FULL REVIEW

Full Review: Mechanical Waves and Wave Speed

Review the essential ideas, relationships, and problem-solving tools for mechanical waves and wave speed.

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

After this full review, you'll be able to…
analyze traveling-wave functions with derivatives, connect phase to propagation, derive local particle motion, and calculate energy transport in string waves.

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: OpenStax University Physics Volume 1 **CHAPTER: Volume 1, Chapter 16** **TOPIC: Mechanical Waves and Wave Speed** **COURSE LEVEL: Calculus-based introductory university physics**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

Read the OpenStax Chapter →

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 relevant wave quantities and connect them using the simplest wave relation.

For $y(x,t) = 0.020 \sin(4x - 12t)$, identify k and ω.

ACTIVITY 2

Recall Activity 2

Use the defining relation and keep units consistent.

Using $k = 4$ rad/m and $\omega = 12$ rad/s, find the wave speed.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Connect a qualitative change in the medium to the wave speed.

For $y = A \sin(kx - \omega t)$, what derivative gives the transverse velocity of a string element?

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

Sinusoidal Traveling Waves and Phase

Write a traveling wave as y(x,t) = A sin(kx − ωt + ϕ). The wave number k measures spatial phase change and angular frequency ω measures temporal phase change. Constant phase gives the propagation speed.

$$k=\frac{2\pi}{\lambda};\omega=2\pi f;v=\frac{\omega}{k}=f\lambda$$

EXAMPLE For y = 0.030 sin(5x − 20t), λ = 2π/5 = 1.26 m, f = 20/(2π) = 3.18 Hz, and v = 4.0 m/s.

SENSEI NOTE The sign of the kx and ωt terms determines propagation direction; kx − ωt moves in +x.

KEY CONCEPT 2

String Dynamics and Local Particle Motion

The wave speed on a stretched string follows from tension and linear density. The wave function also lets you calculate the transverse velocity and acceleration of a particular string element by partial differentiation at fixed position.

$$v=\sqrt{\frac{F_T}{\mu}};u_y=\frac{\partial y}{\partial t};a_y=\frac{\partial^2 y}{\partial t^2}$$

EXAMPLE For y = A sin(kx − ωt), u_y = −Aω cos(kx − ωt) and a_y = −ω²y.

SENSEI NOTE The local transverse particle speed is not the same quantity as the wave propagation speed ω/k.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Wave Equation and Energy Transport

A sinusoidal traveling wave satisfies the one-dimensional wave equation. Time derivatives give local particle motion, while spatial derivatives describe the shape. For a string, the average power carried by a sinusoidal wave follows from the local force and transverse velocity.

$$\frac{\partial^2 y}{\partial x^2}=\frac{1}{v^2}\frac{\partial^2 y}{\partial t^2};P_{avg}=\frac{1}{2}\mu\omega^2 A^2 v$$

EXAMPLE For $y = A\sin(kx - \omega t)$, both second derivatives reproduce y, requiring $v^2 = \omega^2/k^2$.

SENSEI NOTE The wave equation links the spatial curvature of the waveform to its temporal acceleration.

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

Use the central wave relations and show each algebraic step.

For $y = 0.040 \sin(2.5x - 15t)$, find λ, f, and wave speed.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Identify the medium quantities before applying the propagation-speed relation.

For the same wave, find the maximum transverse speed of a string element.

PRACTICE 3

Independent Problem

Connect the wave model to energy transport or a change in conditions.

A string wave has μ = 0.015 kg/m, A = 0.020 m, f = 25 Hz, and v = 40 m/s. Find Pavg.

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

Read a Wave Description

State the relationship first, then evaluate.

A wave is $y = A \sin(kx + \omega t)$. Which direction does it propagate?

QUICK CHECK 2

Check the Medium–Source Distinction

Choose the correct statement and justify it physically.

For a sinusoidal wave, how is local transverse acceleration related to displacement?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Connect Propagation and Local Motion

State the relevant physical distinction clearly.

For $y = A \sin(kx - \omega t)$, show the ratio $(\partial^2 y/\partial t^2)/(\partial^2 y/\partial x^2)$.

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

Read Physics Directly From Phase

From $y = A \sin(kx \mp \omega t + \phi)$, identify k, ω, direction, λ, f, and $v = \omega/k$.

KEY TAKEAWAY 2

Separate Propagation From Particle Motion

Use ω/k for wave speed, but use time derivatives of $y(x,t)$ for the motion of individual medium elements.

KEY TAKEAWAY 3

The Wave Equation Encodes Propagation

A traveling sinusoid satisfies $\partial^2 y/\partial x^2 = (1/v^2)\partial^2 y/\partial t^2$, with $v = \omega/k$.

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

$k = 4$ rad/m and $\omega = 12$ rad/s.

WHY IT WORKS Compare the function with $y = A \sin(kx - \omega t + \varphi)$.

WARM-UP • ACTIVITY 2

Recall Activity 2

$v = \omega/k = 3.0$ m/s.

WHY IT WORKS A point of constant phase moves so that $kx - \omega t$ is constant.

WARM-UP • ACTIVITY 3

Recall Activity 3

$\partial y/\partial t$.

WHY IT WORKS The element's position changes in time at fixed x.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

$\lambda = 2\pi/2.5 = 2.51$ m; $f = 15/(2\pi) = 2.39$ Hz; $v = 15/2.5 = 6.0$ m/s.

WHY IT WORKS Read k and ω directly, then use their definitions and $v = \omega/k$.

PRACTICE 2

Guided Problem

$u_{max} = A\omega = (0.040)(15) = 0.60$ m/s.

WHY IT WORKS Differentiate with respect to time and take the maximum magnitude of the cosine factor.

PRACTICE 3

Independent Problem

$\omega = 157$ rad/s; $P_{avg} = (1/2)(0.015)(157^2)(0.020^2)(40) \approx 2.96$ W.

WHY IT WORKS Convert frequency to angular frequency before using the sinusoidal-wave power expression.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Read a Wave Description

In the −x direction.

WHY IT WORKS Constant phase $kx + \omega t$ = constant gives $x = -(\omega/k)t$ + constant.

QUICK CHECK 2

Check the Medium–Source Distinction

$a_y = -\omega^2 y$.

WHY IT WORKS Two time derivatives of a sinusoid reproduce the displacement with a factor $-\omega^2$.

QUICK CHECK 3

Connect Propagation and Local Motion

The ratio is $\omega^2/k^2 = v^2$.

WHY IT WORKS Both derivatives are proportional to $-y$, leaving only the squared coefficients.

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.

PhysicsSensei.com