

FULL REVIEW

Full Review: Thermal Expansion

Review thermal expansion from physical meaning through representative calculations and applications.

 TIME 45–60 minutes	 BEST FOR A complete topic review	 FINISH WITH A readiness check
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After this full review, you'll be able to...

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explain thermal expansion, select and apply linear, area, and volume models, and analyze constrained expansion.

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 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: Algebra-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 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 Activate prior knowledge.	2 Core Concepts Review the essential ideas.	3 Guided Practice Apply what you learned.
4 Confidence Check Confirm your understanding.	5 Summary Review the key ideas.	6 Next Step 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

Equation match

Match $\Delta L = \alpha L_0 \Delta T$, $\Delta A = 2\alpha A_0 \Delta T$, and $\Delta V = \beta V_0 \Delta T$ to length, area, and volume expansion.

ACTIVITY 2

Units and signs

State the units of α and the sign of ΔL when $\Delta T < 0$ for an ordinary material with $\alpha > 0$.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Coefficient relation

For an isotropic solid, express β in terms of α .

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 →

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

Linear Expansion Model

For a uniform isotropic material over a moderate temperature range, $\Delta L = \alpha L_0 \Delta T$ and $L = L_0(1 + \alpha \Delta T)$. The units of α are inverse temperature, such as $^{\circ}\text{C}^{-1}$ or K^{-1} .

$$\Delta L = \alpha L_0 \Delta T; \quad L = L_0(1 + \alpha \Delta T)$$

EXAMPLE A steel rail of length 20.0 m heated by 25°C with $\alpha = 12 \times 10^{-6}/^{\circ}\text{C}$ expands 6.0 mm.

SENSEI NOTE Keep the sign of ΔT through the calculation.

KEY CONCEPT 2

Area and Volume Expansion

For small fractional changes, $\Delta A = 2\alpha A_0 \Delta T$ and $\Delta V = \beta V_0 \Delta T$. For isotropic solids, $\beta \approx 3\alpha$. Use initial area or volume in these linear approximations.

$$\Delta A = 2\alpha A_0 \Delta T; \quad \Delta V = \beta V_0 \Delta T; \quad \beta \approx 3\alpha$$

EXAMPLE A 0.100 m^3 solid with $\alpha = 20 \times 10^{-6}/^{\circ}\text{C}$ heated by 50°C gains about $3.00 \times 10^{-4} \text{ m}^3$.

SENSEI NOTE Do not use α directly in the volume equation unless you first replace β with 3α .

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Apparent Expansion and Thermal Stress

A liquid and its container both expand. The observed overflow depends on the difference between their volume-expansion coefficients. If a solid is prevented from expanding, the thermal strain $\alpha\Delta T$ leads to thermal stress with magnitude $Y\alpha|\Delta T|$ in the ideal fully constrained model.

$$\text{Fully constrained: } |\sigma| = Y\alpha|\Delta T|$$

EXAMPLE A tightly constrained steel member can experience large stress even when its free expansion would be only millimeters.

SENSEI NOTE Decide first whether the object is free or constrained.

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 →

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**Aluminum rail**

An aluminum rail is 18.0 m long at 10°C. If $\alpha = 23 \times 10^{-6}/^{\circ}\text{C}$, find its length at 45°C.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2**Expansion gap**

Steel bridge sections are 30.0 m long. For a 55°C temperature rise and $\alpha = 12 \times 10^{-6}/^\circ\text{C}$, find the minimum gap needed per section.

PRACTICE 3**Volume change**

A 2.00 L glass vessel has $\alpha = 9.0 \times 10^{-6}/^\circ\text{C}$ and warms by 60°C. Estimate its volume increase.

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 →

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

Solve for coefficient

A 1.50 m rod lengthens by 0.810 mm for $\Delta T = 30^\circ\text{C}$. Find α .

QUICK CHECK 2

Area expansion

A metal sheet has $A_0 = 0.800 \text{ m}^2$, $\alpha = 15 \times 10^{-6}/^\circ\text{C}$, and $\Delta T = 40^\circ\text{C}$. Find ΔA .

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Constraint

A bar would freely expand by $\alpha L_0 \Delta T$, but both ends are fixed. What replaces the free length change?

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 →

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

Linear Expansion Model

For a uniform isotropic material over a moderate temperature range, $\Delta L = \alpha L_0 \Delta T$ and $L = L_0(1 + \alpha \Delta T)$. The units of α are inverse temperature, such as $^{\circ}\text{C}^{-1}$ or K^{-1} .

KEY TAKEAWAY 2

Area and Volume Expansion

For small fractional changes, $\Delta A = 2\alpha A_0 \Delta T$ and $\Delta V = \beta V_0 \Delta T$. For isotropic solids, $\beta \approx 3\alpha$. Use initial area or volume in these linear approximations.

KEY TAKEAWAY 3

Apparent Expansion and Thermal Stress

A liquid and its container both expand. The observed overflow depends on the difference between their volume-expansion coefficients. If a solid is prevented from expanding, the thermal strain $\alpha \Delta T$ leads to thermal stress with magnitude $Y\alpha|\Delta T|$ in the ideal fully constrained model.

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**Equation match**

Use the definitions and relationships from the review.

WHY IT WORKS Identify the dimension, temperature change, and coefficient before calculating.

WARM-UP • ACTIVITY 2**Units and signs**

Use the definitions and relationships from the review.

WHY IT WORKS Identify the dimension, temperature change, and coefficient before calculating.

WARM-UP • ACTIVITY 3**Coefficient relation**

Use the definitions and relationships from the review.

WHY IT WORKS Identify the dimension, temperature change, and coefficient before calculating.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Aluminum rail**

$$\Delta T = 35^\circ\text{C}. \Delta L = (23 \times 10^{-6})(18.0)(35) = 0.01449 \text{ m, so } L = 18.0145 \text{ m.}$$

WHY IT WORKS The model connects fractional size change to temperature change.

PRACTICE 2**Expansion gap**

$$\Delta L = (12 \times 10^{-6})(30.0)(55) = 0.0198 \text{ m} = 1.98 \text{ cm.}$$

WHY IT WORKS The model connects fractional size change to temperature change.

PRACTICE 3**Volume change**

$$\beta \approx 3\alpha = 27 \times 10^{-6}/^\circ\text{C}. \Delta V = \beta V_0 \Delta T = (27 \times 10^{-6})(2.00 \text{ L})(60) = 0.00324 \text{ L} = 3.24 \text{ mL.}$$

WHY IT WORKS The model connects fractional size change to temperature change.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Solve for coefficient

$$\alpha = \Delta L / (L_0 \Delta T) = 0.000810 / (1.50 \times 30) = 1.80 \times 10^{-5} / ^\circ\text{C}.$$

WHY IT WORKS Apply the stated approximation and interpret the sign physically.

QUICK CHECK 2

Area expansion

$$\Delta A = 2\alpha A_0 \Delta T = 2(15 \times 10^{-6})(0.800)(40) = 9.60 \times 10^{-4} \text{ m}^2.$$

WHY IT WORKS Apply the stated approximation and interpret the sign physically.

QUICK CHECK 3

Constraint

The supports prevent the length change and a compressive thermal stress develops for heating.

WHY IT WORKS Apply the stated approximation and interpret the sign physically.

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 Review the key ideas and examples again. Review Again →	 I Need More Practice Continue with additional practice for this topic. Go to Practice →	 I'm Ready Continue to the next recommended resource. Continue →
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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