

FULL REVIEW

Full Review: Entropy and the Second Law — Calculus-Based

Review the essential ideas, relationships, and problem-solving tools for entropy and the second law.

 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-U11
TOPIC: Entropy and the Second Law
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**

Write the differential definition $dS = \delta Q_{\text{rev}}/T$ and distinguish dS from the path-dependent heat differential δQ .

Write the key relationship and explain its physical meaning.

ACTIVITY 2**Recall Activity 2**

Write the finite entropy change as an integral between equilibrium states.

Write the key relationship and explain its physical meaning.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

State the Clausius inequality for a cycle and connect strict inequality with irreversibility.

Write the key relationship and explain its physical meaning.

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

Entropy as a state differential

Entropy is a state function with differential $dS = \delta Q_{\text{rev}}/T$ along a reversible path. For any two equilibrium states, $\Delta S = \int_1^2 \delta Q_{\text{rev}}/T$ evaluated along a convenient reversible path.

$$dS = \delta Q_{\text{rev}}/T; \quad \Delta S = \int_1^2 \delta Q_{\text{rev}}/T$$

Even if the actual process is irreversible, ΔS can be computed using any reversible path connecting the same end states.

Do not replace δQ by dQ conceptually: heat is path dependent, while entropy has an exact differential.

KEY CONCEPT 2

Entropy generation and the second law

A useful balance is $dS = \delta Q/T_b + dS_{\text{gen}}$, where T_b is the boundary temperature for heat transfer and $dS_{\text{gen}} \geq 0$. Reversible processes have $dS_{\text{gen}} = 0$.

$$dS = \delta Q/T_b + dS_{\text{gen}}, \text{ with } dS_{\text{gen}} \geq 0$$

For an isolated system $\delta Q = 0$, so $dS = dS_{\text{gen}} \geq 0$.

Entropy generation is a diagnostic of irreversibility, not an entropy "flow" across the boundary.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Clausius inequality and cycles

For any cycle, $\oint \delta Q/T \leq 0$ when the boundary temperature is used consistently. Equality holds for a reversible cycle; strict inequality signals irreversibility.

For a cycle: $\oint \delta Q/T \leq 0$; equality for a reversible cycle

A real heat-engine cycle has positive entropy generation even though the working substance returns to its initial entropy.

Separate the system's cyclic state change from entropy transfer and entropy generation.

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**

Solve the problem and justify the entropy relation used.

For one mole of an ideal gas heated reversibly at constant volume from T_1 to T_2 with constant C_v , evaluate $\Delta S = \int nC_v dT/T$.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Solve the problem and justify the entropy relation used.

A reversible isothermal ideal-gas expansion goes from V_1 to V_2 . Starting with $\delta Q_{\text{rev}} = nRT \, dV/V$, evaluate ΔS .

PRACTICE 3

Independent Problem

Solve the problem and justify the entropy relation used.

A control mass exchanges heat δQ at boundary temperature T_b and undergoes an irreversible process. Write the entropy balance and identify the nonnegative generation term.

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

Entropy Check

Solve or explain briefly.

Evaluate $\int$ from T_1 to T_2 of $nC_V dT/T$ for constant C_V .

QUICK CHECK 2

Entropy Check

Solve or explain briefly.

For a reversible isothermal expansion, express ΔS in terms of n , R , V_1 , and V_2 .

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Entropy Check

Solve or explain briefly.

If an isolated irreversible process has $\Delta S = 4.0 \text{ J/K}$, what is S_{gen} ?

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

Integrate $dS = \delta Q_{\text{rev}}/T$

Entropy is a state function with differential $dS = \delta Q_{\text{rev}}/T$ along a reversible path.

KEY TAKEAWAY 2

Track entropy generation

A useful balance is $dS = \delta Q/T_b + dS_{\text{gen}}$, where T_b is the boundary temperature for heat transfer and $dS_{\text{gen}} \geq 0$.

KEY TAKEAWAY 3

Use the Clausius inequality

For any cycle, $\oint \delta Q/T \leq 0$ when the boundary temperature is used consistently.

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

$dS = \delta Q_{\text{rev}}/T$; integrating along a reversible path gives $\Delta S = \int_1^2 \delta Q_{\text{rev}}/T$.

This is the governing entropy principle for the activity.

WARM-UP • ACTIVITY 2

Recall Activity 2

For an isolated system, $dS = dS_{\text{gen}} \geq 0$. Reversible means $dS_{\text{gen}} = 0$.

This is the governing entropy principle for the activity.

WARM-UP • ACTIVITY 3

Recall Activity 3

The Clausius inequality is $\oint \delta Q/T \leq 0$; equality applies to a reversible cycle.

This is the governing entropy principle for the activity.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Worked Example**

$$\Delta S = nC_V \int (dT/T) = nC_V \ln(T_2/T_1).$$

Verify the integral/sign convention and interpret the result physically.

PRACTICE 2**Guided Problem**

$$\Delta S = \int nR \, dV/V = nR \ln(V_2/V_1).$$

Verify the integral/sign convention and interpret the result physically.

PRACTICE 3**Independent Problem**

$$dS = \delta Q/T_b + dS_{\text{gen}} \text{ with } dS_{\text{gen}} \geq 0. \text{ The generation term is zero only in the reversible limit.}$$

Verify the integral/sign convention and interpret the result physically.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Entropy Check

$$\Delta S = nC_V \int (dT/T) = nC_V \ln(T_2/T_1).$$

A correct result must also satisfy the second-law entropy balance.

QUICK CHECK 2

Entropy Check

$$\Delta S = \int nR dV/V = nR \ln(V_2/V_1).$$

A correct result must also satisfy the second-law entropy balance.

QUICK CHECK 3

Entropy Check

$$dS = \delta Q/T_b + dS_{\text{gen}} \text{ with } dS_{\text{gen}} \geq 0. \text{ The generation term is zero only in the reversible limit.}$$

A correct result must also satisfy the second-law entropy balance.

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