FULL REVIEW

Full Review: Simple Harmonic Motion

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

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

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

solve representative spring and pendulum SHM problems using timing, phase, and energy relationships.

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: Algebra-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 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

Use the force law before calculating.

A spring has k = 120 N/m and is stretched 0.050 m. Find the spring force, including sign if rightward displacement is positive.

ACTIVITY 2

Recall Activity 2

Connect period, frequency, and angular frequency.

An oscillator has period 0.80 s. Find its frequency and angular frequency.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Use total mechanical energy for an ideal spring oscillator.

For $k = 200$ N/m and amplitude $A = 0.080$ m, find the total mechanical energy.

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

For an ideal spring, $F = -kx$. Combining this with $F = ma$ gives $a = -(k/m)x$. The acceleration is zero at equilibrium, largest in magnitude at the turning points, and always directed toward equilibrium.

$$F = -kx;\ a = -(k/m)x;\ \omega = \sqrt{(k/m)};\ T = 2\pi\sqrt{(m/k)}$$

EXAMPLE For $m = 0.50$ kg and $k = 200$ N/m, $\omega = 20$ rad/s and $T = 2\pi/20 \approx 0.314$ s.

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

A convenient model is $x = A\cos(\omega t + \phi)$, where ϕ sets the phase at $t = 0$. The maximum speed is $A\omega$ and the maximum acceleration is $A\omega^2$. At equilibrium speed is largest; at the turning points speed is zero.

$$f = 1/T;\ \omega = 2\pi f = 2\pi/T;\ x = A\cos(\omega t + \phi);\ v_{max} = A\omega;\ a_{max} = A\omega^2$$

EXAMPLE If $A = 0.060$ m and $\omega = 5.0$ rad/s, $v_{max} = 0.30$ m/s and $a_{max} = 1.5$ m/s^2.

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

For a spring oscillator, $E = \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$. For a simple pendulum at small angle, $T = 2\pi\sqrt{L/g}$. The ideal spring period depends on m and k, not amplitude; the small-angle pendulum period depends on L and g, not bob mass.

$$E = \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2;\ T_s = 2\pi\sqrt{(m/k)};\ T_p \approx 2\pi\sqrt{(L/g)}$$

EXAMPLE A 0.90 m pendulum near small amplitude has $T \approx 2\pi\sqrt{(0.90/9.8)} \approx 1.90$ s.

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 0.40 kg mass is attached to a 100 N/m spring. Find ω and T.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

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

An oscillator has A = 0.050 m and f = 2.0 Hz. Find ω, v_{max}, and a_{max}.

PRACTICE 3

Independent Problem

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

A spring has k = 80 N/m and amplitude 0.10 m. Find total energy and the speed of a 0.50 kg mass at x = 0.060 m.

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 k quadruples while m stays fixed, how do ω and T change?

QUICK CHECK 2

Cycle and phase check

Use the cycle, not memorized slogans.

If amplitude doubles but ω is unchanged, what happens to v_{max} and a_{max}?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Energy and pendulum model check

State the model assumption with the answer.

Does increasing the bob mass change the small-angle period of a simple pendulum?

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

$F = -(120)(0.050) = -6.0$ N.

WHY IT WORKS The minus sign is physical: the force opposes the displacement.

WARM-UP • ACTIVITY 2

Recall Activity 2

$f = 1/T = 1.25$ Hz and $\omega = 2\pi f \approx 7.85$ rad/s.

WHY IT WORKS Period is time per cycle; frequency is cycles per second; angular frequency measures phase advance in radians per second.

WARM-UP • ACTIVITY 3

Recall Activity 3

$E = \frac{1}{2}kA^2 = 0.64$ J.

WHY IT WORKS At a turning point $v = 0$ and all ideal mechanical energy is spring potential energy.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

$\omega = \sqrt{(100/0.40)} = 15.8$ rad/s; $T = 2\pi/\omega \approx 0.397$ s.

WHY IT WORKS The spring-mass period comes from $T = 2\pi\sqrt{(m/k)}$.

PRACTICE 2

Guided Problem

$\omega = 4\pi \approx 12.57$ rad/s; $v_{max} \approx 0.628$ m/s; $a_{max} \approx 7.90$ m/s^2.

WHY IT WORKS Use $v_{max} = A\omega$ and $a_{max} = A\omega^2$ after converting f to ω.

PRACTICE 3

Independent Problem

$E = 0.40$ J; $U = 0.144$ J; $K = 0.256$ J; $v = \sqrt{(2K/m)} \approx 1.01$ m/s.

WHY IT WORKS Energy avoids solving for time or phase when position and speed are the target variables.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Restoring-force model check

ω doubles and T is halved.

WHY IT WORKS $\omega \propto \sqrt{k}$ and $T \propto 1/\sqrt{k}$.

QUICK CHECK 2

Cycle and phase check

Both double.

WHY IT WORKS Both maxima are directly proportional to A.

QUICK CHECK 3

Energy and pendulum model check

No. $T \approx 2\pi\sqrt{(L/g)}$, independent of bob mass.

WHY IT WORKS Mass cancels from the ideal pendulum equation of motion.

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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