Electricity & Magnetism
Lecture 8: Capacitors

Today's Concept:

Capacitors

(Capacitors in a circuits, Dielectrics, Energy in capacitors)

Stuff you asked about:

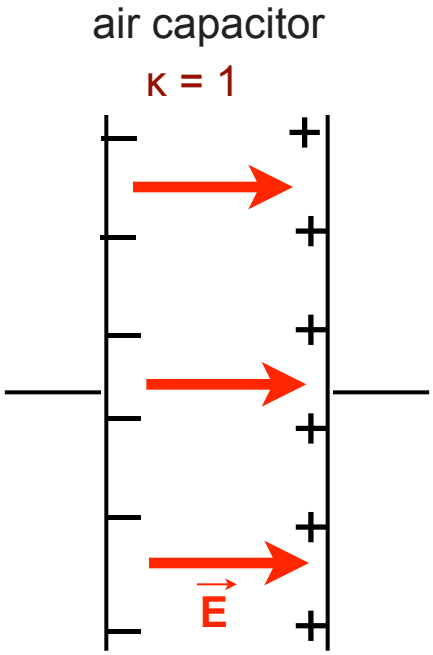
- "Capacitance: parallel and series" -- "Can we go over more on series vs parallel capacitor circuits?"
- "the formula for calculating capacitance in parallel and series are the opposite of the formula for resistance "
- "Please go over the Capactitors with and without a dielectric from checkpoint."
- "this stuff is alot harder than what weve been doing before, one thing i dont understand is when you disconnect a battery from a capacitor what exactly happens, how come it still has a charge?? "
- "I am very confused about the dielectric "

Capacitors, connected and unconnected

- A capacitor that is unconnected to a battery has constant charge: $V = Q/C$ (V is determined by Q)
- Capacitors in parallel have the same voltage. Charge may redistribute among them: $Q_1/C_1 = Q_2/C_2 = Q_2/C_2 \ldots$
- A capacitor connected to a battery has a constant voltage. $Q = CV$ (Q is determined by V)

Dielectric

- Charged capacitor, not connected to battery
- Dielectric makes ΔV smaller



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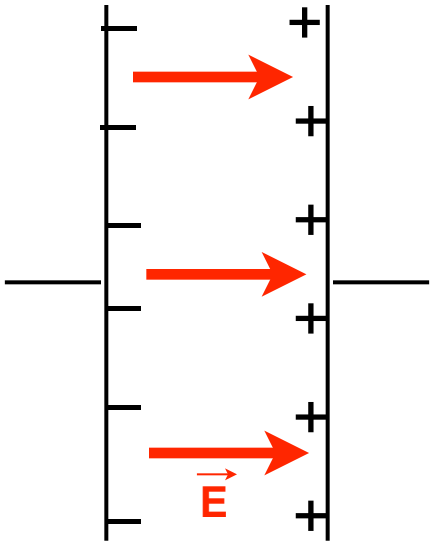
air capacitor

$\kappa = 1$



dielectric capacitor

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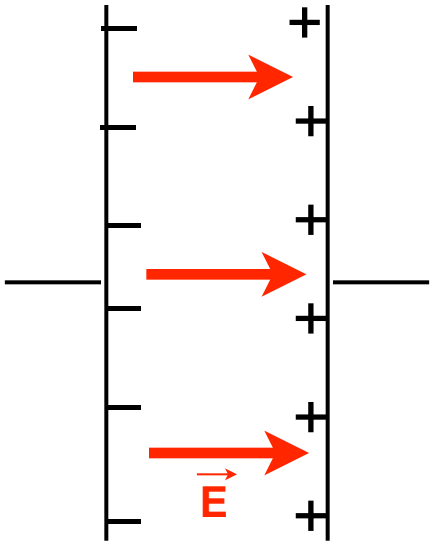

dielectric capacitor

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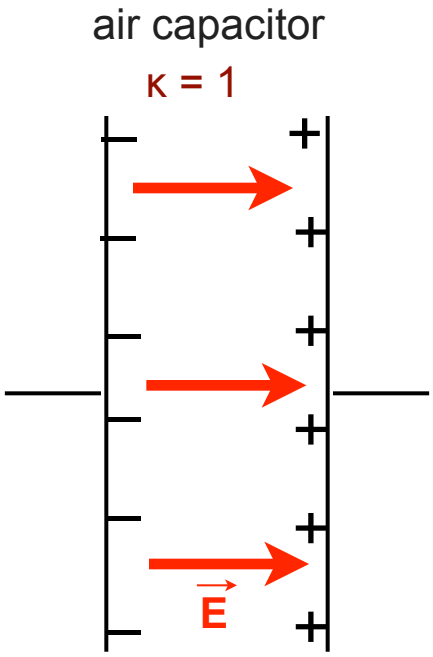

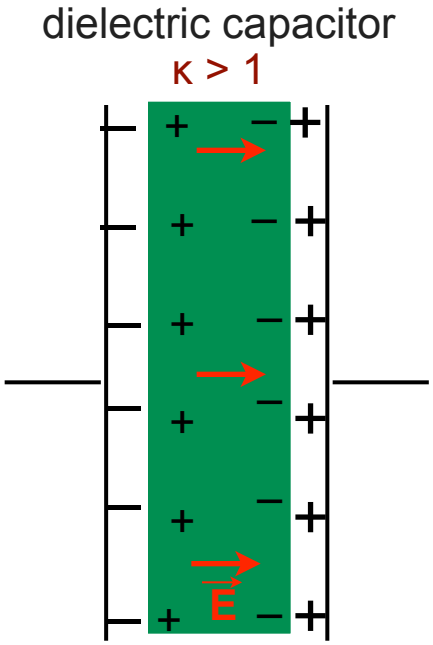

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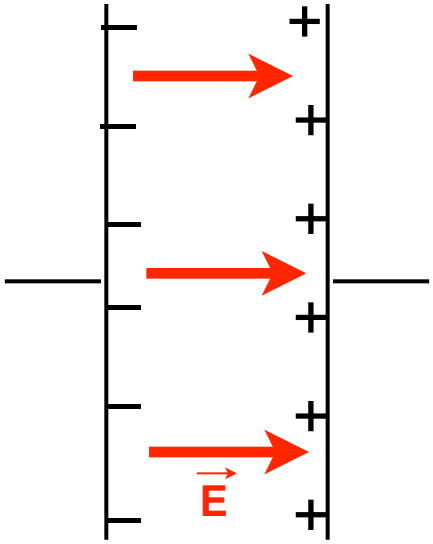

dielectric capacitor

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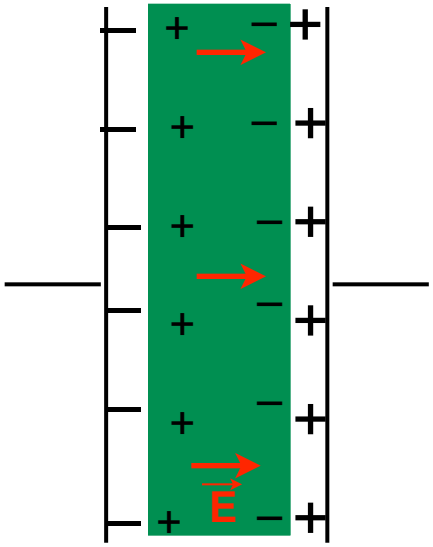

E inside dielectric is smaller than E outside.
The charge on the surface of the dielectric partially cancels the E field from the charge on the plates.
Therefore the ΔV between the plates is less.

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- Dielectric makes ΔV smaller

air capacitor

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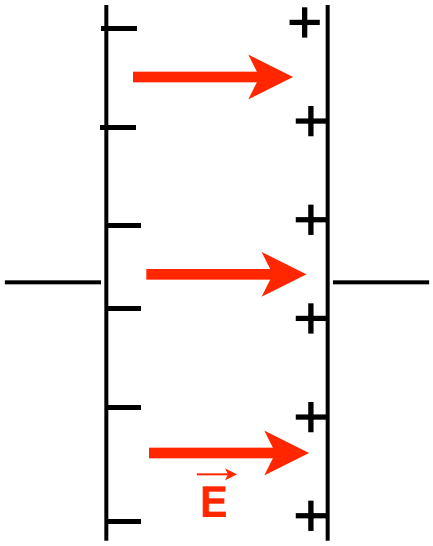
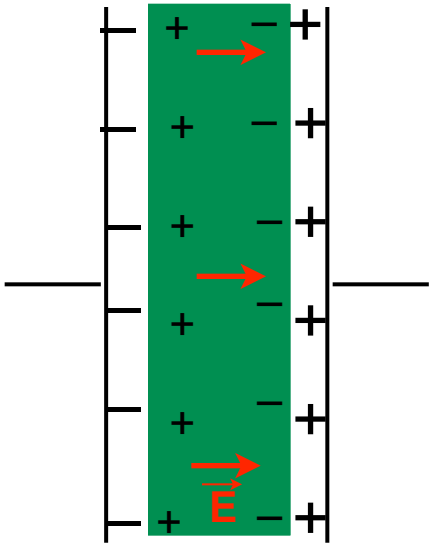


$C = \varepsilon_0 A/L$

dielectric capacitor

$\kappa > 1$



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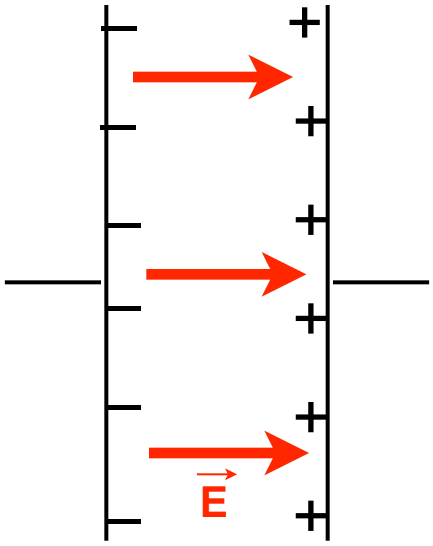

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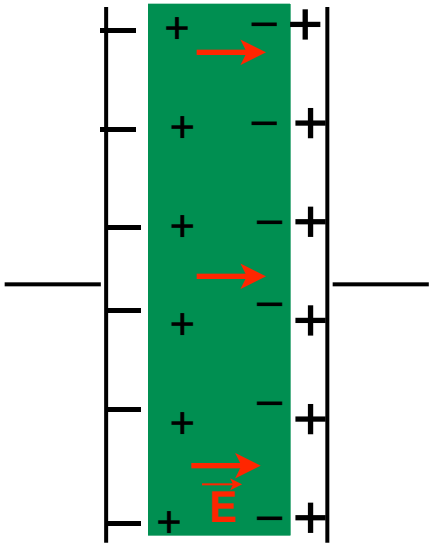

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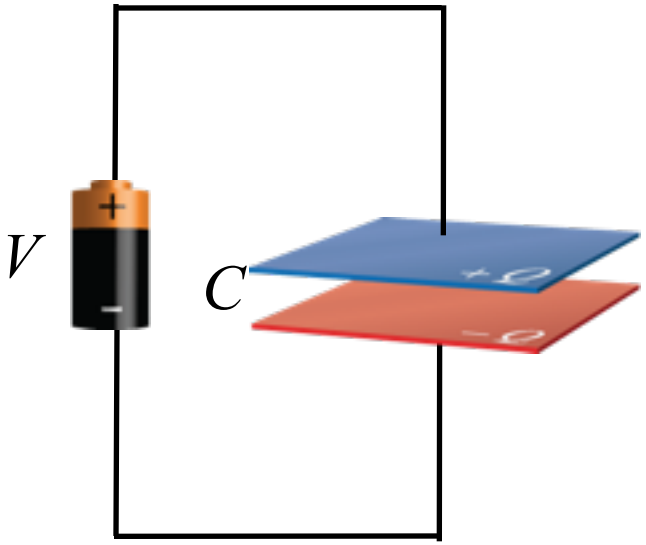
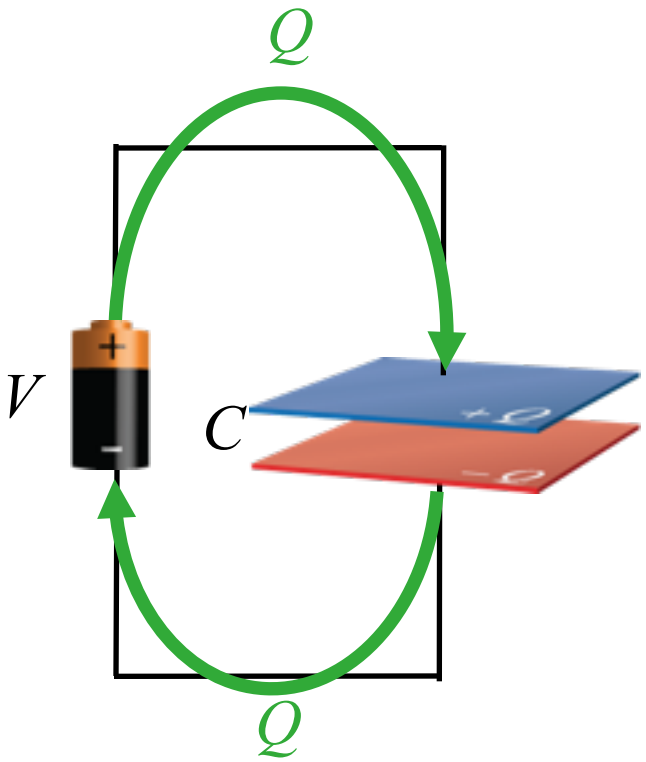
Simple Capacitor Circuit



Simple Capacitor Circuit



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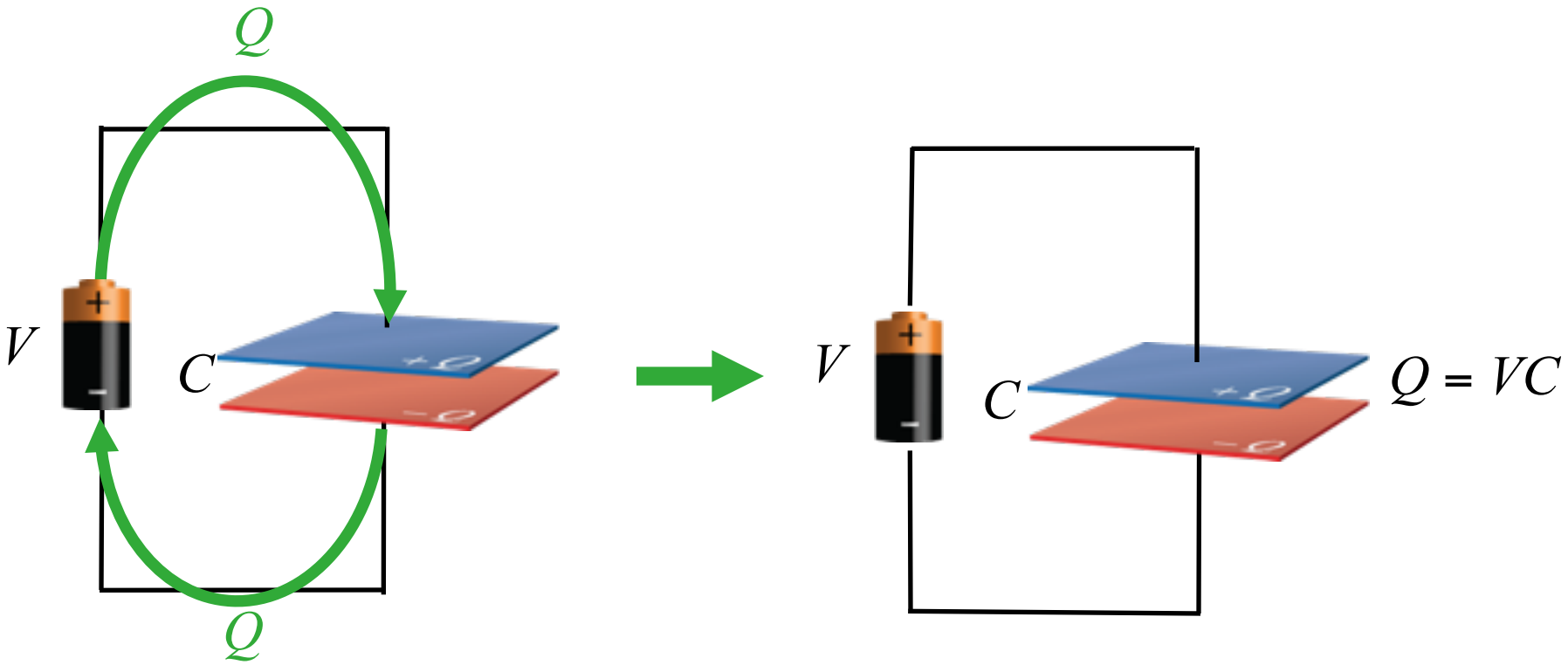

