

FOCUSED REVIEW

Focused Review: Thermal Expansion

Review the most important thermal-expansion ideas, reinforce the essential calculations, and confirm you are ready to move on.

 TIME 15–20 minutes	 BEST FOR Focused review	 FINISH WITH Greater confidence
---	--	---

After this focused review, you'll be able to...

After this focused review, you'll be able to...

connect temperature change to length, area, and volume changes and solve representative thermal-expansion problems.

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 • COURSE ALIGNMENT

Course Alignment

This Physics Sensei Unit Review is an independent learning resource. Use it to reinforce key concepts, prepare for homework, or review before a quiz or exam.

RESOURCE: Physics Sensei Unit Review
UNIT ID: THM-U02
TOPIC: Thermal Expansion
COURSE LEVEL: Calculus-based college physics

BEST USED

- ✓ After learning the unit
- ✓ Before starting homework
- ✓ Before a quiz or exam

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 Refresh key ideas.	2 Core Concepts Reinforce the essentials.	3 Guided Practice Strengthen key skills.
4 Confidence Check Confirm your understanding.	5 Summary Remember the essentials.	6 Next Step 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**Derivative definition**

Write α in terms of L and dL/dT .

WARM-UP 2**First-order relation**

Starting from $V \propto L^3$, predict β/α for an isotropic solid.

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Stress sign

With tension positive, predict the sign of stress in a fully constrained bar that is heated.

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 →

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

Expansion Coefficient as a Derivative

The instantaneous linear expansion coefficient is $\alpha(T) = (1/L)(dL/dT)$. If α varies with temperature, integrate: $\ln(L/L_0) = \int \alpha(T) dT$. For nearly constant α and small fractional change, $L \approx L_0(1 + \alpha\Delta T)$.

$$\alpha(T) = (1/L)(dL/dT); \ln(L/L_0) = \int \alpha(T) dT$$

EXAMPLE For constant α , the exact integrated form is $L = L_0 e^{\alpha\Delta T}$; the familiar linear formula is its first-order approximation.

SENSEI NOTE State when the constant- α approximation is being used.

KEY CONCEPT 2

Multidimensional Expansion

For isotropic scaling, $A \propto L^2$ and $V \propto L^3$. Differentiation gives $(1/A)(dA/dT) = 2\alpha$ and $(1/V)(dV/dT) = 3\alpha$, so $\beta = 3\alpha$ for an isotropic solid to first order.

$$(1/A)(dA/dT) = 2\alpha; (1/V)(dV/dT) = 3\alpha$$

EXAMPLE The products $(\alpha\Delta T)^2$ and higher are discarded in the usual small-expansion approximation.

SENSEI NOTE The relations 2α and 3α assume isotropy.

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 →](#)

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**Variable coefficient**

Let $\alpha(T) = a + bT$. Derive $L(T)$ relative to L_0 at T_0 .

PRACTICE 2**First-order volume**

Use $L = L_0(1 + x)$, with $x = \alpha\Delta T$, to derive the first-order volume change of a cube.

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 →

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

Exact versus linear

For constant α , give the exact integrated expression for L and its first-order approximation.

CONFIDENCE CHECK 2

Anisotropy

Why can $\beta = 3\alpha$ fail for a crystal?

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 →

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

Expansion Coefficient as a Derivative

The instantaneous linear expansion coefficient is $\alpha(T) = (1/L)(dL/dT)$. If α varies with temperature, integrate: $\ln(L/L_0) = \int \alpha(T) dT$. For nearly constant α and small fractional change, $L \approx L_0(1 + \alpha\Delta T)$.

KEY TAKEAWAY 2

Multidimensional Expansion

For isotropic scaling, $A \propto L^2$ and $V \propto L^3$. Differentiation gives $(1/A)(dA/dT) = 2\alpha$ and $(1/V)(dV/dT) = 3\alpha$, so $\beta = 3\alpha$ for an isotropic solid to first order.

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 →

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

Derivative definition

Use the definitions and sign conventions from the review.

WHY IT WORKS Thermal expansion begins with identifying ΔT , the relevant dimension, and the correct coefficient.

WARM-UP • ACTIVITY 2

First-order relation

Use the definitions and sign conventions from the review.

WHY IT WORKS Thermal expansion begins with identifying ΔT , the relevant dimension, and the correct coefficient.

WARM-UP • ACTIVITY 3

Stress sign

Use the definitions and sign conventions from the review.

WHY IT WORKS Thermal expansion begins with identifying ΔT , the relevant dimension, and the correct coefficient.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Variable coefficient**

Integrate $dL/L = (a + bT)dT$: $L = L_0 \exp[a(T - T_0) + (b/2)(T^2 - T_0^2)]$.

WHY IT WORKS Substitute signed quantities into the matching expansion equation and check units.

PRACTICE 2**First-order volume**

$V/V_0 = (1 + x)^3 = 1 + 3x + 3x^2 + x^3$. Keeping first order gives $\Delta V/V_0 \approx 3\alpha\Delta T$, so $\beta \approx 3\alpha$.

WHY IT WORKS Substitute signed quantities into the matching expansion equation and check units.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Exact versus linear

Exact: $L = L_0 e^{\alpha \Delta T}$. First order: $L \approx L_0(1 + \alpha \Delta T)$.

WHY IT WORKS The result follows from proportionality and the correct geometric factor.

CONFIDENCE CHECK 2

Anisotropy

A crystal can have direction-dependent expansion coefficients, so equal fractional expansion in all three directions is not guaranteed.

WHY IT WORKS The result follows from proportionality and the correct geometric factor.

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 Review the focused review again to strengthen the essential concepts. Review Again →	🎯 I Need More Practice Build confidence with additional practice problems. Go to Practice →	✓ I'm Ready Continue to the next topic or learning resource. Continue →
---	---	---

RECOMMENDED LINKS

[Review this topic again →](#)

[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