FOCUSED REVIEW

Focused Review: Superposition, Standing Waves, and Sound

Review the most important 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…**
> 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 • UNIT ALIGNMENT

Unit Alignment

This bundle is aligned to the approved Physics Sensei unit specification below. Use it to recover the unit structure, reinforce key decisions, and confirm readiness for the next study task.

ARCHITECTURE: Physics Sensei Independent Mechanics UNIT: MEC-U12 — Superposition, Standing Waves, and Sound RESOURCE: Unit Review PROFILE: University Physics • Calculus-Based	BEST USED ✓ Before homework on waves or sound ✓ Before a quiz or exam ✓ When interference, resonance, or sound relationships need reinforcement

Review Prerequisites →Review Prerequisites →

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 — page 4** Refresh key ideas.	2 **Core Concepts — page 6** Reinforce the essentials.	3 **Guided Practice — page 7** Strengthen key skills.
4 **Confidence Check — page 8** Confirm your understanding.	5 **Summary — page 10** Remember the essentials.	6 **Next Step — page 14** 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

Add the wave functions, not their amplitudes in isolation.

If $y1=A\ \sin(kx-\omega t)$ and $y2=A\ \sin(kx-\omega t+\pi)$, what is $y1+y2$?

WARM-UP 2

Common Mistakes

Use the standing-wave function.

For $y=2A\ \sin(kx)\ \cos(\omega t)$, where are the nodes?

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Quick Application

Connect two angular frequencies to the beat rate.

Two waves have frequencies 500 Hz and 506 Hz. What is the beat frequency?

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

Superposition as addition of wave functions

Because the linear wave equation is linear, sums of valid solutions are also solutions. Trigonometric identities convert equal-frequency counter-propagating waves into a standing-wave product and close frequencies into a beat envelope.

$$y_{total} = y_1 + y_2 \quad • \quad \sin a + \sin b = 2 \sin[(a+b)/2] \cos[(a-b)/2]$$

KEY RELATIONSHIP Linearity permits superposition; the relative phase of component solutions determines the resulting amplitude envelope.

EXAMPLE $A \sin(kx-\omega t)+A \sin(kx+\omega t)=2A \sin(kx) \cos(\omega t)$.

SENSEI NOTE Use the actual phase in the wave functions; amplitude addition alone is only valid in special phase relationships.

KEY CONCEPT 2

Boundary conditions quantize standing-wave modes

Applying endpoint conditions to the standing-wave solution restricts k and therefore λ and f. Fixed-fixed and open-open systems give integer half-wavelengths; closed-open systems give odd quarter-wave modes.

$$k_n = n\pi/L \quad • \quad f_n = nv/(2L) \quad • \quad \text{closed-open: n odd}$$

KEY RELATIONSHIP Boundary conditions quantize k; the discrete k-values determine the allowed wavelengths and resonance frequencies.

EXAMPLE For L=0.80 m and v=240 m/s, $k_3=3\pi/L$ and $f_3=450$ Hz.

SENSEI NOTE The harmonic spectrum follows from boundary conditions; it is not an arbitrary list to memorize.

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

Apply the fixed-end boundary condition to the standing-wave form.

A string of length 1.20 m has wave speed 180 m/s. Use $k_n = n\pi/L$ to find f_1 and f4.

PRACTICE 2

Independent Check

Use a ratio before evaluating the logarithm.

A point source produces 72 dB at distance r. What level is expected at 2r in the ideal far field?

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

Standing-wave nodes

Use the spatial factor of the standing-wave solution.

For $y=2A\sin(kx)\cos(\omega t)$, what condition on x gives a node?

CONFIDENCE CHECK 2

Mode spacing

Use $f_n=nv/(2L)$ for a fixed-fixed string.

If adjacent harmonics differ by 120 Hz, what is $v/(2L)$?

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

Linearity makes superposition powerful

Add wave functions first; identities expose interference, standing waves, and beats.

KEY TAKEAWAY 2

Boundary conditions quantize k

Allowed modes come from enforcing endpoint conditions on the spatial part of the solution.

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. Replace each placeholder with a concise answer and the essential explanation.

WARM-UP • ACTIVITY 1

Key Ideas

0 everywhere the two ideal waves overlap.

WHY IT WORKS The functions differ by π in phase, so $\sin(\theta+\pi)=-\sin\theta$ and the displacements cancel point by point.

WARM-UP • ACTIVITY 2

Common Mistakes

At $\sin(kx)=0$, so $x=n\pi/k=n\lambda/2$.

WHY IT WORKS At those positions the spatial factor is zero for all time.

WARM-UP • ACTIVITY 3

Quick Application

6 Hz.

WHY IT WORKS Adding close-frequency sinusoids produces a slowly varying envelope at $|f_1-f_2|$.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Guided Example

f_1=75.0 Hz; f4=300 Hz.

WHY IT WORKS Since ω=vk and f=ω/(2π), f_n=v(nπ/L)/(2π)=nv/(2L).

PRACTICE 2

Independent Check

About 66.0 dB.

WHY IT WORKS I2/I1=1/4, so Δβ=10$\log_{10}$(1/4)=−6.02 dB.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Standing-wave nodes

$kx=n\pi$, or $x=n\lambda/2$.

WHY IT WORKS A node is zero for every t, so the spatial factor must vanish.

CONFIDENCE CHECK 2

Mode spacing

120 Hz.

WHY IT WORKS The harmonic spacing is the fundamental frequency v/(2L).

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.

PhysicsSensei.com