FULL REVIEW

Full Review: Damping, Driving, and Resonance — Foundational

Review damping, driven oscillations, resonance, phase, and energy transfer using the Foundational treatment.

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

After this full review, you'll be able to…
explain how damping and periodic driving change an oscillator and recognize resonance from graphs and physical behavior.

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 Physics Sensei Unit Review supports MEC-U10 — Damping, Driving, and Resonance. Use it to reinforce concepts, prepare for homework, or review before a quiz or exam.

UNIT: MEC-U10 **TOPIC: Damping, Driving, and Resonance** **TREATMENT: Foundational** **RESOURCE: Physics Sensei Unit Review**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

Explore Physics Sensei →

Physics Sensei is an independent physics learning resource. This review uses original Physics Sensei organization, explanations, examples, and practice.

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 damping from a time trace.

A displacement-time graph crosses equilibrium repeatedly while successive peaks shrink. What damping regime is this?

ACTIVITY 2

Recall Activity 2

Separate free and forced behavior.

A system is driven continuously at 4 Hz although its natural frequency is 3 Hz. Long after startup, what frequency dominates?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Interpret a resonance curve.

What happens to the height and width of a resonance peak when damping increases?

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

Damping Regimes and Free Decay

Real oscillators lose mechanical energy. Underdamped systems continue oscillating with shrinking amplitude. Critical damping gives the fastest return to equilibrium without overshoot. Overdamped systems also do not oscillate but settle more slowly. The distinction is about how the system returns to equilibrium, not about whether damping exists.

$$r(t) = \langle x(t), y(t), z(t)\rangle;\ \text{displacement} = r_2 - r_1;\ v_{avg} = \text{displacement/elapsed time};\ v(t) = dr/dt;\ a(t) = dv/dt;\ \text{speed} = \sqrt{(v_x^2 + v_y^2 + v_z^2)}.$$

EXAMPLE Vehicle suspension and instrument mechanisms are often designed near a target damping regime to control overshoot and settling time.

SENSEI NOTE Overdamped does not mean “more efficient”; too much damping can make the return slower.

KEY CONCEPT 2

Driven Oscillations and Transients

A periodic external force continuously supplies energy. During startup, the motion contains both a transient response associated with the system’s own dynamics and a forced response associated with the driver. Damping causes the transient to fade. The long-time motion follows the driving frequency.

$$v_{0x} = v_0 \cos(\theta);\ v_{0y} = v_0 \sin(\theta);\ x = x_0 + v_{0x}\, t;\ y = y_0 + v_{0y}\, t - (1/2)gt^2;\ v_y = v_{0y} - gt.\ \text{For equal heights: } T = 2v_{0y/g,}\ R = v_0^2 \sin(2\theta)/g,\ H = v_{0y}^2/(2g).$$

EXAMPLE A motor starts a flexible platform: early motion can look complicated, but after settling the platform oscillates at the motor’s forcing frequency.

SENSEI NOTE Do not identify every observed frequency with the natural frequency; driven steady-state motion follows the driver.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Resonance, Phase, and Energy Transfer

Resonance occurs when repeated forcing transfers energy especially effectively. Weak damping allows a large, sharp response near the natural frequency. Stronger damping limits the buildup and broadens the response. The timing between force and motion also changes with driving frequency; this phase relationship controls how effectively the force does work.

$$a_{rad} = v^2/r = \omega^2 r \text{ (inward)};\ a_{tan} = dv/dt;\ |a| = \sqrt{(a_{rad}^2 + a_{tan}^2)};\ v_{A/C} = v_{A/B} + v_{B/C}.$$

EXAMPLE A swing gains energy when pushes are timed with the motion; poorly timed pushes can add little energy or even oppose the motion.

SENSEI NOTE Resonance does not create energy. The driver supplies the energy and damping removes it.

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

Classify behavior from descriptions.

System A crosses equilibrium many times with shrinking peaks. System B returns fastest without overshoot. System C returns without overshoot but takes much longer. Classify A, B, and C.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Trace the energy story.

A lightly damped oscillator is driven near resonance until it reaches steady state. Describe energy flow over one cycle.

PRACTICE 3

Independent Problem

Compare two resonance curves.

Oscillator X has a narrow tall response peak; oscillator Y has a broad low peak. Which has greater damping and which is more frequency-selective?

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 Damped Trace

Use crossing behavior and settling time.

A response returns to equilibrium without crossing it and is faster than any other nonoscillatory response. What regime is it?

QUICK CHECK 2

Check Driving Frequency

Choose the long-time frequency.

A natural 2 Hz oscillator is driven steadily at 6 Hz. After transients fade, what frequency remains?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Check Resonance Reasoning

Evaluate a claim.

A student says “At resonance the oscillator makes energy.” Correct the statement.

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

Damping Determines How Free Motion Settles

Underdamped, critical, and overdamped responses differ in overshoot and settling behavior.

KEY TAKEAWAY 2

The Driver Determines the Steady Frequency

Transients fade with damping; persistent forcing controls the long-time oscillation frequency.

KEY TAKEAWAY 3

Resonance Is Frequency-Selective Energy Transfer

Weak damping produces a stronger, sharper resonance; phase and damping govern how efficiently the driver transfers energy.

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

Underdamped.

WHY IT WORKS The system still oscillates, but dissipative forces reduce its mechanical energy and amplitude.

WARM-UP • ACTIVITY 2

Recall Activity 2

4 Hz.

WHY IT WORKS The steady-state response follows the driver; the natural frequency mainly shapes how large and phase-shifted that response is.

WARM-UP • ACTIVITY 3

Recall Activity 3

The peak becomes lower and broader.

WHY IT WORKS Stronger damping removes energy more rapidly and reduces frequency selectivity.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

A underdamped; B critically damped; C overdamped.

WHY IT WORKS Oscillation identifies underdamping. Among nonoscillatory responses, critical damping settles fastest.

PRACTICE 2

Guided Problem

The driver supplies energy on average; damping removes the same average amount at steady state, so the average stored mechanical energy stops increasing.

WHY IT WORKS Steady state does not mean no energy transfer. It means average input balances average dissipation.

PRACTICE 3

Independent Problem

Y has greater damping; X is more frequency-selective.

WHY IT WORKS Weak damping permits larger buildup over a narrow frequency range; strong damping suppresses and broadens the response.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Read a Damped Trace

Critically damped.

WHY IT WORKS Critical damping is the boundary between oscillatory and nonoscillatory motion and gives the fastest nonoscillatory settling.

QUICK CHECK 2

Check Driving Frequency

6 Hz.

WHY IT WORKS The external force persists at 6 Hz and sustains the steady-state response at that frequency.

QUICK CHECK 3

Check Resonance Reasoning

The oscillator receives energy from the driver especially effectively; damping removes energy. Resonance does not create energy.

WHY IT WORKS Energy conservation still applies. Large amplitude reflects sustained energy input, not energy creation.

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