

FULL REVIEW

Full Review: Thermodynamic Processes and PV Diagrams — Calculus-Based

Review the essential ideas, relationships, and problem-solving tools for Thermodynamic Processes and PV Diagrams.

 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-U09
TOPIC: Thermodynamic Processes and PV Diagrams
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 the differential constraints for the four common processes.

State the local constraint for isochoric, isobaric, isothermal, and adiabatic processes.

ACTIVITY 2**Recall Activity 2**

Write the quasistatic P–V work integral.

Give W by the gas for a path $P(V)$ from V_1 to V_2 and state the sign for ordinary expansion.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Recall the cycle integral.

Write the expression for net work around a closed P - V cycle and interpret its geometry.

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

Differential constraints organize thermodynamic processes

For a simple compressible system using work done by the gas, the differential first law is $dU = \delta Q - P dV$. A process constraint then restricts one variable or transfer: $dV = 0$ for isochoric, $dP = 0$ for isobaric, $dT = 0$ for isothermal, and $\delta Q = 0$ for adiabatic.

$$dU = \delta Q - P dV \cdot dV = 0 \cdot dP = 0 \cdot dT = 0 \cdot \delta Q = 0$$

EXAMPLE Along an isochoric path, $dV = 0$, so the boundary-work contribution $P dV$ vanishes even though pressure and temperature may change.

SENSEI NOTE δQ is written differently from dU because heat is path dependent while internal energy is a state function.

KEY CONCEPT 2

Work is the integral of pressure along the volume path

For a quasistatic process, W depends on $P(V)$ along the entire path. Geometrically, the integral is the signed area under the P - V curve. A curved process cannot generally be replaced by a single pressure times ΔV unless that pressure represents the integral correctly.

$$W = \int \text{from } V_1 \text{ to } V_2 P(V) dV$$

EXAMPLE For a linear path from 3.0×10^5 Pa to 2.0×10^5 Pa while volume rises from 2.0 L to 4.0 L, the trapezoid area gives $W = 500$ J.

SENSEI NOTE Two paths connecting the same end states can have different work because $P(V)$ differs between them.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Ideal-gas paths and closed cycles

For an isothermal ideal-gas process, $P = nRT/V$, so integration gives a logarithmic work expression. For a closed cycle, the system returns to its initial state and the net work is the closed P – V integral. Clockwise orientation gives positive net work by the gas.

$$\text{Isothermal ideal gas: } W = nRT \ln(V_2/V_1) \bullet \text{ Cycle: } W_{\text{cycle}} = \oint P \, dV$$

EXAMPLE One mole at 300 K expanding isothermally from 10 L to 20 L does about 1.73 kJ of work.

SENSEI NOTE The cycle integral depends on orientation; reversing the same loop reverses the sign of the work.

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**

Evaluate the integral for a linear pressure path.

Pressure decreases linearly from $3.0 \times 10^5 \text{ Pa}$ at 2.0 L to $2.0 \times 10^5 \text{ Pa}$ at 4.0 L . Find W .

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Integrate the isothermal ideal-gas curve.

One mole of ideal gas at 300 K expands isothermally from 10 L to 20 L. Calculate W .

PRACTICE 3

Independent Problem

Use the closed integral for a rectangular cycle.

A clockwise rectangle spans pressures 1.0×10^5 to 3.0×10^5 Pa and volumes 2.0 to 5.0 L. Evaluate W_{cycle} .

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**Linear path integral**

Use the trapezoid or integrate explicitly.

P rises linearly from 2.0×10^5 Pa to 4.0×10^5 Pa while V increases from 1.0 L to 3.0 L. Find W.

QUICK CHECK 2**Isothermal compression**

Use the logarithmic expression.

For an ideal gas compressed isothermally from V_1 to $V_1/2$, what is the sign of W by the gas?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Cycle orientation

Use the sign of the closed integral.

If the same P - V loop is traversed first clockwise and then counterclockwise, how are the two values of $\oint P dV$ related?

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

Use differentials to state the constraint

Isochoric, isobaric, isothermal, and adiabatic paths impose $dV = 0$, $dP = 0$, $dT = 0$, and $\delta Q = 0$.

KEY TAKEAWAY 2

Work is path dependent

Quasistatic work is $W = \int P(V)dV$, so knowing only the endpoints is not enough unless the path is specified.

KEY TAKEAWAY 3

Integrals turn P–V geometry into energy

An isothermal ideal-gas path gives a logarithm, while a complete cycle gives $W_{\text{cycle}} = \oint P dV$, the signed enclosed area.

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. Focus on the essential explanation behind each result.

WARM-UP • ACTIVITY 1

Recall Activity 1

$dV = 0$, $dP = 0$, $dT = 0$, and $\delta Q = 0$, respectively.

WHY IT WORKS These constraints determine which terms and state relations simplify.

WARM-UP • ACTIVITY 2

Recall Activity 2

$W = \int \text{from } V_1 \text{ to } V_2 P(V) dV$. For positive pressure and $V_2 > V_1$, W is positive.

WHY IT WORKS Work is accumulated along the volume coordinate, so the integration direction sets the sign.

WARM-UP • ACTIVITY 3

Recall Activity 3

$W_{\text{cycle}} = \oint P dV$; it is the signed area enclosed by the loop.

WHY IT WORKS The contributions from expansion and compression combine into a closed-path area.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Worked Example**

The integral equals the trapezoid area: $W = [(3.0 + 2.0)/2 \times 10^5 \text{ Pa}](2.0 \times 10^{-3} \text{ m}^3) = 500 \text{ J}$.

WHY IT WORKS For a linear function, the average value over the interval is the arithmetic mean of the endpoint pressures.

PRACTICE 2**Guided Problem**

$W = nRT \ln(V_2/V_1) = (1)(8.314)(300)\ln 2 \approx 1.73 \times 10^3 \text{ J}$.

WHY IT WORKS Substituting $P = nRT/V$ into $\int P \, dV$ gives the logarithm.

PRACTICE 3**Independent Problem**

$W_{\text{cycle}} = \text{enclosed area} = (2.0 \times 10^5 \text{ Pa})(3.0 \times 10^{-3} \text{ m}^3) = +600 \text{ J}$.

WHY IT WORKS The vertical legs have $dV = 0$, and the two horizontal integrals differ by the rectangle area.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Linear path integral

$$W = P_{\text{avg}}\Delta V = (3.0 \times 10^5)(2.0 \times 10^{-3}) = 600 \text{ J.}$$

WHY IT WORKS A linear $P(V)$ integrates to the trapezoid area.

QUICK CHECK 2

Isothermal compression

Negative, because $W = nRT \ln(1/2) < 0$.

WHY IT WORKS The final volume is smaller than the initial volume, so the logarithm is negative.

QUICK CHECK 3

Cycle orientation

They have equal magnitude and opposite sign.

WHY IT WORKS Reversing the path reverses the orientation of the line integral.

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