

FULL REVIEW

Full Review: Capacitance and Dielectrics — Algebra-Based

Review the essential ideas, relationships, and problem-solving tools for Capacitance and Dielectrics.

 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: EME-U05
TOPIC: Capacitance and Dielectrics
COURSE LEVEL: Algebra-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**Key Ideas**

Write $C = Q/\Delta V$ and the equivalent-capacitance rules for parallel and series. Identify the units of C , Q , and ΔV .

Complete the activity in the space below.

ACTIVITY 2**Common Mistakes**

For each network, state what is common: series capacitors share charge magnitude; parallel capacitors share potential difference. Explain why mixing these rules gives wrong answers.

Complete the activity in the space below.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Quick Application

A $3\ \mu\text{F}$ and $6\ \mu\text{F}$ capacitor are connected in parallel across $12\ \text{V}$. Find the equivalent capacitance and the total charge supplied by the battery.

Complete the activity in the space below.

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

Capacitance and capacitor networks

Capacitance relates the magnitude of plate charge to potential difference. Reduce networks first: parallel capacitances add directly, while reciprocals add in series. After finding the equivalent value, work backward using equal voltage in parallel and equal charge magnitude in series.

$$C = \frac{Q}{\Delta V}$$

EXAMPLE For 3 μF and 6 μF in parallel, $C_{\text{eq}} = 9 \mu\text{F}$.

SENSEI NOTE Do not use the resistor rules for capacitors; series and parallel behavior is reversed.

KEY CONCEPT 2

Energy and dielectrics

A charged capacitor stores electric potential energy. Equivalent energy forms are $U = \frac{1}{2}C(\Delta V)^2 = \frac{Q^2}{2C} = \frac{1}{2}Q\Delta V$. A fully inserted dielectric changes C to κC_0 . The energy change depends on what is held fixed.

$$U = \frac{1}{2}C(\Delta V)^2 = \frac{Q^2}{2C} = \frac{1}{2}Q\Delta V$$

EXAMPLE For fixed voltage, increasing C increases U ; for fixed charge, increasing C decreases U .

SENSEI NOTE Before choosing an energy expression, decide whether Q or ΔV is fixed.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Parallel-plate geometry

For an ideal parallel-plate capacitor, $C = \epsilon_0 A/d$. Filling the gap with a dielectric changes ϵ_0 to $\kappa\epsilon_0$, so $C = \kappa\epsilon_0 A/d$. This model neglects fringing and assumes the plate dimensions are large compared with d .

$$C = \frac{\kappa\epsilon_0 A}{d}$$

EXAMPLE Doubling A doubles C ; doubling d halves C .

SENSEI NOTE Keep SI units consistent: area in m^2 and spacing in m .

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**Guided Example**

A $4.0\ \mu\text{F}$ and $12\ \mu\text{F}$ capacitor are in series across $24\ \text{V}$. Find C_{eq} , the charge magnitude on each capacitor, and each voltage.

Show the governing relation, substitution or reasoning, and final conclusion.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Independent Check

A $5.0\ \mu\text{F}$ capacitor at $20\ \text{V}$ is disconnected from the battery. A dielectric with $\kappa = 4$ fills the gap. Find the new voltage.

Show the governing relation, substitution or reasoning, and final conclusion.

PRACTICE 3

Independent Problem

A parallel-plate capacitor has $A = 0.020\ \text{m}^2$ and $d = 1.0\ \text{mm}$. Find C in vacuum, then with $\kappa = 5$ filling the gap.

Show the governing relation, substitution or reasoning, and final conclusion.

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**Energy Check**

Work independently, then check the solution.

A $10\ \mu\text{F}$ capacitor is charged to $30\ \text{V}$. Find the stored energy.

QUICK CHECK 2**Combination Check**

Work independently, then check the solution.

Find the equivalent capacitance of $6\ \mu\text{F}$ and $3\ \mu\text{F}$ in series.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Fixed-Q Dielectric

Work independently, then check the solution.

An isolated capacitor receives a dielectric $\kappa = 3$. What happens to C , V , and U ?