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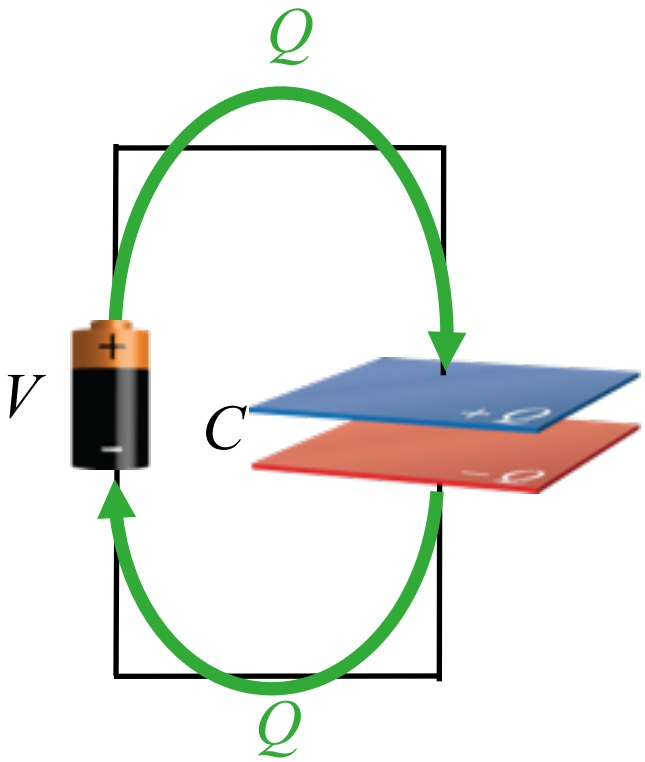
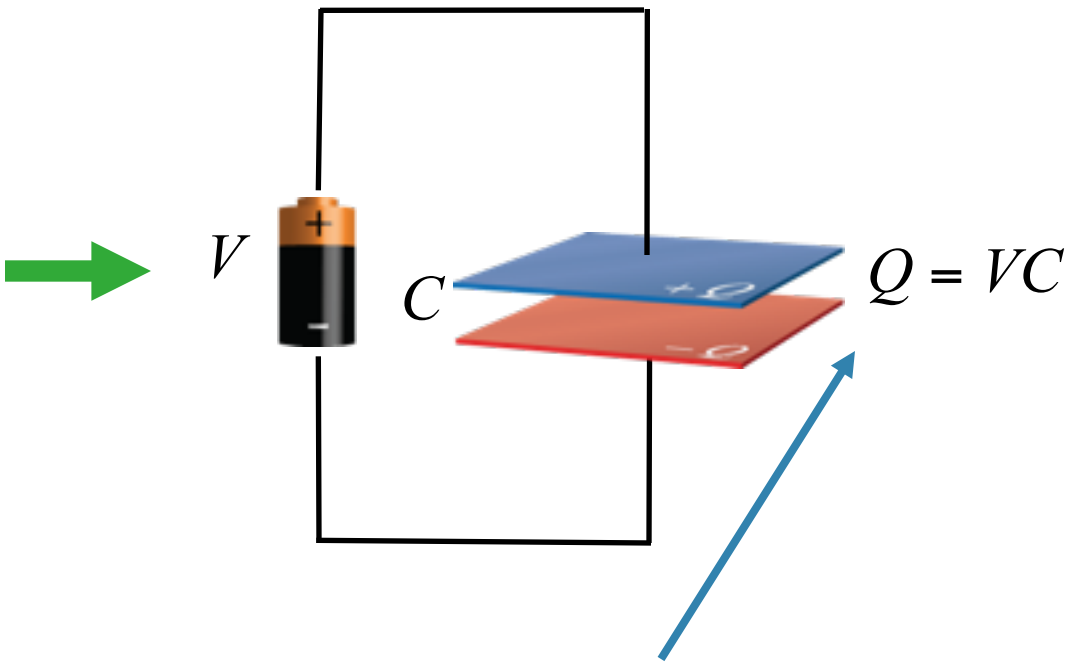
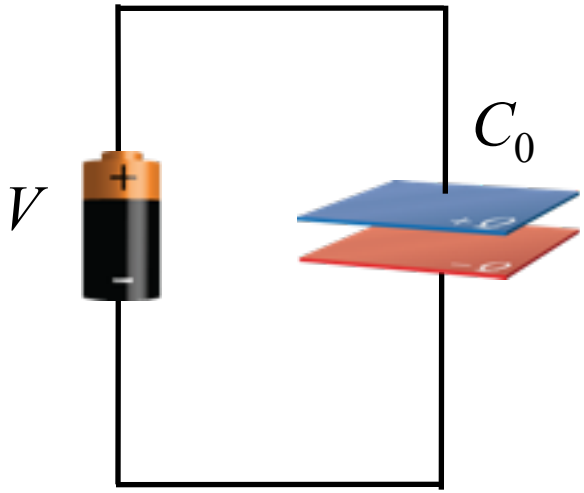




This "Q" really means that the battery has moved charge Q from one plate to the other, so that one plate holds $+Q$ and the other $-Q$.

Dielectrics



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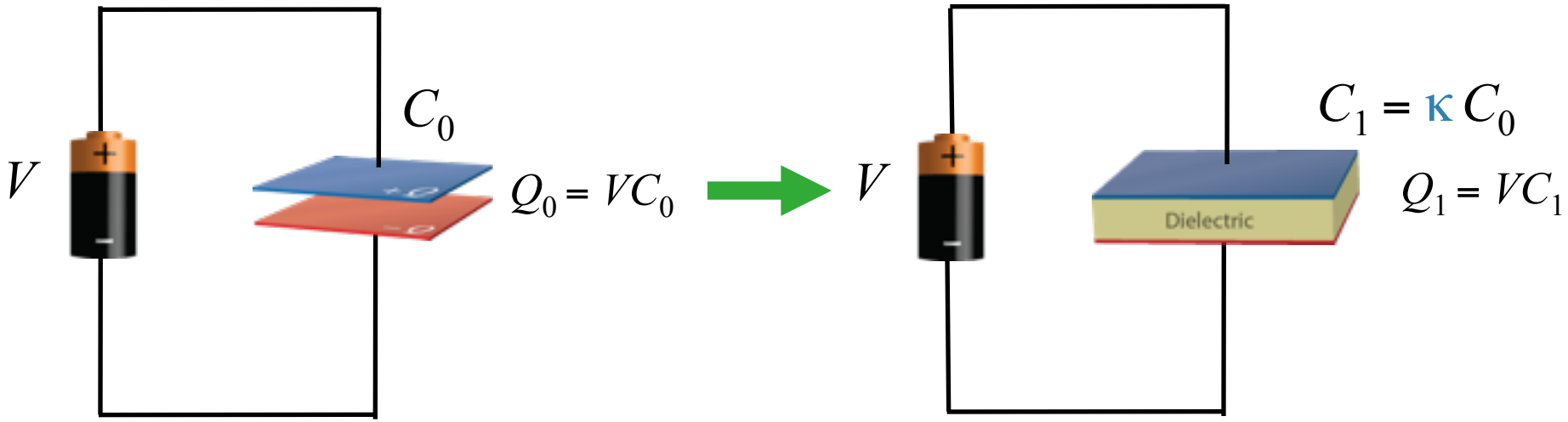

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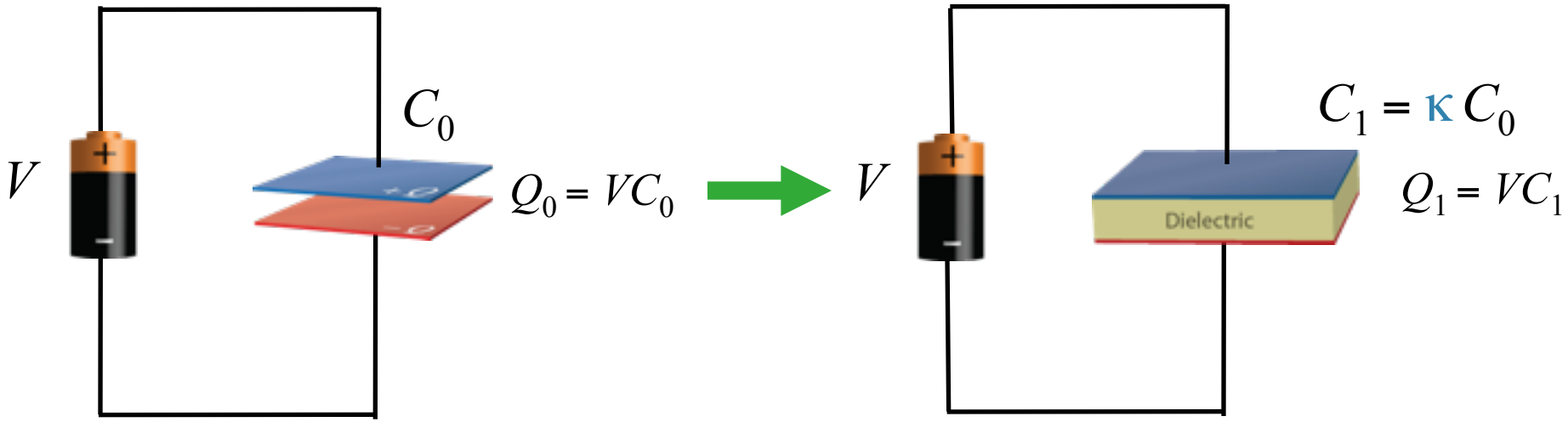
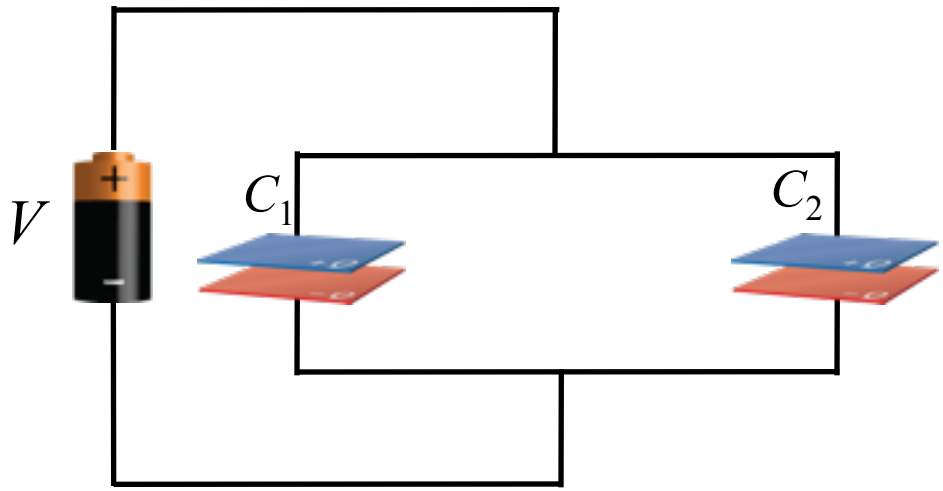
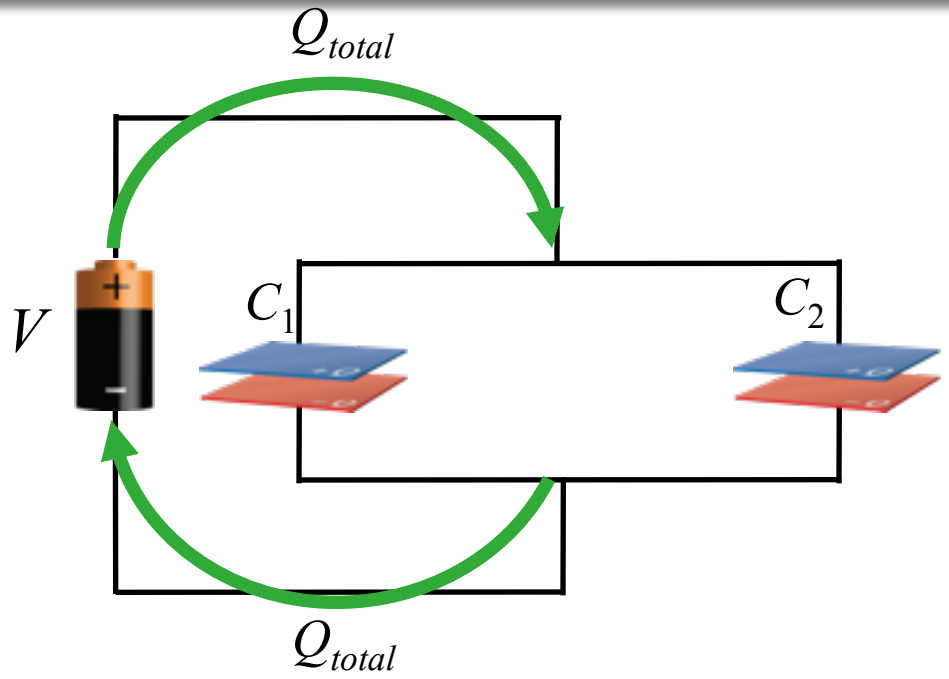


By adding a dielectric you are just making a new capacitor with larger capacitance (factor of κ)

Parallel Capacitor Circuit



Parallel Capacitor Circuit



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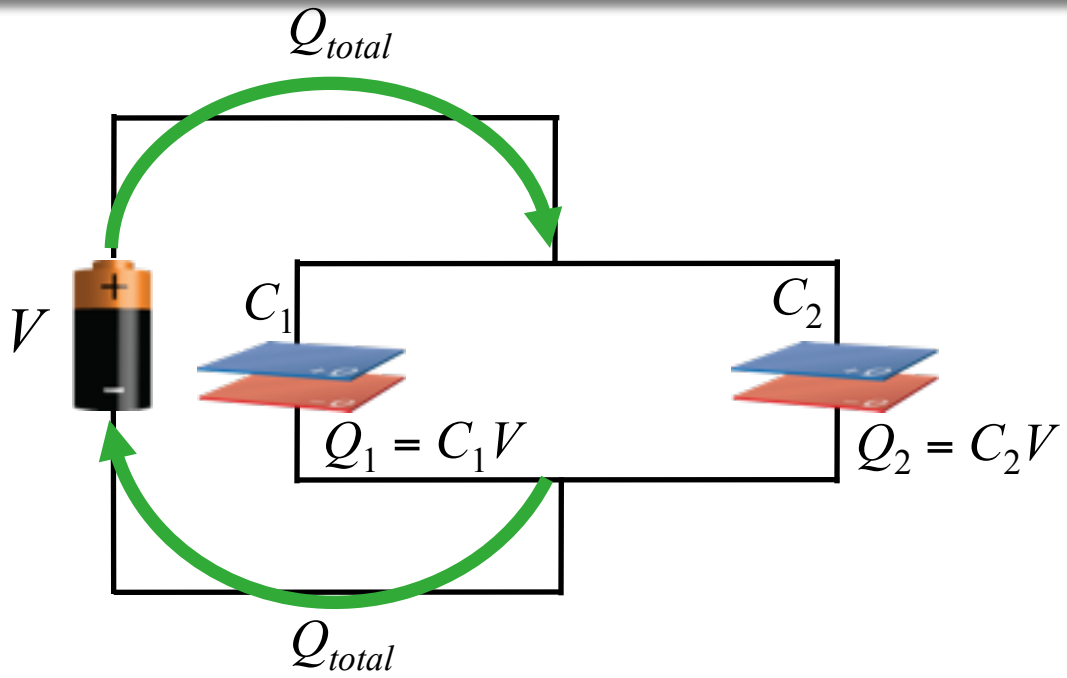

