

FULL REVIEW

Full Review: Heat Transfer

Review the essential ideas, relationships, and problem-solving tools for Heat Transfer.

 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...

recall the essential ideas, apply them to representative problems, and determine what to study next.

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-U05
TOPIC: Heat Transfer
COURSE LEVEL: Calculus-Based

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**Recall Activity 1**

Recall conduction, convection, radiation, heat flux, and the temperature quantities used in each model.

List each mode, its physical carrier/mechanism, and one governing relation.

ACTIVITY 2**Recall Activity 2**

Classify three situations by dominant mode and explain why.

Solid wall → conduction; moving heated fluid → convection; transfer across vacuum → radiation.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Predict how changing area, thickness, or temperature affects the heat-transfer rate.

Use the appropriate rate relation and state the proportionality before calculating.

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

Conduction and Thermal Resistance

Model heat transfer with gradients, boundary conditions, and fluxes. Conduction follows Fourier's law; convection is a boundary law; radiation is nonlinear in absolute temperature.

$$\text{Heat flux: } \mathbf{q} = -k\nabla T. \text{ 1-D conduction: } \dot{Q} = -kA(dT/dx). \text{ Convection: } \dot{Q} = hA(T_{\text{surface}} - T_{\text{fluid}}). \text{ Radiation: } \dot{Q} = \epsilon\sigma A(T_{\text{surface}}^4 - T_{\text{surroundings}}^4).$$

EXAMPLE For steady 1-D conduction with constant k , integrating Fourier's law gives $\dot{Q} = kA(T_{\text{hot}} - T_{\text{cold}})/L$.

SENSEI NOTE Keep the sign convention consistent: heat flows down the temperature gradient.

KEY CONCEPT 2

Convection

Convection is heat transfer between a surface and moving fluid; its coefficient h summarizes fluid properties, geometry, and flow conditions.

$$\text{Heat flux: } \mathbf{q} = -k\nabla T. \text{ 1-D conduction: } \dot{Q} = -kA(dT/dx). \text{ Convection: } \dot{Q} = hA(T_{\text{surface}} - T_{\text{fluid}}). \text{ Radiation: } \dot{Q} = \epsilon\sigma A(T_{\text{surface}}^4 - T_{\text{surroundings}}^4).$$

EXAMPLE Convection sets a surface boundary flux proportional to $T_s - T_\infty$.

SENSEI NOTE Keep the sign convention consistent: heat flows down the temperature gradient.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Thermal Radiation

Thermal radiation is electromagnetic energy emitted by matter; net exchange depends strongly on absolute temperature.

$$\text{Heat flux: } \mathbf{q} = -k\nabla T. \text{ 1-D conduction: } \dot{Q} = -kA(dT/dx). \text{ Convection: } \dot{Q} = hA(T_{\text{surface}} - T_{\text{fluid}}). \text{ Radiation: } \dot{Q} = \epsilon\sigma A(T_{\text{surface}}^4 - T_{\text{surroundings}}^4).$$

EXAMPLE Linearizing radiation near T_m gives an effective $h_r \approx 4\epsilon\sigma T_m^3$.

SENSEI NOTE Keep the sign convention consistent: heat flows down the temperature gradient.

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**Worked Example**

Follow the model selection and calculation steps.

Integrate steady 1-D Fourier conduction through a plane wall of thickness L with constant k . $\dot{Q} = -kA(dT/dx) = \text{constant}$; integration gives $\dot{Q} = kA(T_1 - T_2)/L$ for $T_1 > T_2$.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Use the appropriate relation and show your setup.

A composite wall has layers L_{i,k_i} and common area A . Write total thermal resistance and $\dot{Q}$. Check: identify knowns, choose the mode/model, then solve.

PRACTICE 3

Independent Problem

Solve independently, including units.

Linearize net radiation about a mean absolute temperature T_m for a small ΔT .

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

Conduction Check

Answer without notes.

What direction does $-\nabla T$ point?

QUICK CHECK 2

Convection Check

Answer without notes.

Write series thermal resistance for two plane layers.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Radiation Check

Answer without notes.

Give the linearized radiation coefficient near T_m .

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**Conduction**

Conduction is driven by temperature differences/gradients and limited by thermal resistance.

KEY TAKEAWAY 2**Convection**

Convection couples surface heat transfer to fluid motion through h .

KEY TAKEAWAY 3**Radiation**

Radiation depends on emissivity and absolute temperature to the fourth power.

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

Recall Activity 1

$\vec{q} = -k\nabla T$; the minus sign means heat flux points toward lower temperature.

WHY IT WORKS The temperature gradient points toward increasing T , opposite spontaneous heat flow.

WARM-UP • ACTIVITY 2

Recall Activity 2

Conduction relates flux to an internal temperature gradient; convection relates surface flux to a fluid-surface temperature difference.

WHY IT WORKS The two equations apply in different physical regions.

WARM-UP • ACTIVITY 3

Recall Activity 3

$$\dot{Q} = \epsilon \sigma A (T_s^4 - T_{\text{sur}}^4).$$

WHY IT WORKS Net exchange is emitted minus absorbed environmental radiation in the gray-body model.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

$\dot{Q} = -kA(dT/dx) = \text{constant}$; integration gives $\dot{Q} = kA(T_1 - T_2)/L$ for $T_1 > T_2$.

WHY IT WORKS Steady energy conservation makes the 1-D heat rate constant through the slab.

PRACTICE 2

Guided Problem

$R_{\text{total}} = \Sigma[L_i/(k_i A)]$, so $\dot{Q} = (T_{\text{hot}} - T_{\text{cold}})/R_{\text{total}}$.

WHY IT WORKS Series layers carry the same steady heat rate, so temperature drops add.

PRACTICE 3

Independent Problem

$T_{\text{surface}}^4 - T_{\text{surroundings}}^4 \approx 4T_m^3(T_{\text{surface}} - T_{\text{surroundings}})$, so $\dot{Q} \approx h_r A \Delta T$ with $h_r = 4\epsilon\sigma T_m^3$.

WHY IT WORKS A first-order Taylor expansion converts the nonlinear radiation law to a local linear form.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Conduction Check

Toward decreasing temperature.

WHY IT WORKS Heat flows down the temperature field.

QUICK CHECK 2

Convection Check

$$R = L1/(k1A) + L2/(k2A).$$

WHY IT WORKS Steady series resistances add because the same heat rate crosses each layer.

QUICK CHECK 3

Radiation Check

$$h_r \approx 4\epsilon\sigma T_m^3.$$

WHY IT WORKS It is the derivative of $\epsilon\sigma T^4$ with respect to T evaluated near T_m .

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.

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