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**Core capacitor relations**

Use $C = Q/\Delta V$, the parallel-plate model, and series/parallel equivalent-capacitance rules to connect charge, voltage, geometry, and circuit combinations.

KEY TAKEAWAY 2**Stored electric energy**

Energy can be written in equivalent forms using C , Q , and ΔV . Pick the form that matches the quantities held fixed or given.

KEY TAKEAWAY 3**Dielectric factor κ**

A dielectric increases a fully filled capacitor's capacitance by κ . For fixed Q , voltage and energy decrease; for fixed V , the battery supplies extra charge and the stored energy increases.

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 governing idea and the essential explanation.

WARM-UP • ACTIVITY 1

Key Ideas

$C = Q/\Delta V$. Parallel: $C_{\text{eq}} = C_1 + C_2 + \dots$. Series: $1/C_{\text{eq}} = 1/C_1 + 1/C_2 + \dots$. Units: C in farads (F), Q in coulombs (C), and ΔV in volts (V).

WHY IT WORKS The defining relation connects charge and voltage; equivalent-capacitance rules follow from common voltage in parallel and common charge magnitude in series.

WARM-UP • ACTIVITY 2

Common Mistakes

Series: the charge magnitude is the same on each capacitor. Parallel: the potential difference is the same across each branch.

WHY IT WORKS Using the wrong shared quantity reverses the network logic and produces the wrong equivalent capacitance and component values.

WARM-UP • ACTIVITY 3

Quick Application

$C_{\text{eq}} = 3 \mu\text{F} + 6 \mu\text{F} = 9 \mu\text{F}$. $Q_{\text{total}} = C_{\text{eq}}\Delta V = (9 \mu\text{F})(12 \text{ V}) = 108 \mu\text{C}$.

WHY IT WORKS Parallel capacitors share the same voltage, so their capacitances add directly; the battery supplies the total charge associated with the equivalent capacitance.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Guided Example**

$1/C_{\text{eq}} = 1/4 + 1/12 \text{ (}\mu\text{F)}^{-1}$, so $C_{\text{eq}} = 3.0 \text{ }\mu\text{F}$. $Q = C_{\text{eq}}V = 72 \text{ }\mu\text{C}$. Voltages are 18 V across $4.0 \text{ }\mu\text{F}$ and 6 V across $12 \text{ }\mu\text{F}$.

WHY IT WORKS Series capacitors have the same charge magnitude. Find C_{eq} first, use $Q = C_{\text{eq}}\Delta V$, and then use $V_i = Q/C_i$ for each capacitor.

PRACTICE 2**Independent Check**

Q stays fixed and C becomes $20 \text{ }\mu\text{F}$, so $V = Q/C = 5.0 \text{ V}$.

WHY IT WORKS Disconnecting the battery fixes Q . Inserting $\kappa = 4$ makes C four times larger, so $V = Q/C$ falls by a factor of four.

PRACTICE 3**Independent Problem**

$C_0 = \epsilon_0 A/d \approx 177 \text{ pF}$. With dielectric, $C = 5C_0 \approx 885 \text{ pF}$.

WHY IT WORKS Use $C = \epsilon_0 A/d$ in vacuum; a dielectric multiplies the capacitance by κ .

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Energy Check

$$U = \frac{1}{2}CV^2 = 4.5 \text{ mJ.}$$

WHY IT WORKS Stored energy at fixed C and V is $U = \frac{1}{2}CV^2$.

QUICK CHECK 2

Combination Check

$$C_{\text{eq}} = 2 \text{ } \mu\text{F.}$$

WHY IT WORKS For two capacitors in series, $1/C_{\text{eq}} = 1/C_1 + 1/C_2$.

QUICK CHECK 3

Fixed-Q Dielectric

C triples; V becomes one-third; U becomes one-third.

WHY IT WORKS For an isolated capacitor Q stays fixed. A dielectric makes $C \rightarrow \kappa C$, so $V = Q/C$ and $U = Q^2/(2C)$ each decrease by κ .

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](https://www.physicssensei.com)