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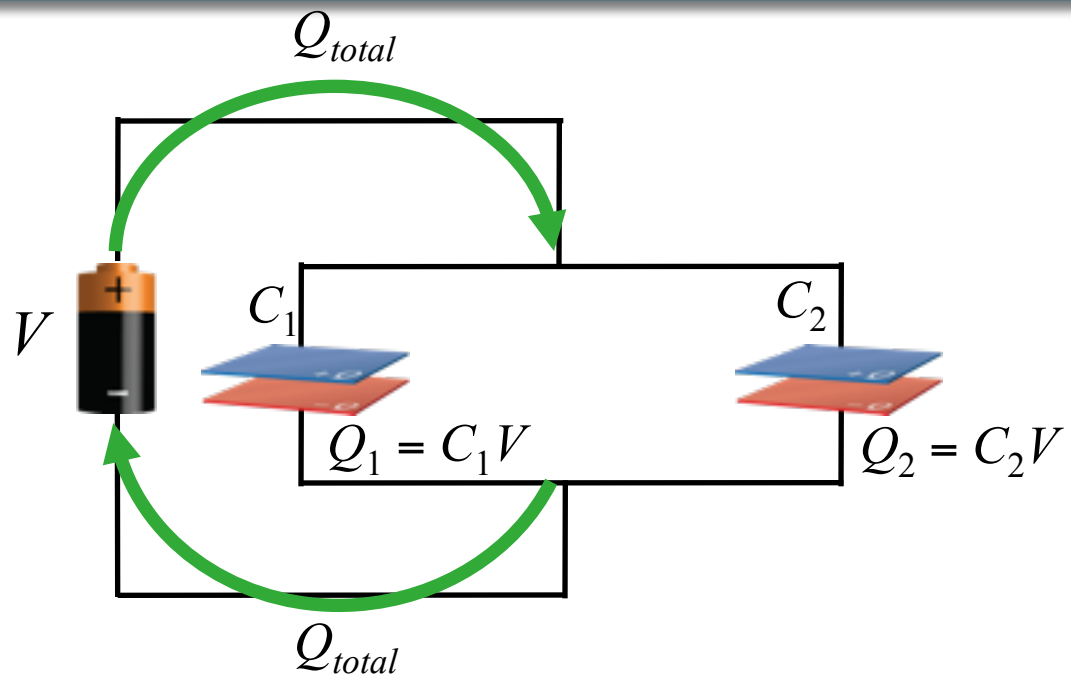
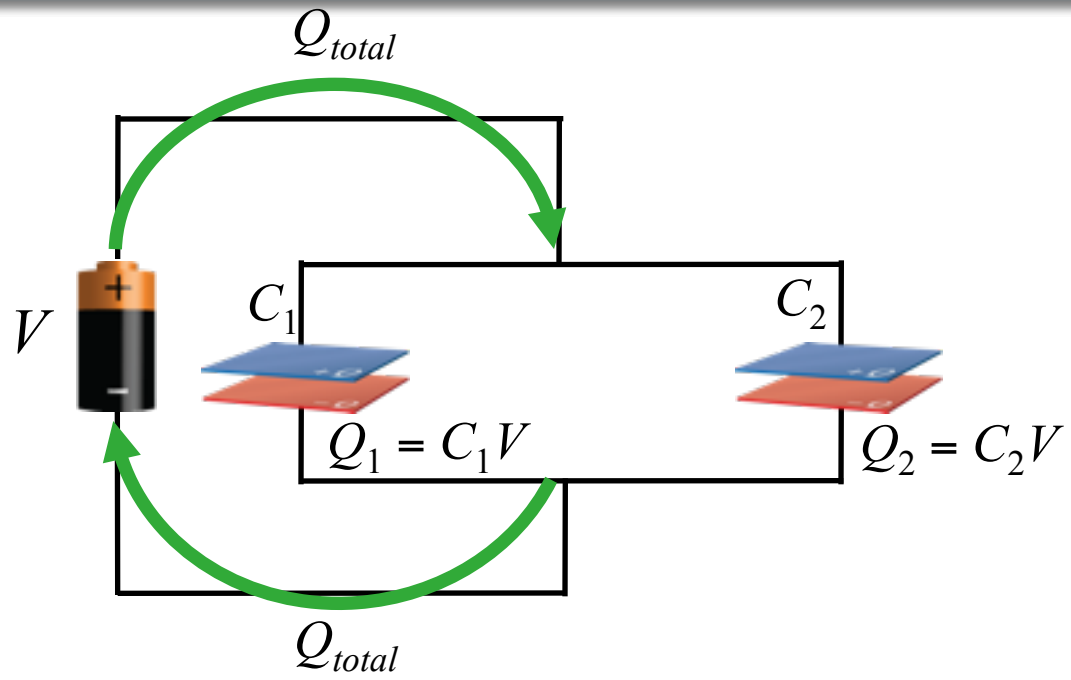


Key point: V is the same for both capacitors

Parallel Capacitor Circuit



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Key Point: $Q_{total} = Q_1 + Q_2 = VC_1 + VC_2 = V(C_1 + C_2)$

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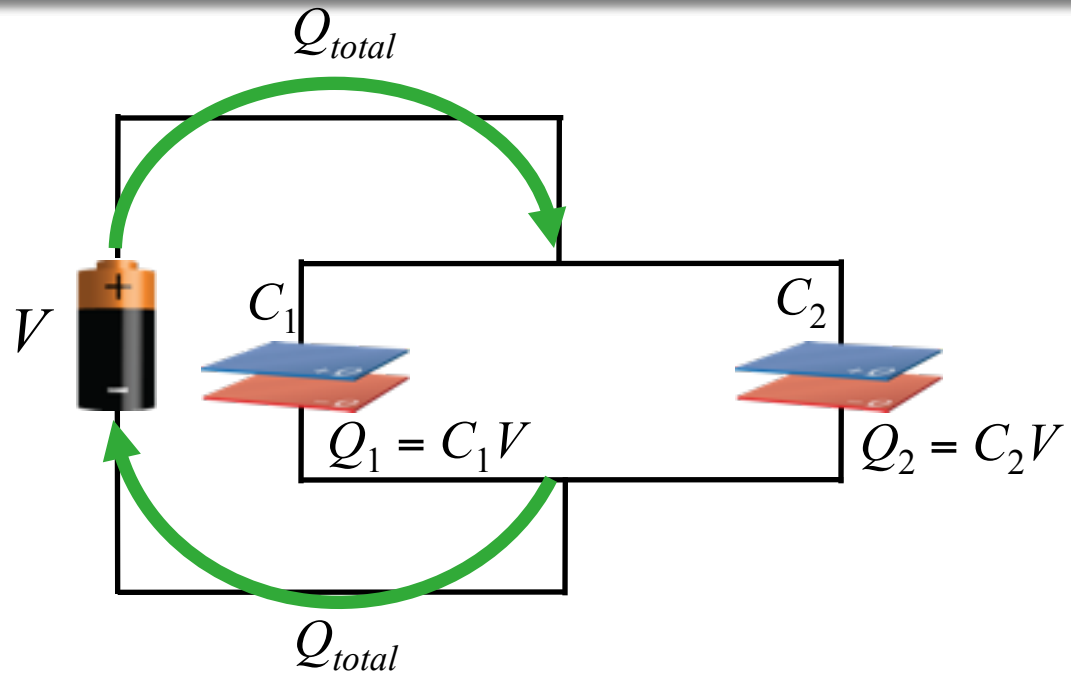

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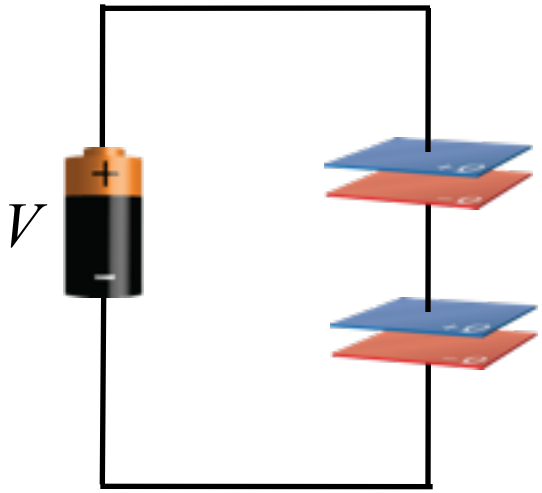
$C_{total} = C_1 + C_2$

Series Capacitor Circuit



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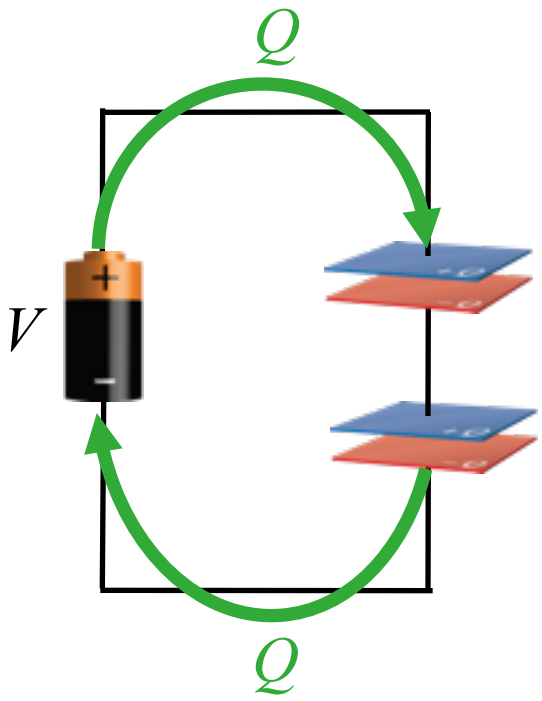

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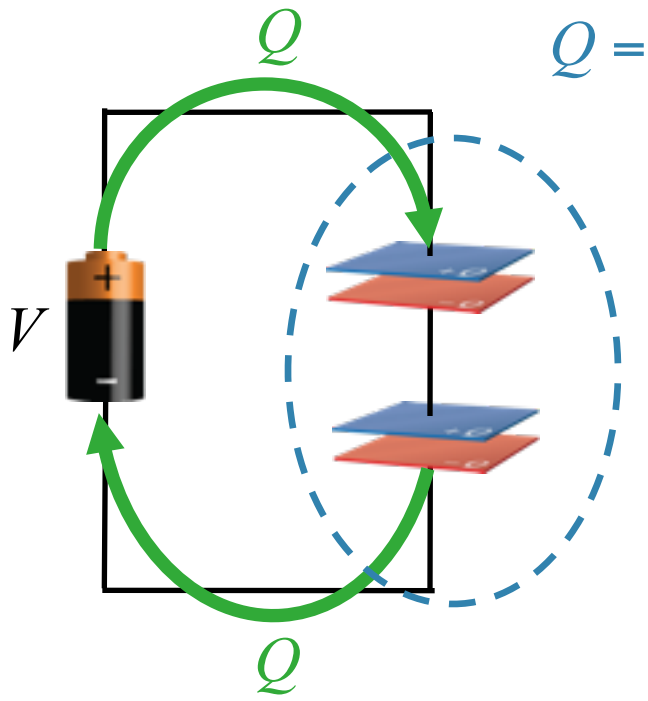
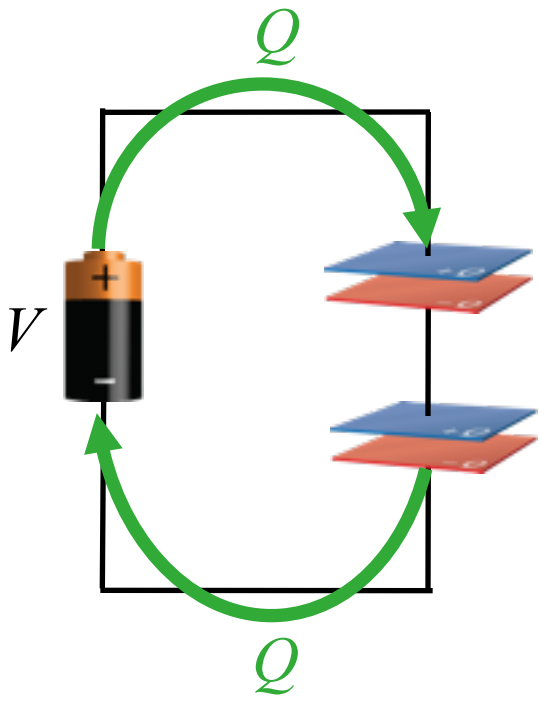


$$Q = VC_{total}$$

Series Capacitor Circuit



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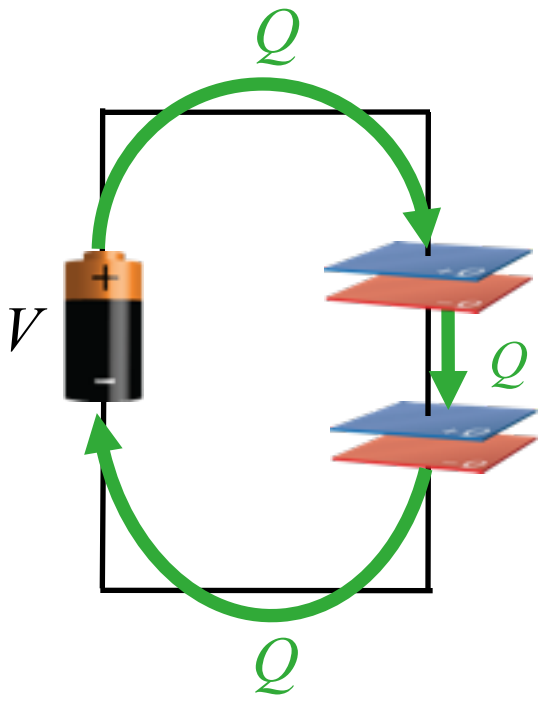

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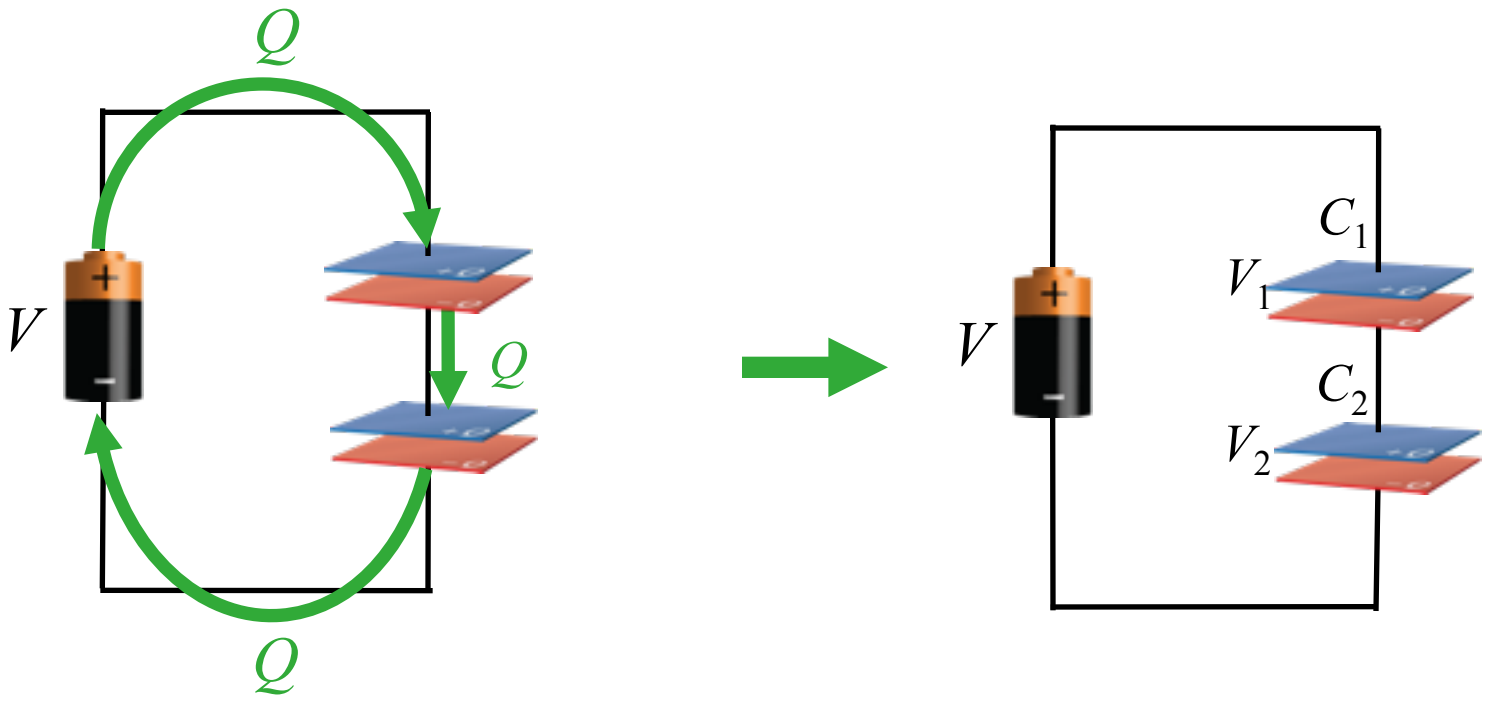

