

FOCUSED REVIEW

Focused Review: First Law of Thermodynamics — Calculus-Based

Review the most important ideas, reinforce the essential skills, and confirm you're ready to move on.

 TIME 15–20 minutes	 BEST FOR Focused review	 FINISH WITH Greater confidence
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After this focused review, you'll be able to...

recognize the key concepts, reinforce your problem-solving skills, and continue with greater confidence.

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-U08
TOPIC: First Law of Thermodynamics
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 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**Key Ideas**

Differential form

Write the first law for an infinitesimal change using the work-by-system convention.

WARM-UP 2**Common Mistakes**

Boundary work

Write the quasistatic pressure-volume work element.

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Quick Application

Path integral

Write the work for a quasistatic process from initial volume to final volume.

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

First Law and Exact Differentials

For the work-by-system convention, $dU = \delta Q - \delta W$ and over a finite process $\Delta U = Q - W$. Because U is a state function, dU is exact; heat and work are process-dependent and are commonly written with inexact differentials.

$$dU = \delta Q - \delta W \quad \text{and} \quad \Delta U = Q - W$$

EXAMPLE For a complete cycle, $\Delta U = 0$, so net Q equals net W .

SENSEI NOTE Keep the sign convention fixed throughout a derivation.

KEY CONCEPT 2

Path Dependence and State Functions

Between fixed equilibrium states, ΔU is unique. Q and W may change with the path while their difference remains ΔU . This is central to interpreting P-V diagrams and thermodynamic cycles.

$$\Delta U = \int dU = U_2 - U_1$$

EXAMPLE Different paths between the same endpoints can enclose different areas and therefore produce different work.

SENSEI NOTE Endpoint data alone determine ΔU but generally not Q or W separately.

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**Guided Example**

A system absorbs 1.60 kJ and performs 0.55 kJ of work. Find ΔU .

Apply the finite first-law balance.

PRACTICE 2**Independent Check**

A quasistatic expansion follows $P(V) = a/V$ with $a = 500$ J from initial volume = 2.0 L to final volume = 5.0 L. Find W .

Integrate $W = \int (a/V) dV = a \ln(\text{final volume}/\text{initial volume})$.

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

Cycle relation

Solve using the first law and the stated sign convention.

For a complete cycle, what relation connects net heat and net work?

CONFIDENCE CHECK 2

Integral work

Solve using the first law and the stated sign convention.

For constant $P = 3.0 \times 10^5 \text{ Pa}$ and $\Delta V = 1.5 \times 10^{-3} \text{ m}^3$, evaluate $\int P dV$.

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**Differential first law**

$dU = \delta Q - \delta W$; over a finite process, $\Delta U = Q - W$.

KEY TAKEAWAY 2**Path dependence**

U is a state function; heat and work depend on the path.

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

Key Ideas

$$dU = \delta Q - \delta W.$$

WHY IT WORKS U is a state function, while heat and work are path-dependent transfers.

WARM-UP • ACTIVITY 2

Common Mistakes

$$\delta W = P \, dV.$$

WHY IT WORKS Positive dV gives positive work by the system.

WARM-UP • ACTIVITY 3

Quick Application

$$W = \int P \, dV \text{ from initial volume to final volume.}$$

WHY IT WORKS The value depends on the path $P(V)$, not only the endpoints.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Guided Example

$$\Delta U = 1.60 \text{ kJ} - 0.55 \text{ kJ} = 1.05 \text{ kJ}.$$

WHY IT WORKS This is the integral form of $dU = \delta Q - \delta W$.

PRACTICE 2

Independent Check

$$W = 500 \ln(5/2) \approx 458 \text{ J}.$$

WHY IT WORKS The logarithm uses a dimensionless volume ratio.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Cycle relation

net Q = net W .

WHY IT WORKS Because ΔU for the cycle = 0.

CONFIDENCE CHECK 2

Integral work

$W = 450 \text{ J}$.

WHY IT WORKS Constant P factors out of the integral.

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 →
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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