAKEAWAY 2

Read the cycle through phase relationships

Use $\omega = 2\pi f$, $x = A\cos(\omega t + \phi)$, $v = dx/dt$, and $a = -\omega^2 x$. At equilibrium speed is maximum; at turning points speed is zero.

KEY TAKEAWAY 3

Use energy and respect the small-angle limit

For an ideal spring, $E = \frac{1}{2}kA^2$ is constant. A simple pendulum is approximately SHM only when $\sin\theta \approx \theta$ is valid.

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

Recall Activity 1

Toward equilibrium, to the left.

WHY IT WORKS In SHM the restoring effect points opposite the displacement from stable equilibrium.

WARM-UP • ACTIVITY 2

Recall Activity 2

A = 4 cm.

WHY IT WORKS Amplitude is the maximum distance from equilibrium, not the full peak-to-peak distance.

WARM-UP • ACTIVITY 3

Recall Activity 3

Maximum.

WHY IT WORKS At equilibrium the spring potential energy is minimum, so the kinetic energy and speed are maximum.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

Displacement is rightward; force and acceleration are leftward, toward equilibrium.

WHY IT WORKS The restoring effect opposes displacement; acceleration follows the net force.

PRACTICE 2

Guided Problem

$v = 0$; acceleration points toward equilibrium, in the negative direction.

WHY IT WORKS Turning points are maximum $|x|$ and maximum $|a|$ but zero speed.

PRACTICE 3

Independent Problem

K is largest at equilibrium; spring U is largest at the turning points.

WHY IT WORKS Ideal mechanical energy is conserved as it shifts between kinetic and potential forms.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Restoring-force model check

Right, toward equilibrium.

WHY IT WORKS The acceleration must oppose the displacement.

QUICK CHECK 2

Cycle and phase check

Zero.

WHY IT WORKS Since $a \propto -x$, acceleration is zero at $x = 0$.

QUICK CHECK 3

Energy and pendulum model check

No. Maximum speed occurs at equilibrium, while maximum spring potential energy occurs at the turning points.

WHY IT WORKS The two energy forms trade off while total energy stays 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: 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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