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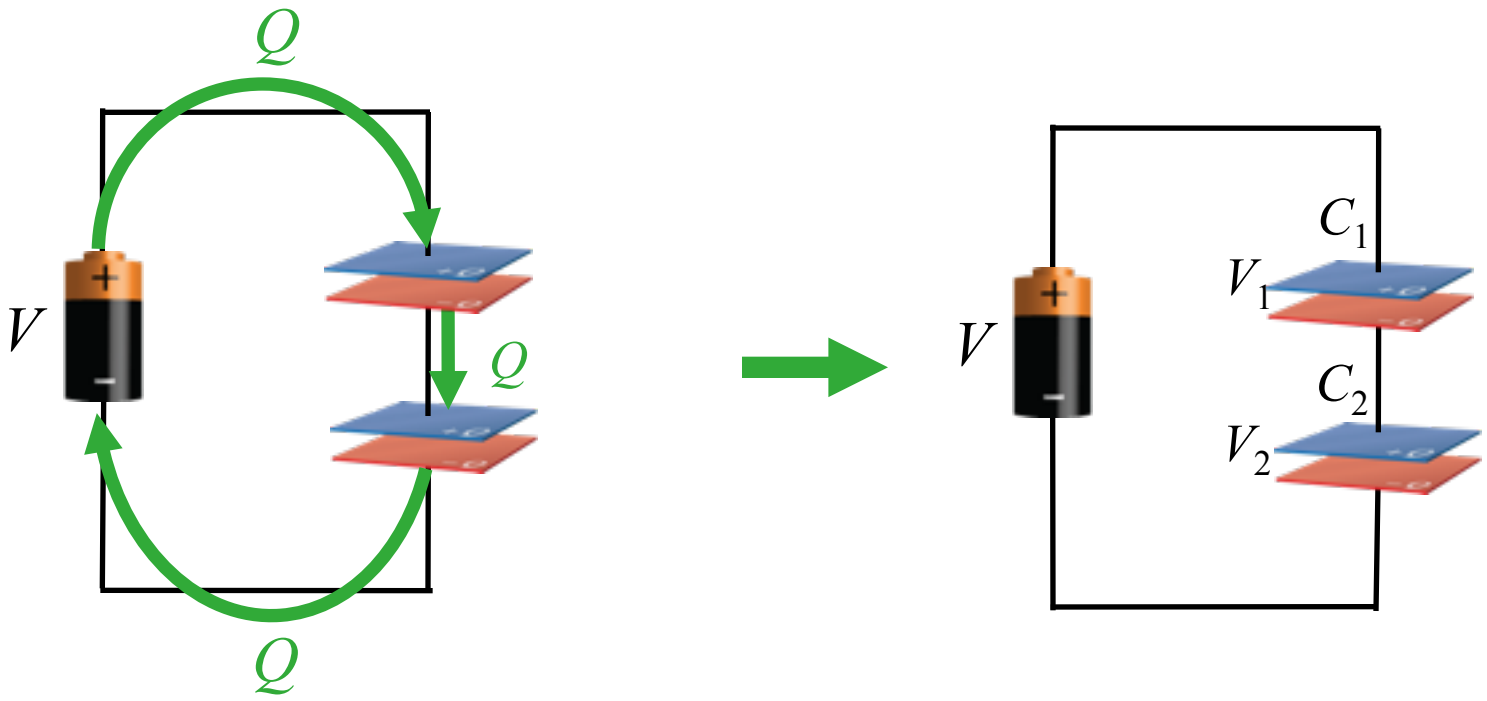

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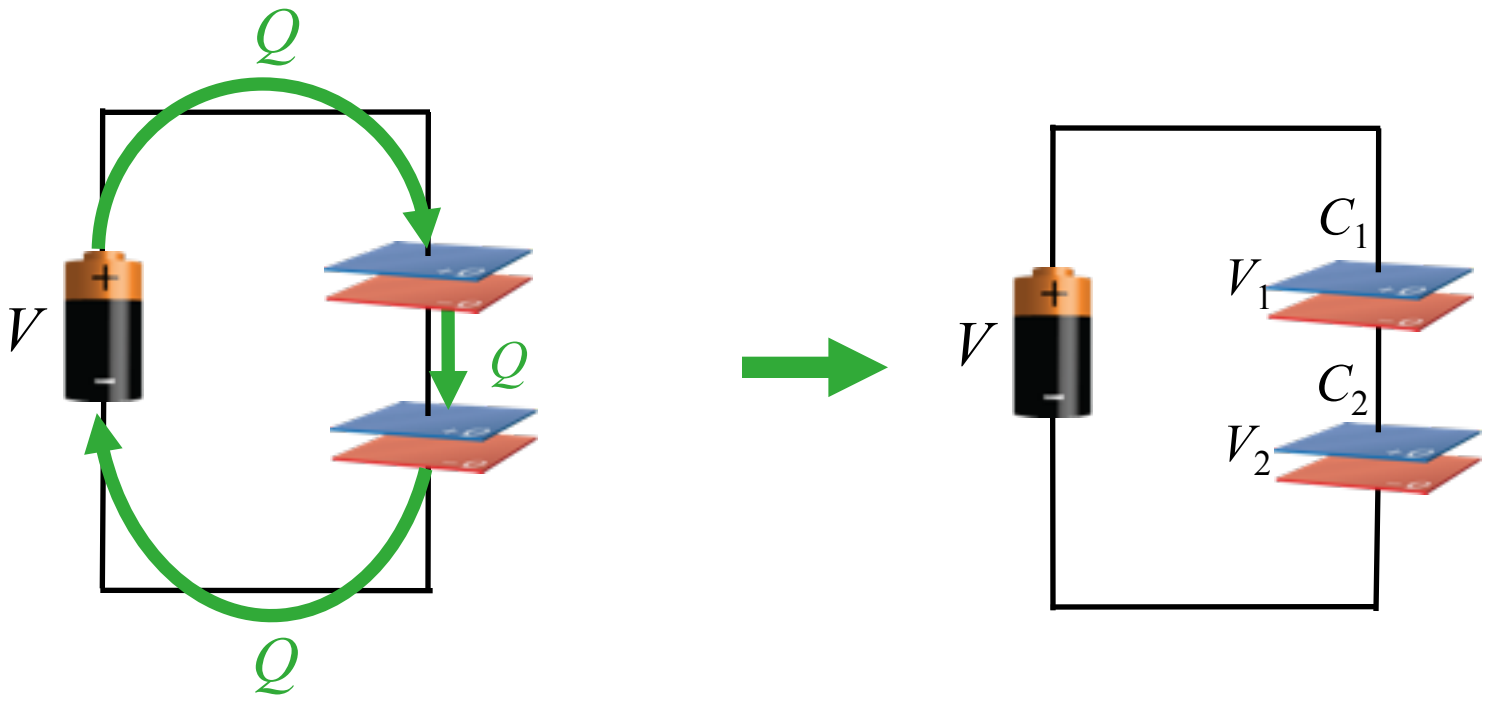

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Key point: $Q = VC_{total} = V_1C_1 = V_2C_2$

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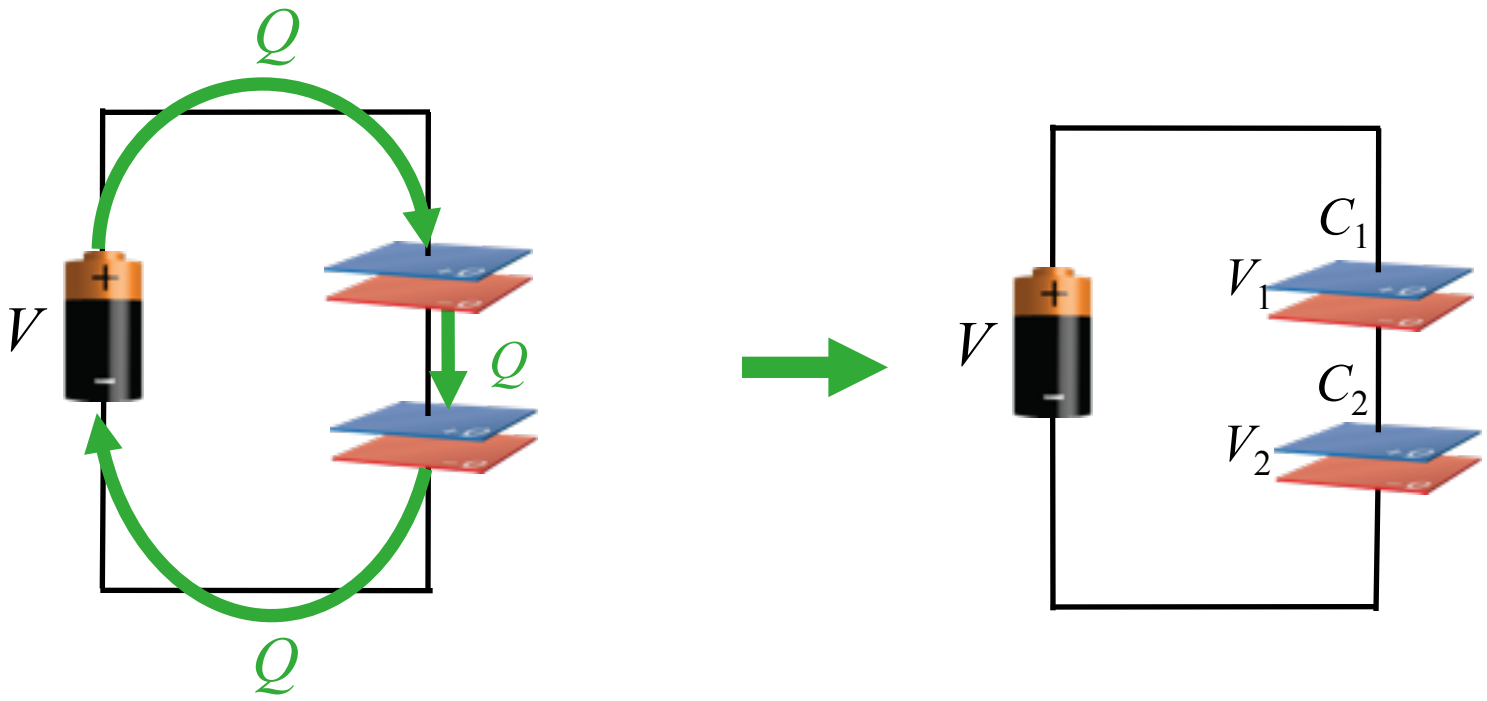

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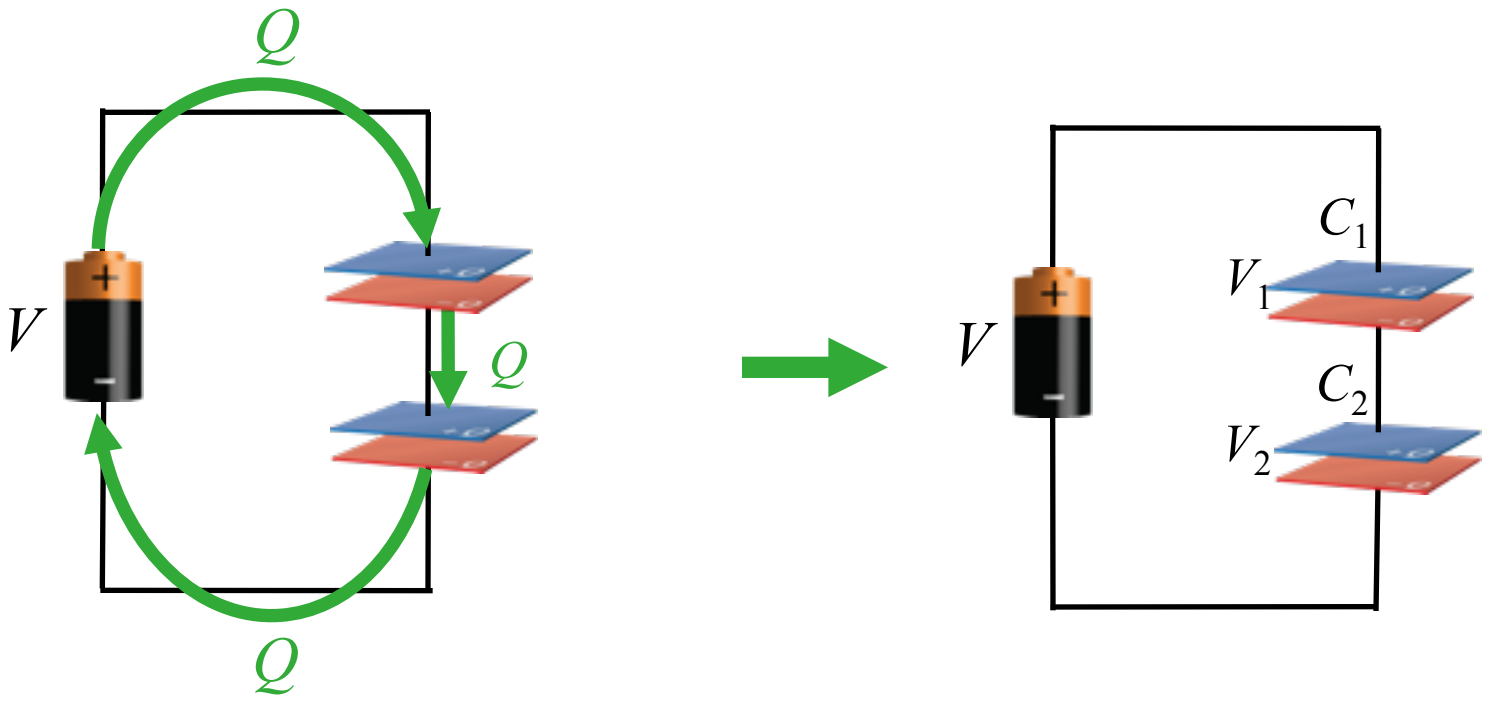
Key point: $Q = VC_{total} = V_1C_1 = V_2C_2$

Also: $V = V_1 + V_2$

Series Capacitor Circuit

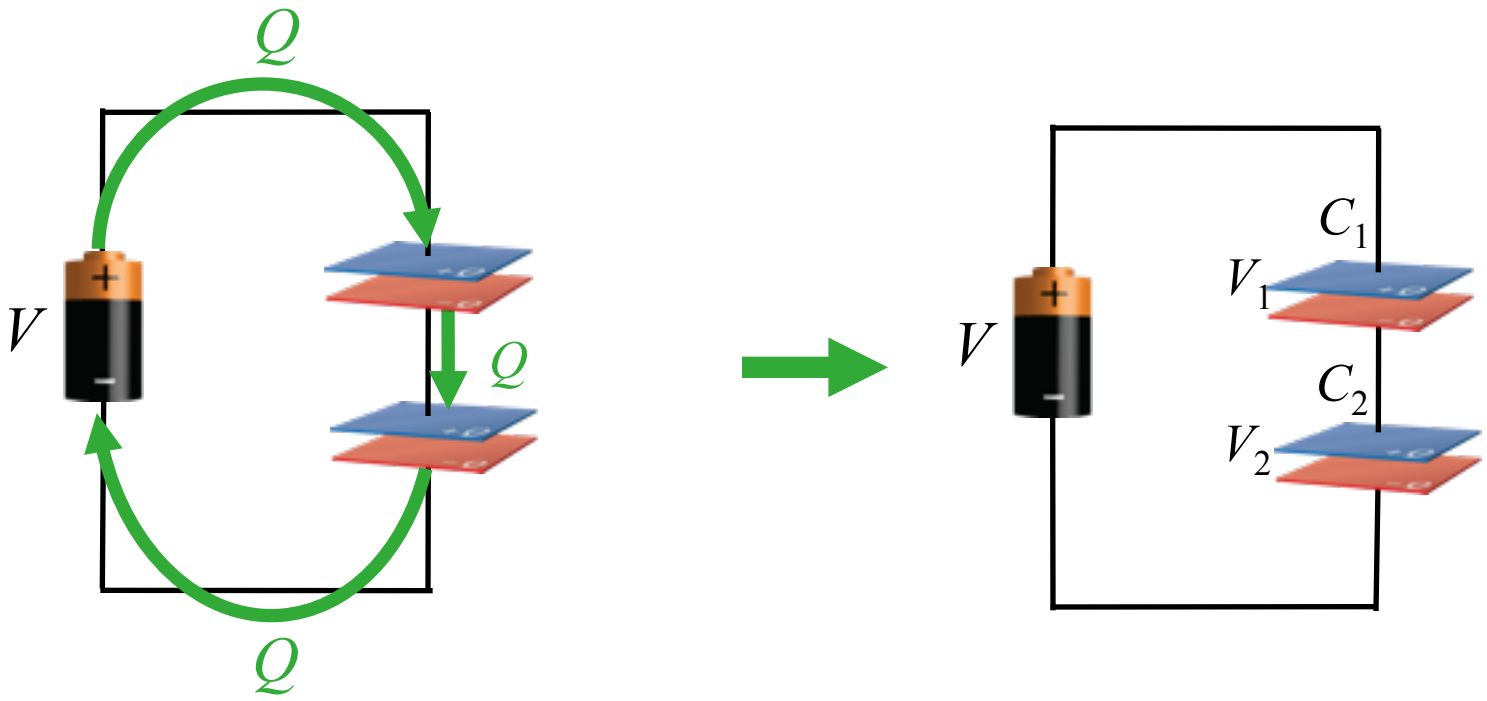


Key point: Q is the same for both capacitors

Key point: $Q = VC_{total} = V_1C_1 = V_2C_2$

Also: $V = V_1 + V_2$ → $Q/C_{total} = Q/C_1 + Q/C_2$

Series Capacitor Circuit



Key point: Q is the same for both capacitors

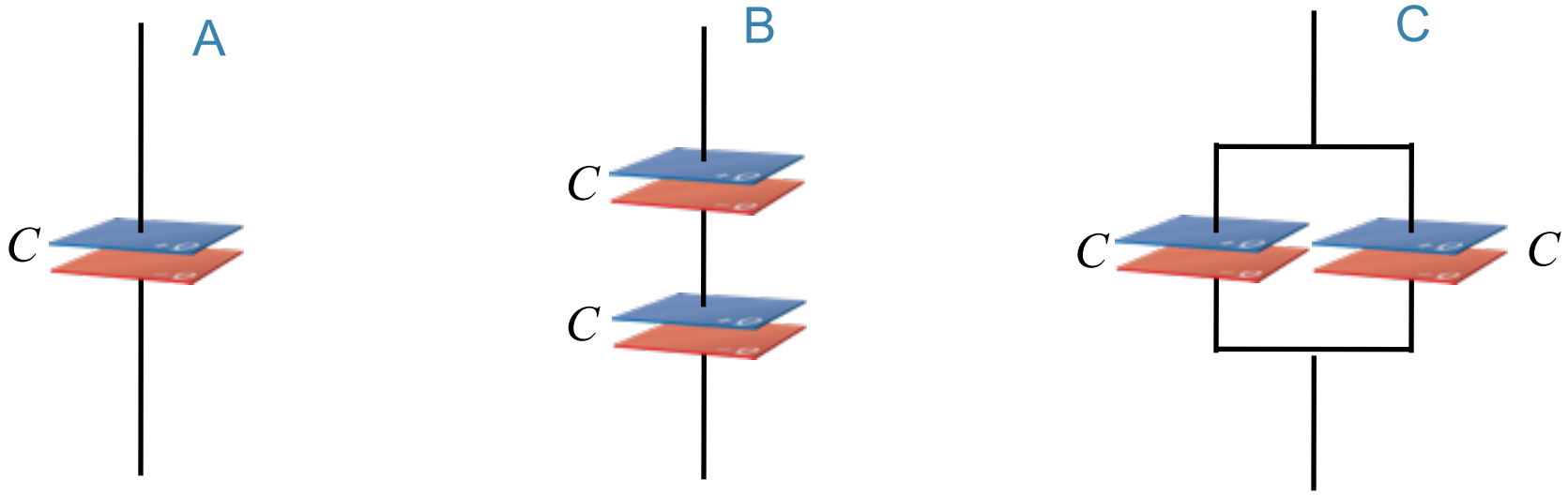
Key point: $Q = VC_{total} = V_1C_1 = V_2C_2$

Also: $V = V_1 + V_2$ $\longrightarrow$ $Q/C_{total} = Q/C_1 + Q/C_2$

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

CheckPoint: Three Capacitor Configurations

The three configurations shown below are constructed using identical capacitors. Which of these configurations has lowest total capacitance?



