FULL REVIEW

Full Review: Superposition, Standing Waves, and Sound

Review the essential ideas, relationships, and problem-solving tools for superposition, standing waves, and sound.

TIME	BEST FOR	FINISH WITH
45–60 minutes	A complete unit review	A readiness check

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

recall the essential ideas, apply them to representative problems, and determine what to study next.

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 • 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: College Physics • Algebra-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 →

Physics Sensei is an independent educational resource designed to complement independently authored Physics Sensei materials. Physics Sensei content is independently authored and organized under the approved topic architecture.

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

1 **Warm-Up Check — page 4** Activate prior knowledge.	2 **Core Concepts — page 6** Review the essential ideas.	3 **Guided Practice — page 8** Apply what you learned.
4 **Confidence Check — page 10** Confirm your understanding.	5 **Summary — page 12** Review the key ideas.	6 **Next Step — page 16** Continue your learning.

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

Reason from the principle of superposition before calculating.

Two identical sinusoidal waves meet in phase at a point. If each has amplitude A, what is the instantaneous resultant amplitude there?

ACTIVITY 2

Recall Activity 2

Use the geometry of a standing wave.

A standing wave on a string has adjacent nodes separated by 0.30 m. What is the wavelength?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Connect frequency difference to the audible envelope.

Two tones of 256 Hz and 262 Hz are sounded together. What beat frequency is heard?

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

Superposition, interference, and beats

When waves overlap, the medium displacement is the algebraic sum of the individual displacements. Relative phase determines constructive or destructive interference. Waves with nearby frequencies produce beats.

$$y_{total} = y_1 + y_2 \quad \bullet \quad \Delta\varphi = 2\pi\Delta r/\lambda \quad \bullet \quad \text{beat frequency} = |f_1 - f_2|$$

KEY RELATIONSHIP Use phase difference to decide reinforcement or cancellation; beats arise from interference between nearby frequencies.

EXAMPLE Equal-amplitude waves arriving with path difference λ reinforce; with path difference $\lambda/2$ they cancel ideally.

SENSEI NOTE Interference changes the local resultant displacement; it does not mean one wave permanently destroys the other.

KEY CONCEPT 2

Standing waves, boundary conditions, and resonance

A standing wave forms when compatible waves of the same frequency travel in opposite directions. Nodes remain at zero displacement and antinodes oscillate with maximum amplitude. Boundary conditions determine the allowed resonant frequencies.

$$\text{fixed/open-open: } f_n = nv/(2L) \quad \bullet \quad \text{closed-open: } f_n = nv/(4L),\ n \text{ odd}$$

KEY RELATIONSHIP The allowed harmonic series depends on the endpoints: fixed-fixed and open-open allow integer harmonics; closed-open allows odd harmonics.

EXAMPLE For a 0.80 m string with wave speed 240 m/s, the third harmonic is $f_3 = 3(240)/(2\times0.80) = 450$ Hz.

SENSEI NOTE Do not memorize one harmonic formula for every system; first identify the boundary conditions.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Sound waves, intensity, and sound level

Sound in air is primarily a longitudinal pressure/density wave. Frequency sets pitch, amplitude is related to intensity, and sound level uses a logarithmic decibel scale. For a point source, intensity follows inverse-square spreading.

$$I = P/(4\pi r^2) \quad \bullet \quad \beta = 10 \log_{10}(I/I_0)$$

KEY RELATIONSHIP Wave speed links frequency and wavelength; intensity is power per area, and decibels compare intensities logarithmically.

EXAMPLE An intensity of 2.0×10^{-6} W/m² corresponds to $\beta \approx 63$ dB.

SENSEI NOTE Decibels are logarithmic: adding 10 dB corresponds to ten times the intensity, not ten times the perceived loudness.

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 the boundary conditions, then select the harmonic rule.

A string fixed at both ends has length 1.20 m and wave speed 180 m/s. Find the fundamental frequency and the fourth harmonic.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Use the allowed-harmonic sequence for a pipe closed at one end.

A 0.85 m pipe is closed at one end. Using v = 343 m/s, find its fundamental frequency and the next allowed resonance.

PRACTICE 3

Independent Problem

Use the decibel definition and keep the reference intensity explicit.

A sound has intensity 2.0×10^{-6} W/m². Find its sound intensity level relative to $I_0=10^{-12}$ W/m².

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

Interference from path difference

Compare the path difference with the wavelength.

Two coherent sources arrive at a point with path difference 3λ/2. Is the interference constructive or destructive?

QUICK CHECK 2

Standing-wave geometry

Use node and antinode spacing.

What are the separations between adjacent nodes and between a node and its nearest antinode?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Sound spreading

Assume a point source radiating uniformly.

If distance from a point sound source doubles, what happens to intensity?

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

Add displacements, track phase

Superposition is algebraic addition; constructive and destructive interference follow from relative phase or path difference.

KEY TAKEAWAY 2

Boundary conditions choose resonances

Standing-wave modes are not arbitrary. The endpoints determine which wavelengths and harmonics are allowed.

KEY TAKEAWAY 3

Sound connects waves to measurement

Use $v=f\lambda$ for propagation, inverse-square spreading for intensity, and the logarithmic decibel scale for sound level.

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

WARM-UP • ACTIVITY 1

Recall Activity 1

The resultant amplitude is 2A at that instant.

WHY IT WORKS Superposition adds displacements algebraically. Equal in-phase displacements reinforce one another.

WARM-UP • ACTIVITY 2

Recall Activity 2

λ = 0.60 m.

WHY IT WORKS Adjacent nodes are separated by half a wavelength, so λ/2 = 0.30 m.

WARM-UP • ACTIVITY 3

Recall Activity 3

6 Hz.

WHY IT WORKS The beat frequency is the magnitude of the frequency difference: |262 – 256| = 6 Hz.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

f_1 = 75.0 Hz; f4 = 300 Hz.

WHY IT WORKS For a fixed-fixed string, $f_n = nv/(2L)$. Thus $f_1=180/(2.40)=75.0$ Hz and $f4=4f_1=300$ Hz.

PRACTICE 2

Guided Problem

$f_1 \approx 101$ Hz; next allowed resonance $f_3 \approx 303$ Hz.

WHY IT WORKS For a closed-open pipe, $f_n=nv/(4L)$ with odd n only. $f_1=343/(3.40)=100.9$ Hz and $f_3=3f_1=302.6$ Hz.

PRACTICE 3

Independent Problem

$\beta \approx 63$ dB.

WHY IT WORKS $\beta=10\log_{10}(2.0\times10^{6})=10(6.301)=63.0$ dB.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Interference from path difference

Destructive.

WHY IT WORKS An odd multiple of λ/2 gives an odd multiple of π in phase difference.

QUICK CHECK 2

Standing-wave geometry

Adjacent nodes: λ/2. Node to nearest antinode: λ/4.

WHY IT WORKS The pattern repeats node-to-node every half wavelength; antinodes lie halfway between nodes.

QUICK CHECK 3

Sound spreading

It becomes one-fourth as large.

WHY IT WORKS Spherical area grows as r^2, so $I \propto 1/r^2$.

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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