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<br>UNIT: MEC-U12 — Superposition, Standing Waves, and Sound<br>RESOURCE: Unit Review<br>PROFILE: College Physics • Algebra-Based | BEST USED<br>✓ Before homework on waves or sound<br>✓ Before a quiz or exam<br>✓ 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 focused stages in order. Each stage reinforces your understanding and prepares you for a final confidence check.

**6 stages • Approximately 15–20 minutes**

| | | |
|---|---|---|
| 1<br>**Warm-Up Check — page 4**<br>Refresh key ideas. | 2<br>**Core Concepts — page 6**<br>Reinforce the essentials. | 3<br>**Guided Practice — page 7**<br>Strengthen key skills. |
| 4<br>**Confidence Check — page 8**<br>Confirm your understanding. | 5<br>**Summary — page 10**<br>Remember the essentials. | 6<br>**Next Step — page 14**<br>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

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?*

WARM-UP 2

## Common Mistakes

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

WARM-UP 3

## Quick Application

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 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, 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 $\lambda$ 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.

**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

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.*

PRACTICE 2

## Independent Check

Use the decibel definition and keep the reference intensity explicit.

*A sound has intensity $2.0\times10^{-6}$ W/m². Find its sound intensity level relative to $I_0=10^{-12}$ W/m².*

**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

## 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?*

CONFIDENCE 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?*

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

### 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.

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

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

## Common Mistakes

$\lambda = 0.60$ m.

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

WARM-UP • ACTIVITY 3

## Quick Application

6 Hz.

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

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

## Guided 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

## Independent Check

β ≈ 63 dB.

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

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE 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.

CONFIDENCE 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.

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**