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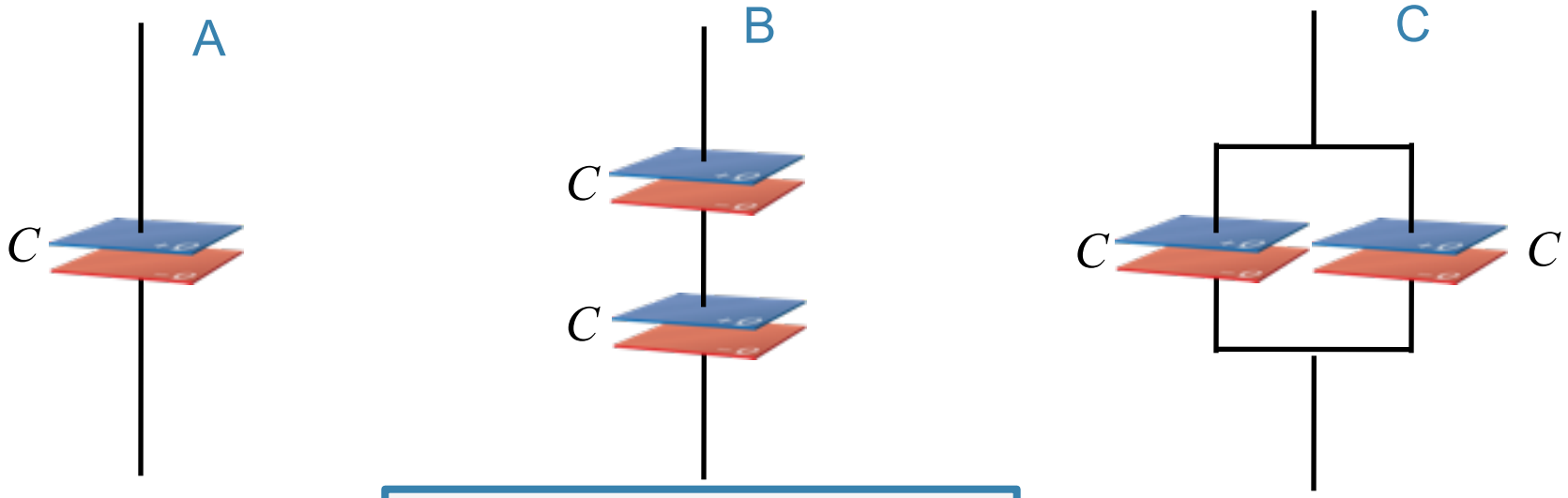

$$1/C_{total} = 1/C + 1/C$$
$$= 2/C$$

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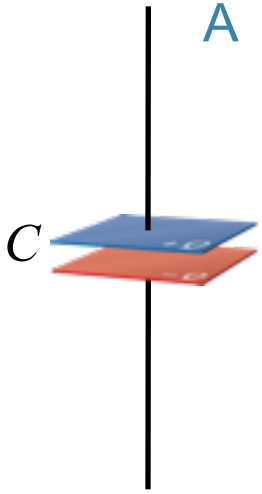
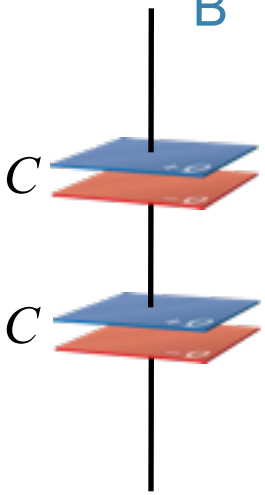


$C_{total} = C$

B



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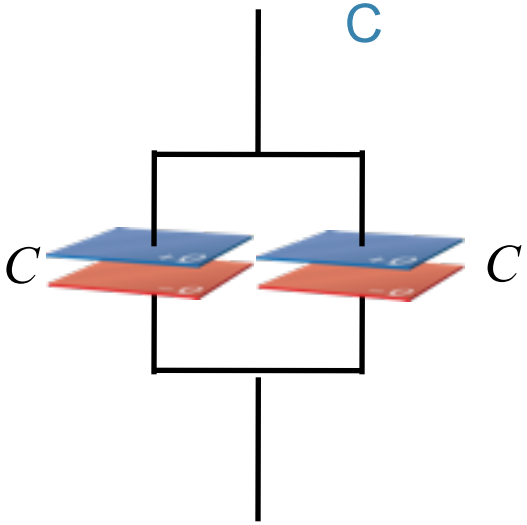

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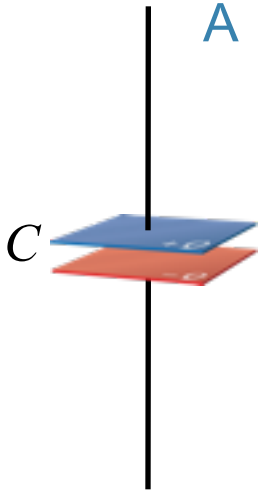
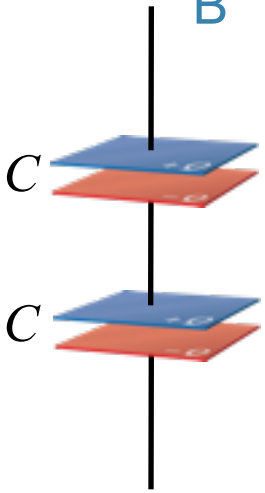


$C_{total} = C$

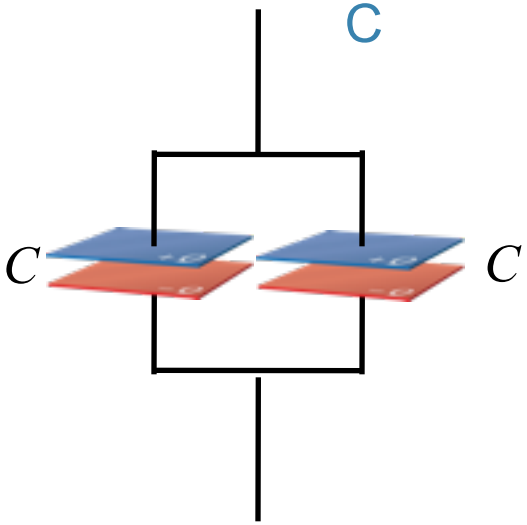
B



$$1/C_{total} = 1/C + 1/C$$
$$= 2/C$$

$C_{total} = C/2$

C



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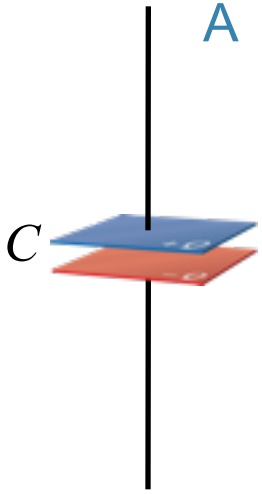
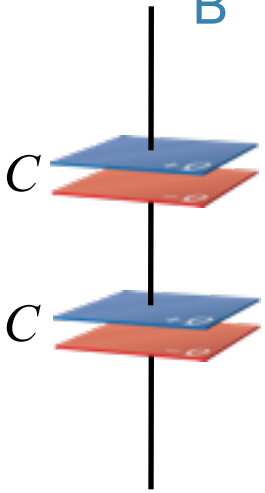


$C_{total} = C$

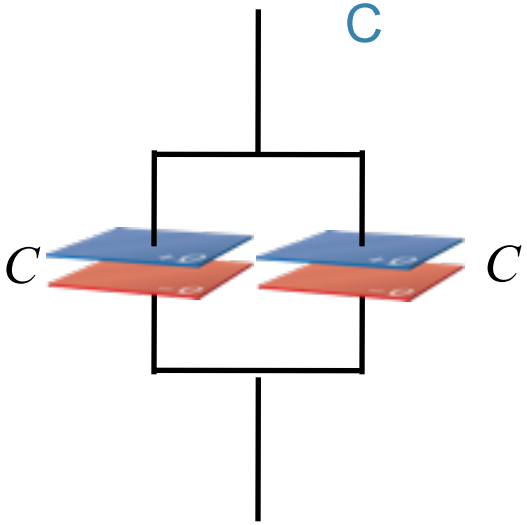
B



$$1/C_{total} = 1/C + 1/C$$
$$= 2/C$$

$C_{total} = C/2$

C



$C_{total} = 2C$

D: All 3 are the same

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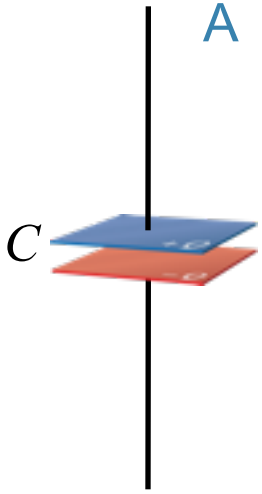
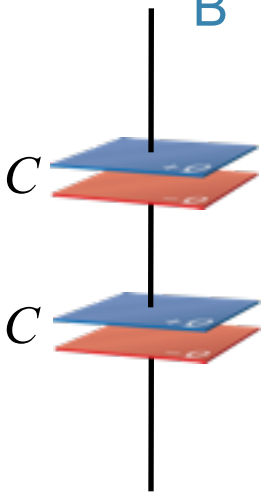
A



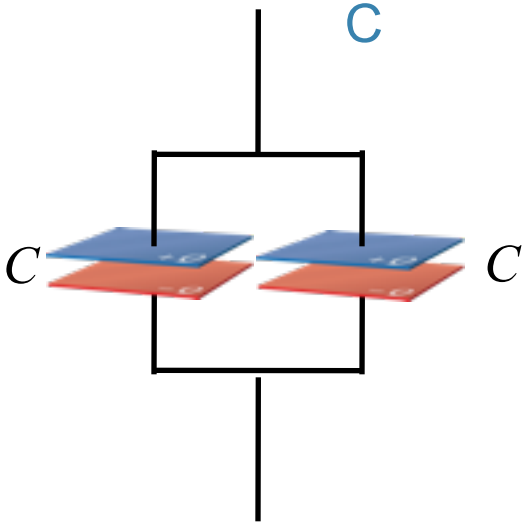
$C_{total} = C$

B



$$1/C_{total} = 1/C + 1/C$$
$$= 2/C$$

C



$C_{total} = 2C$

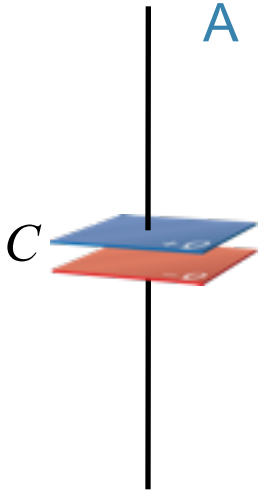
$C_{total} = C/2$

D: All 3 are the same

CheckPoint: Three Capacitor Configurations

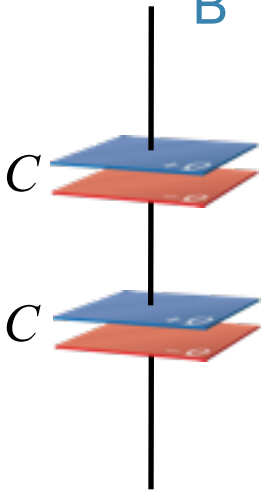
The three configurations shown below are constructed using identical capacitors. Which of these configurations has lowest total capacitance?

A



$C_{total} = C$

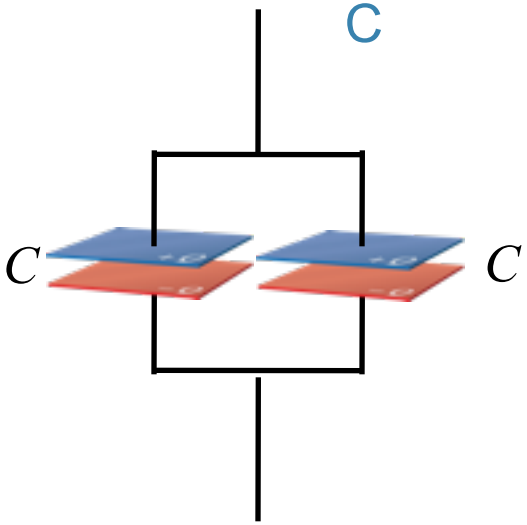
B



$$1/C_{total} = 1/C + 1/C$$
$$= 2/C$$

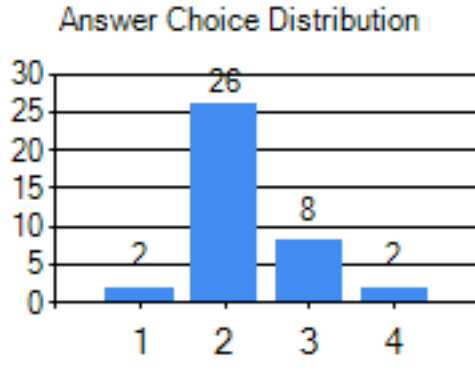
$C_{total} = C/2$

C



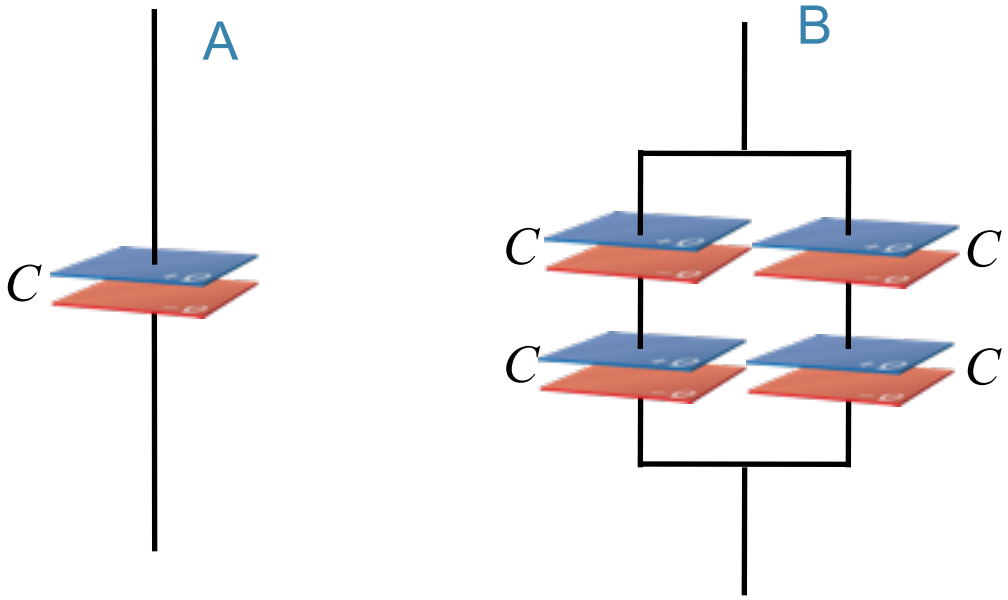
$C_{total} = 2C$

D: All 3 are the same



CheckPoint: Two Capacitor Configurations

The two configurations shown below are constructed using identical capacitors. Which of these configurations has the lowest overall capacitance?



- ○ A
- ○ B
- ○ Both configurations have the same capacitance

CheckPoint: Two Capacitor Configurations

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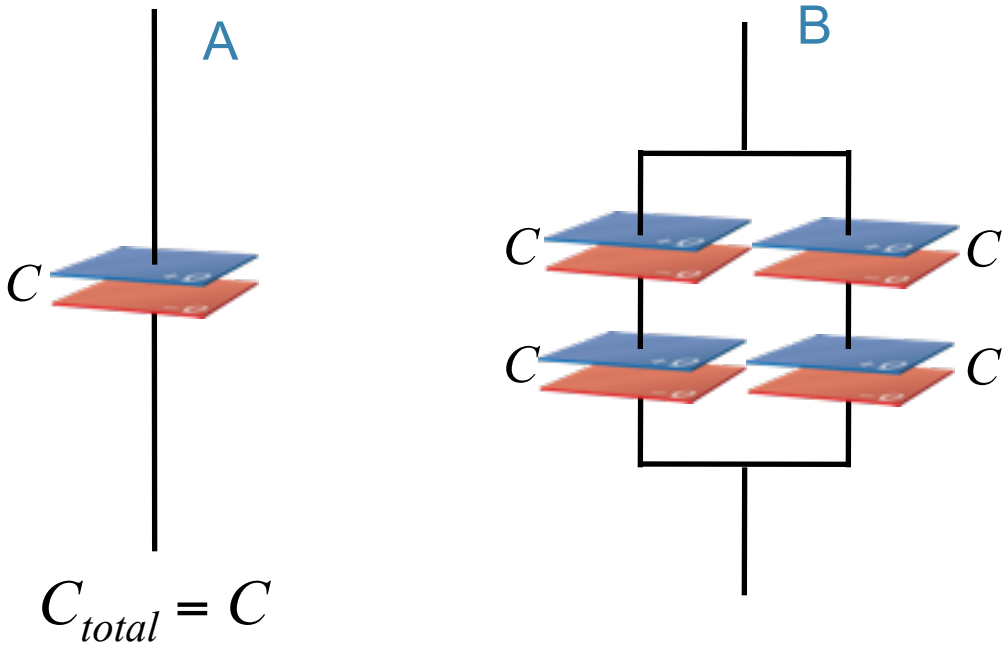
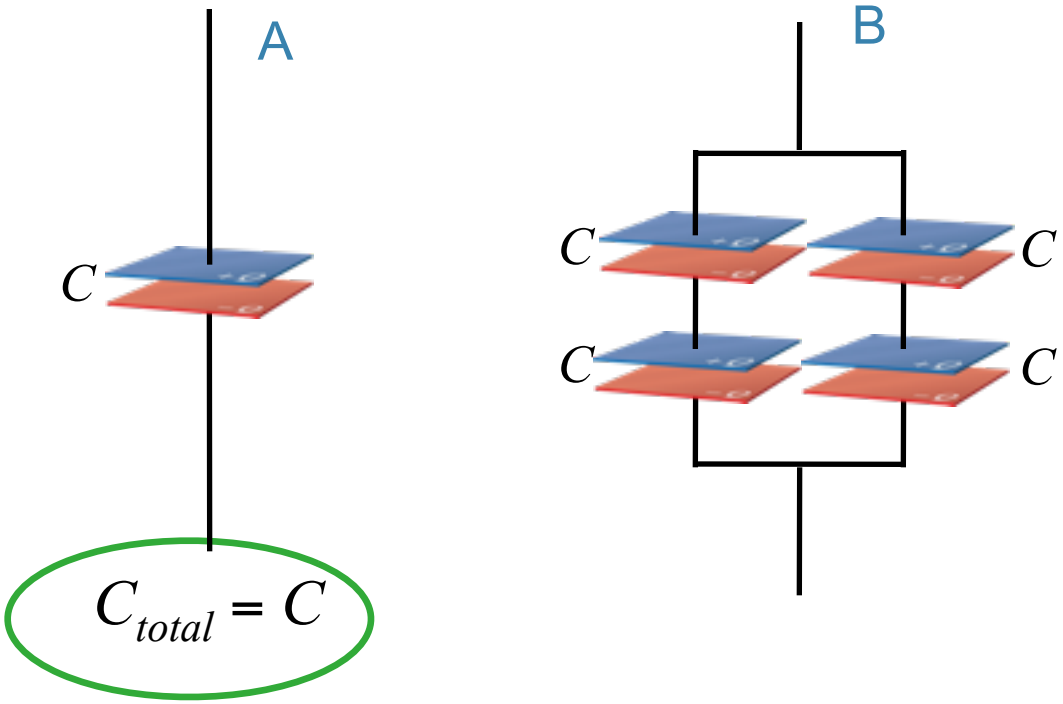


$C_{total} = C$

- ○ A
- ○ B
- ○ Both configurations have the same capacitance

CheckPoint: Two Capacitor Configurations

The two configurations shown below are constructed using identical capacitors. Which of these configurations has the lowest overall capacitance?



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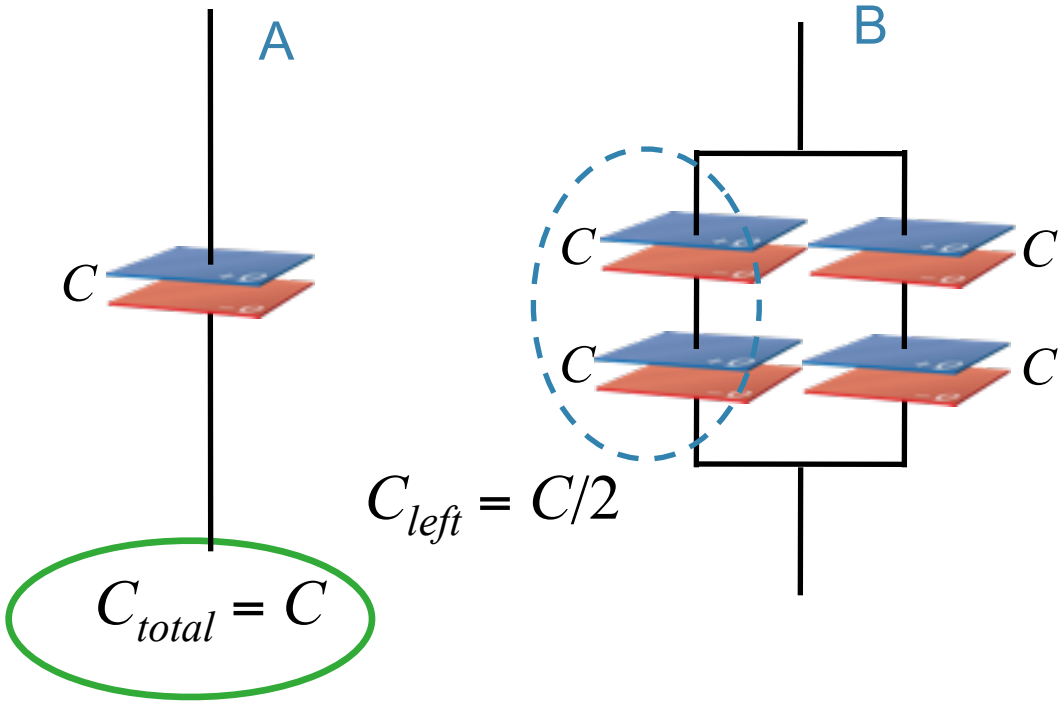

- A
- B
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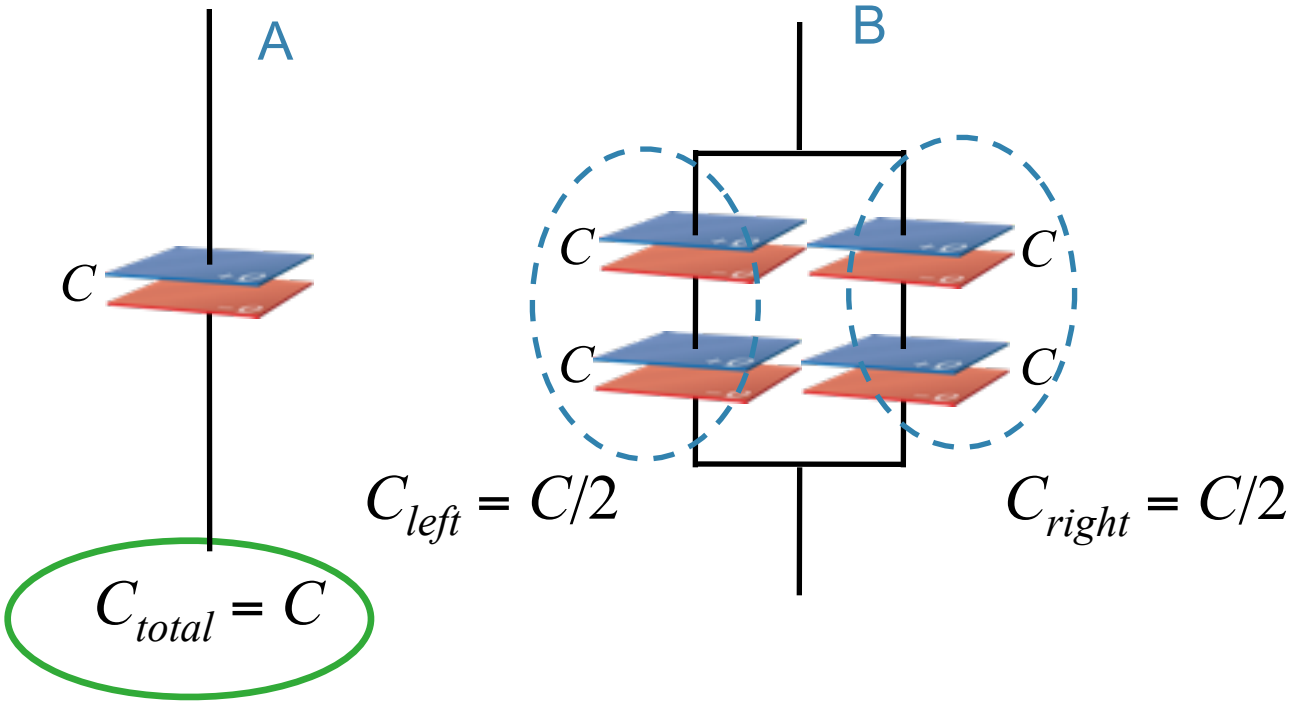

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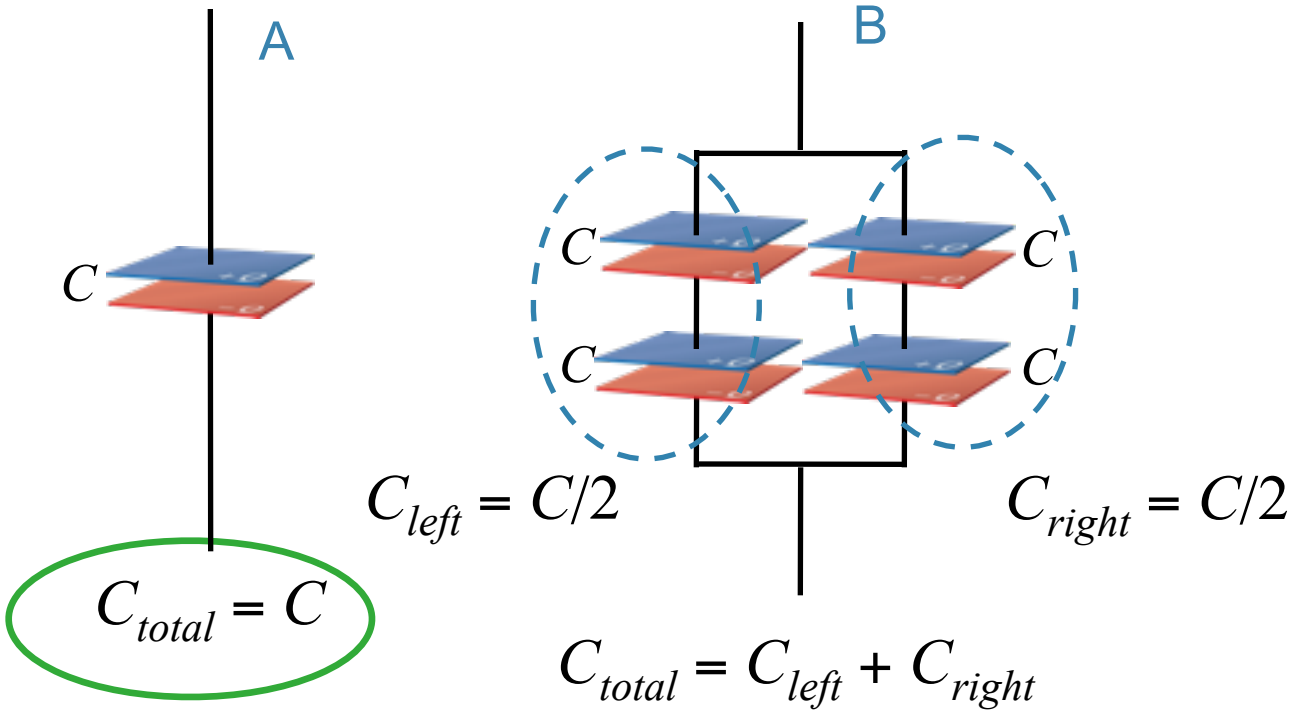

- ○ A
- ○ B
- ○ Both configurations have the same capacitance

CheckPoint: Two Capacitor Configurations

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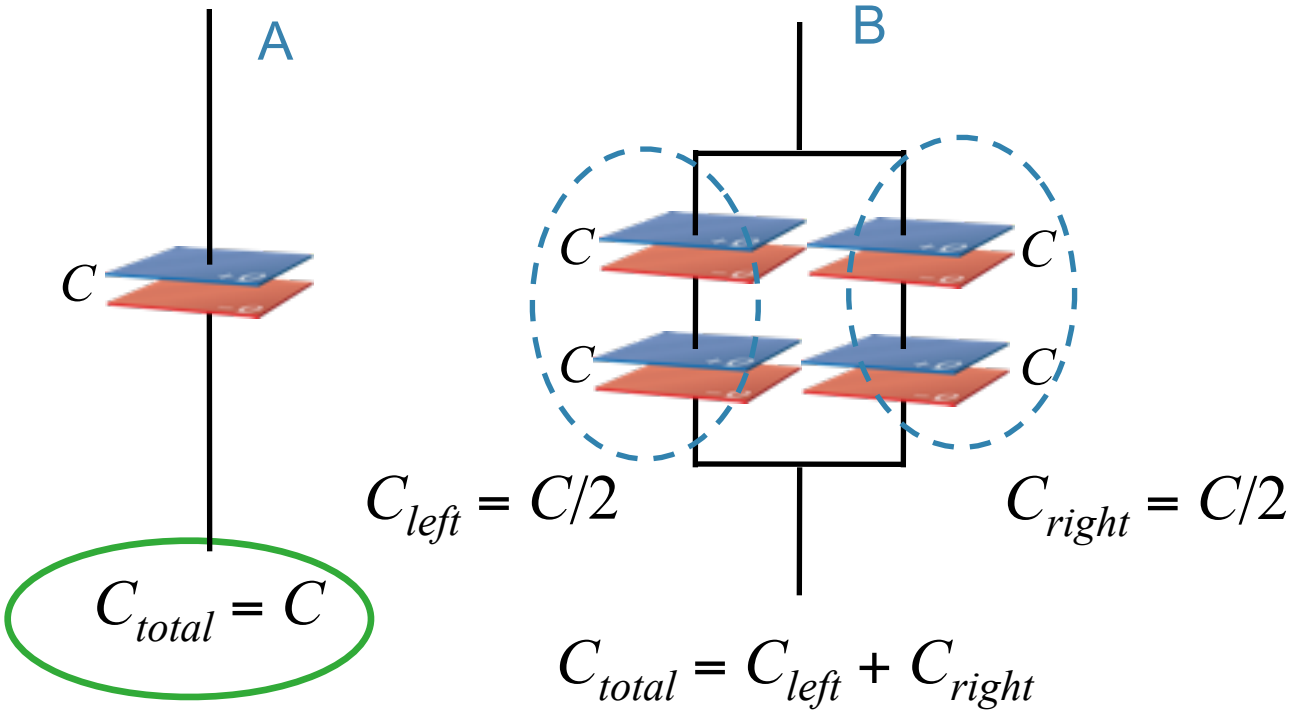

- ○ A
- ○ B
- ○ Both configurations have the same capacitance

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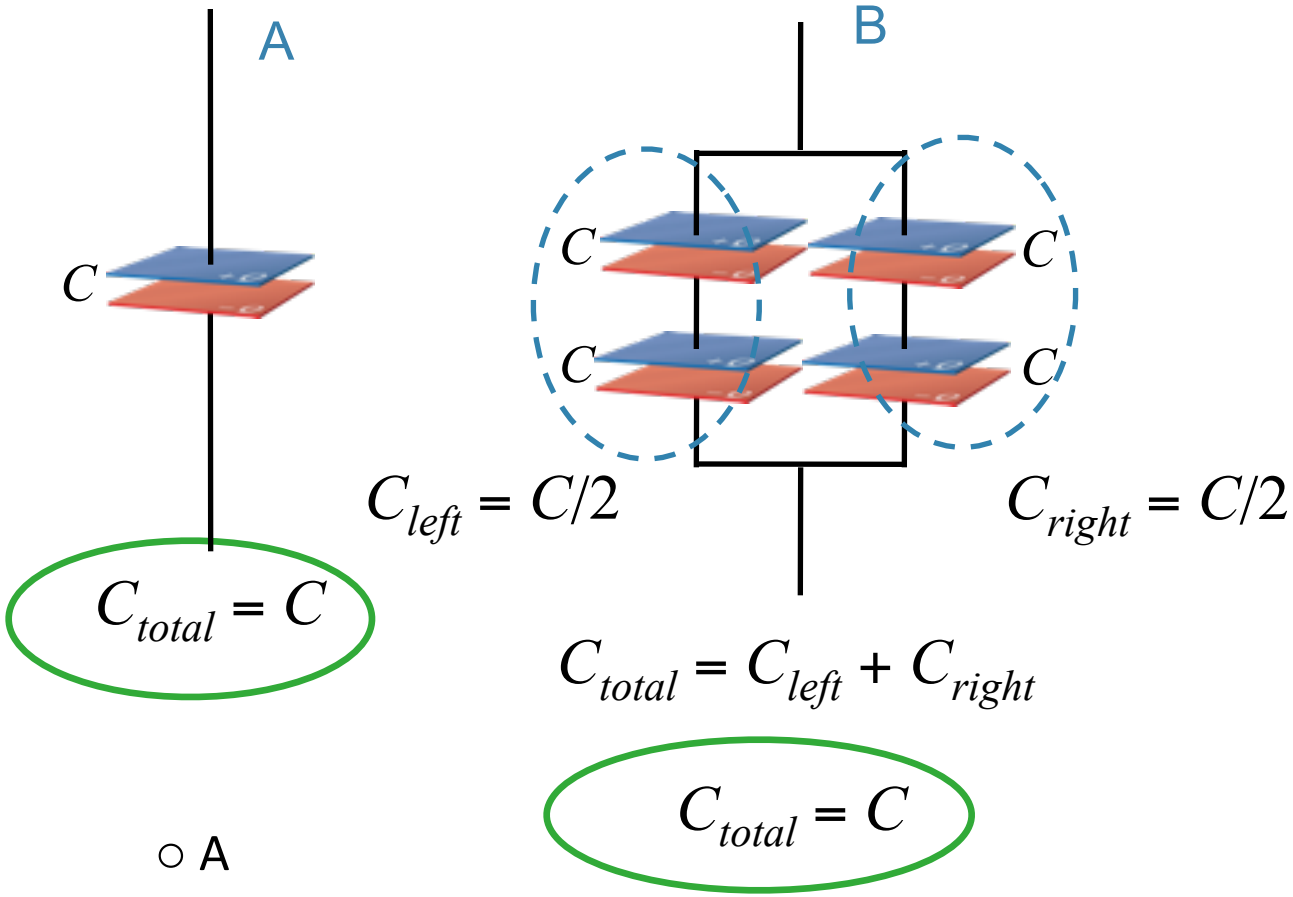

- ○ A
- ○ B
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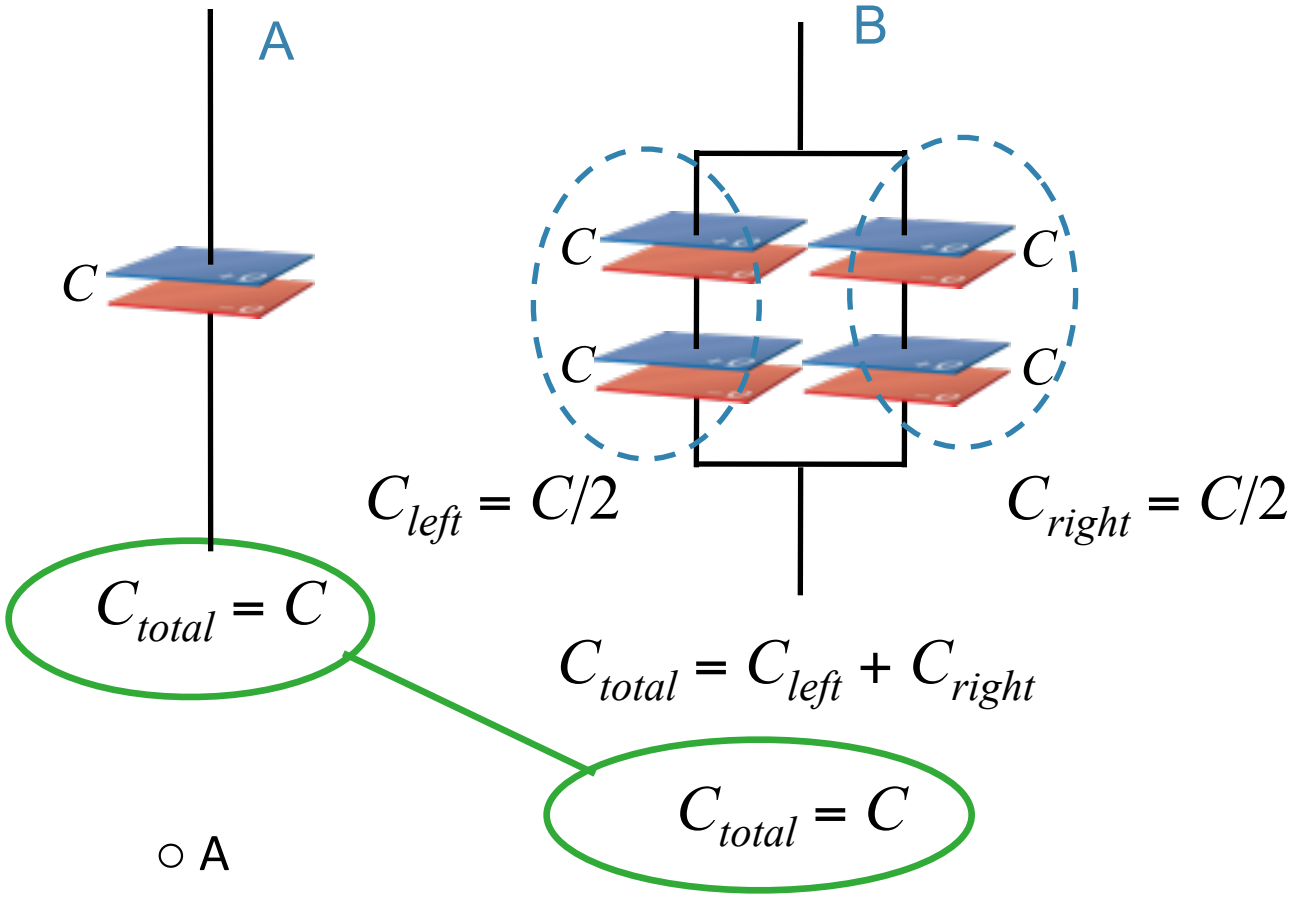

- A
- B
- Both configurations have the same capacitance

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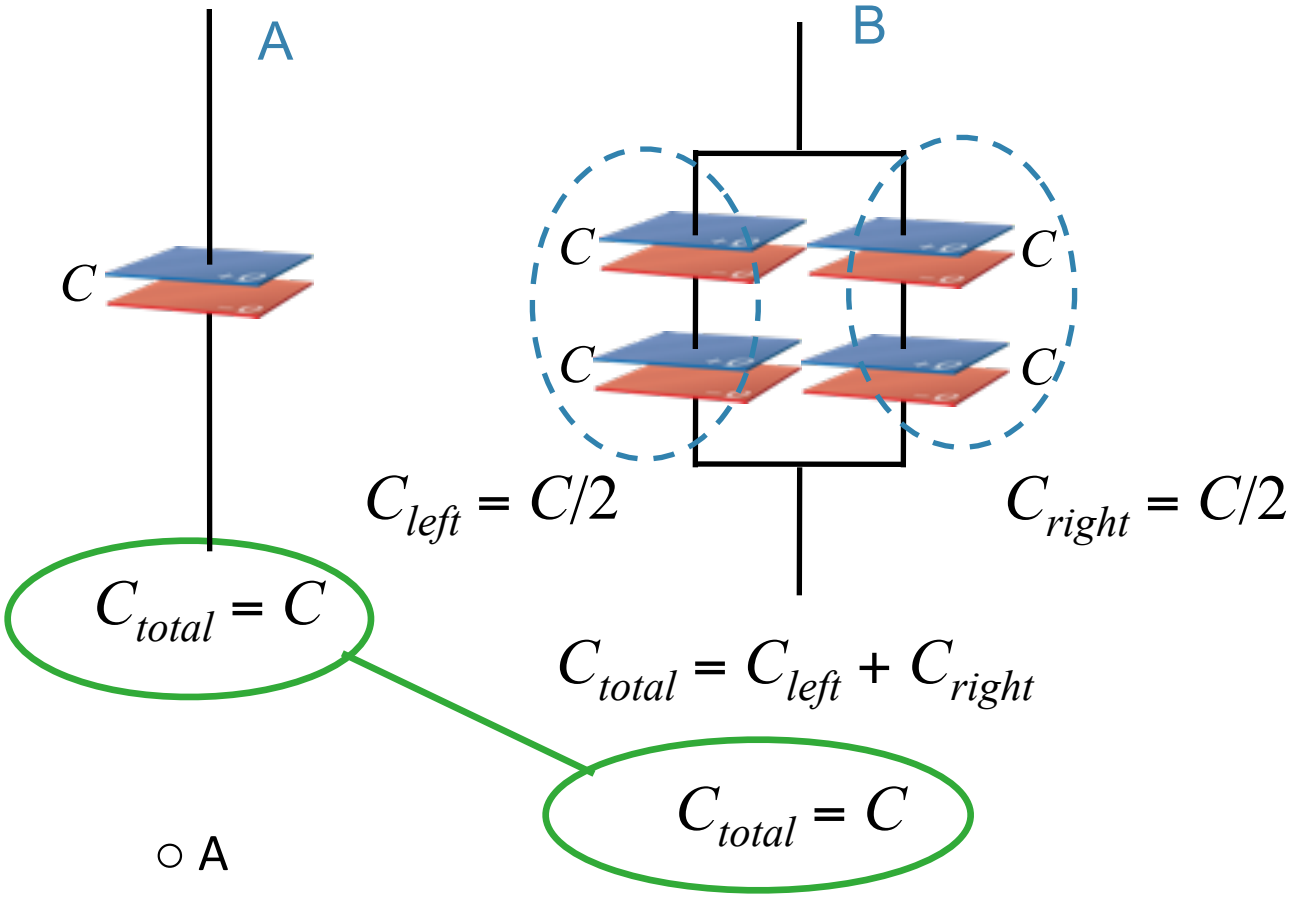

- A
- B
- Both configurations have the same capacitance

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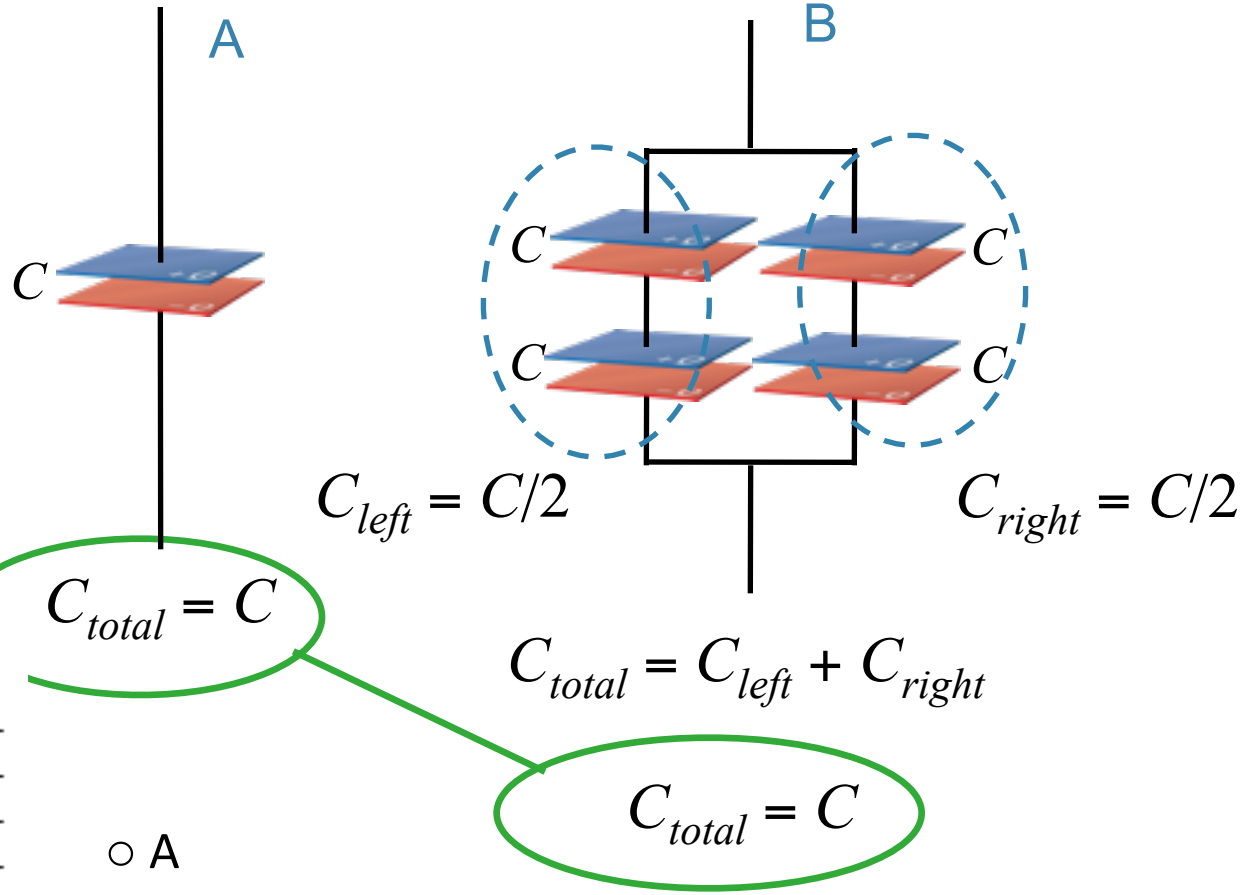
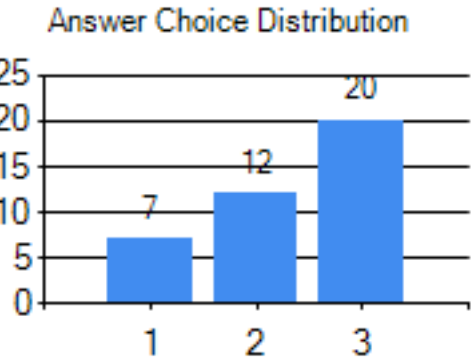
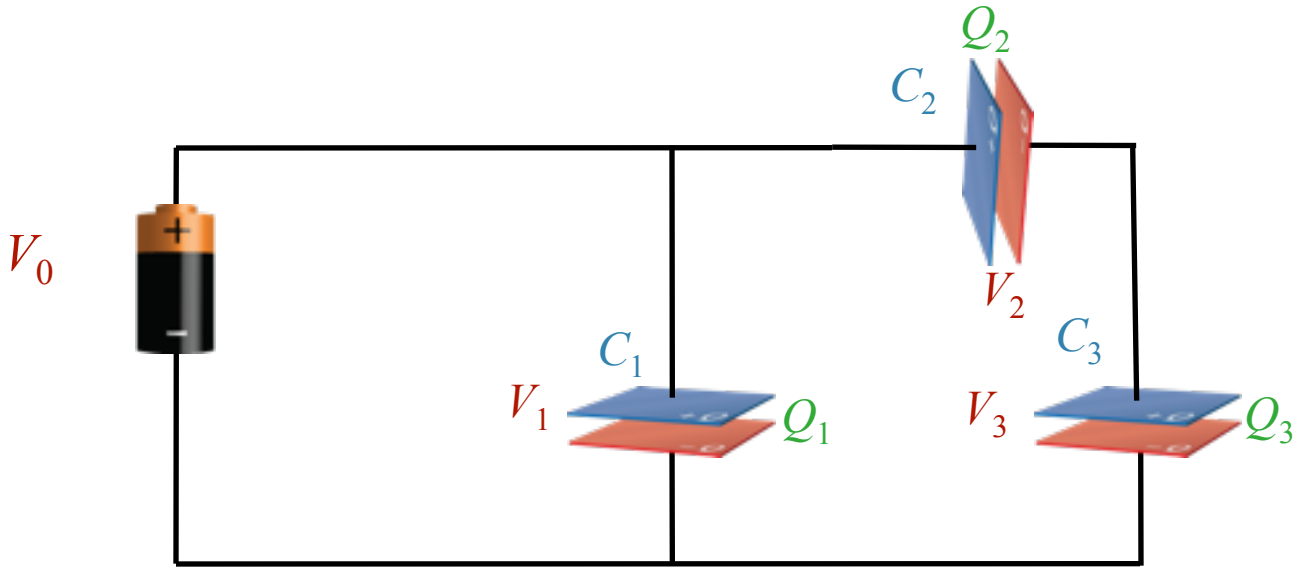


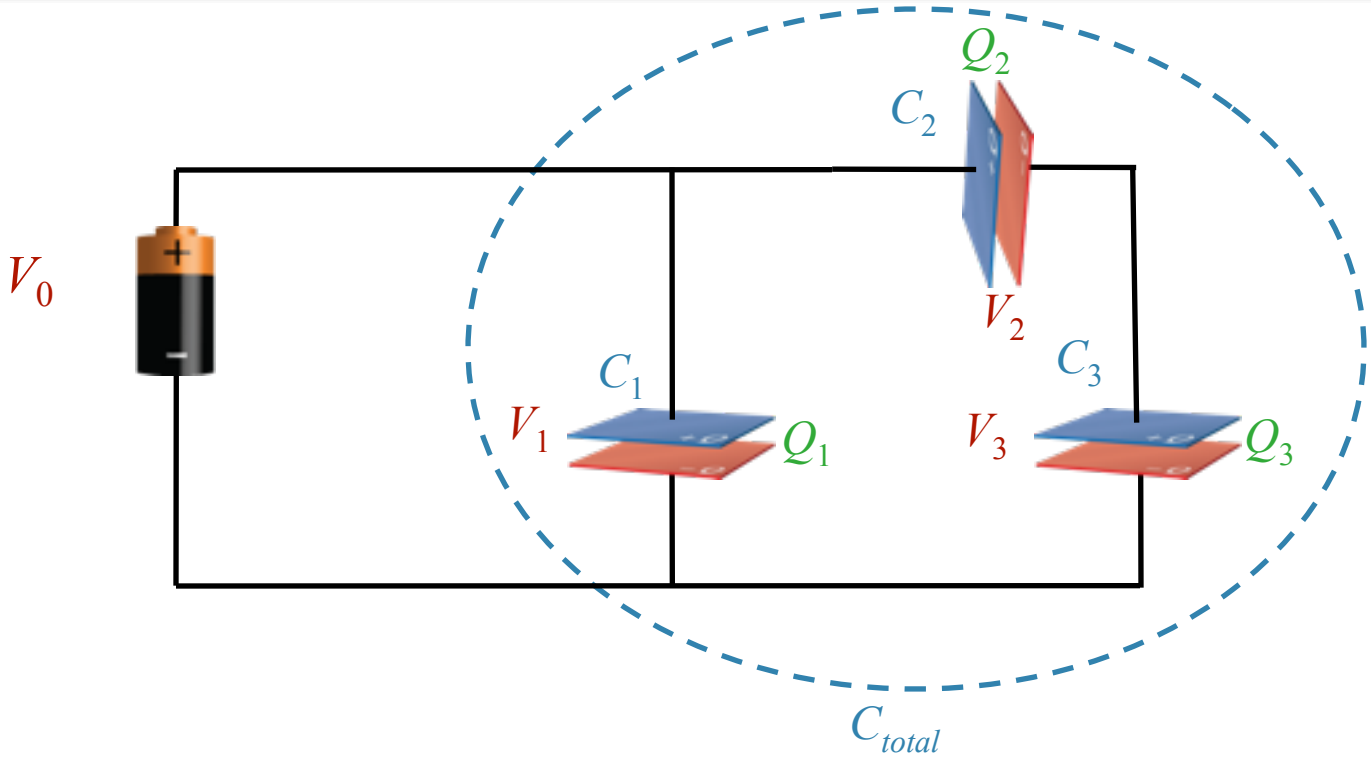


- ○ A
- ○ B
- ○ Both configurations have the same capacitance

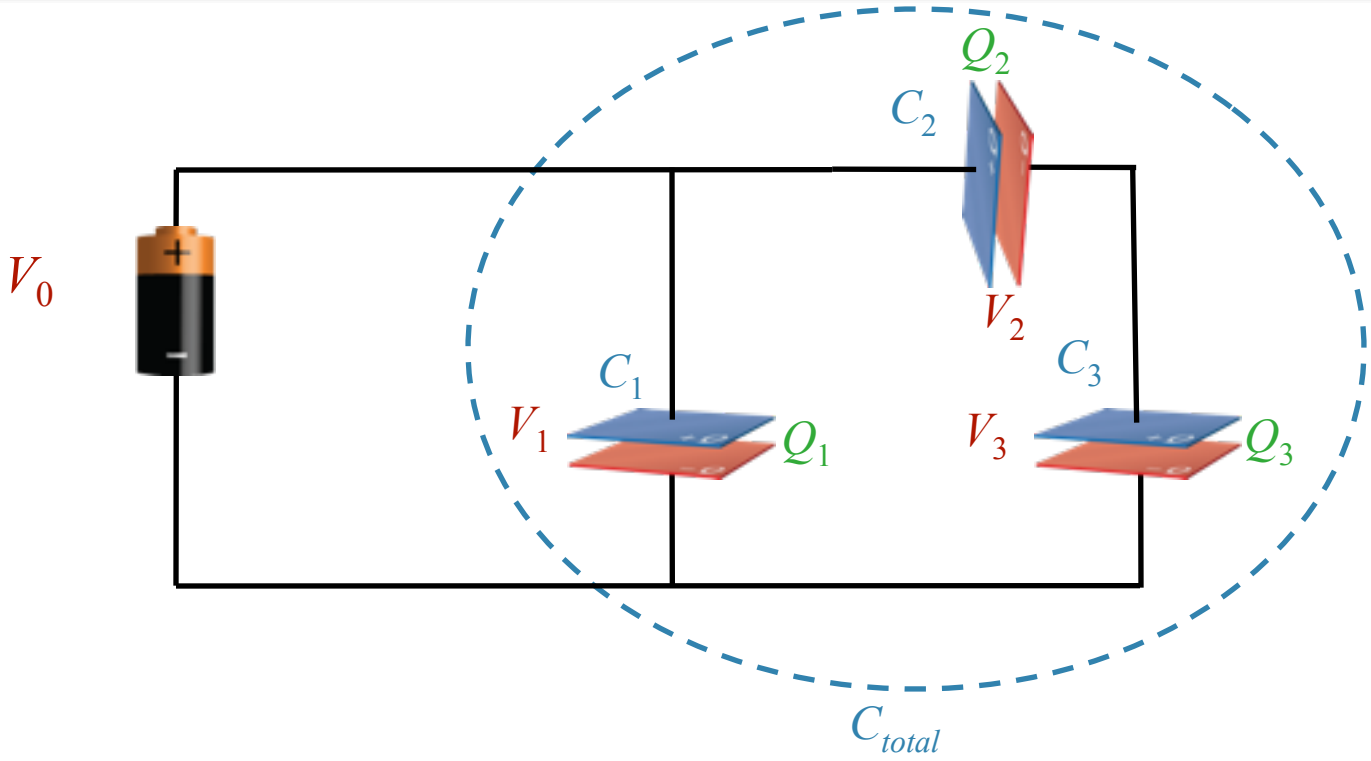
Clicker Question: Capacitor Network



Clicker Question: Capacitor Network



Clicker Question: Capacitor Network



Which of the following is NOT necessarily true:

A) $V_0 = V_1$

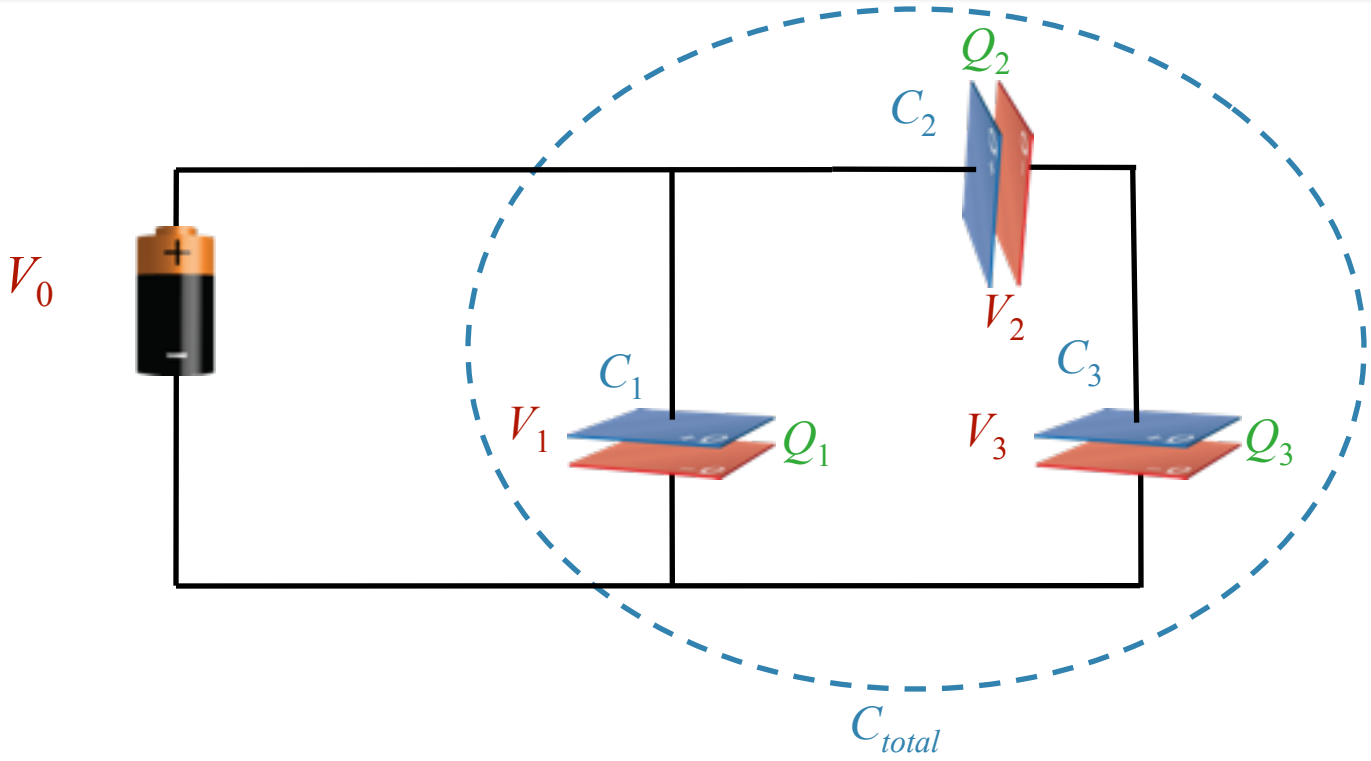
B) $C_{total} > C_1$

C) $V_2 = V_3$

D) $Q_2 = Q_3$

E) $V_1 = V_2 + V_3$

Clicker Question: Capacitor Network



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B) $C_{total} > C_1$

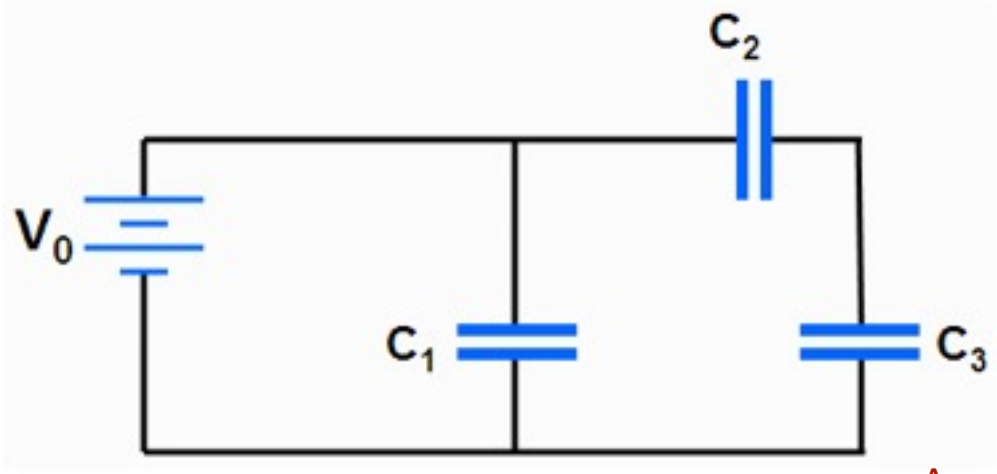
C) $V_2 = V_3$

D) $Q_2 = Q_3$

E) $V_1 = V_2 + V_3$

Clicker Question: Capacitor Network

7) A circuit consists of three unequal capacitors C_1, C_2, and C_3 which are connected to a battery of voltage V_0. The capacitors obtain charges Q_1, Q_2, Q_3, and have voltages across their plates V_1, V_2, and V_3. C_{eq} is the equivalent capacitance of the circuit.



To simplify,
Assume $C_1 = C_2 = C_3$

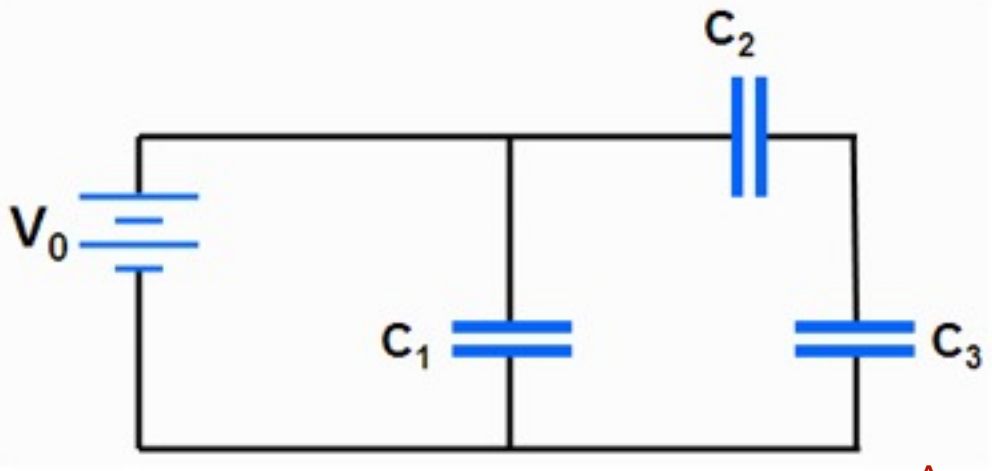
Check all of the following that apply in the general case for all values of the capacitors:

- ☐ $Q_1 = Q_2$
- ☐ $Q_2 = Q_3$
- ☐ $V_2 = V_3$
- ☐ $V_0 = V_1$
- ☐ $V_1 < V_2$
- ☐ $C_{eq} > C_1$

(A)	(B)	(C)	(D)
$Q_1 = Q_2$ $V_1 < V_2$	$Q_1 = Q_2$ $V_1 \not< V_2$	$Q_1 \neq Q_2$ $V_1 < V_2$	$Q_1 \neq Q_2$ $V_1 \not< V_2$

Clicker Question: Capacitor Network

7) A circuit consists of three unequal capacitors C_1, C_2, and C_3 which are connected to a battery of voltage V_0. The capacitors obtain charges Q_1, Q_2, Q_3, and have voltages across their plates V_1, V_2, and V_3. C_{eq} is the equivalent capacitance of the circuit.



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Assume $C_1 = C_2 = C_3$

Check all of the following that apply in the general case for all values of the capacitors:

- ☐ $Q_1 = Q_2$
- ☐ $Q_2 = Q_3$
- ☐ $V_2 = V_3$
- ☐ $V_0 = V_1$
- ☐ $V_1 < V_2$
- ☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3$

(A)	(B)	(C)	(D)
$Q_1 = Q_2$ $V_1 < V_2$	$Q_1 = Q_2$ $V_1 \not< V_2$	$Q_1 \neq Q_2$ $V_1 < V_2$	$Q_1 \neq Q_2$ $V_1 \not< V_2$

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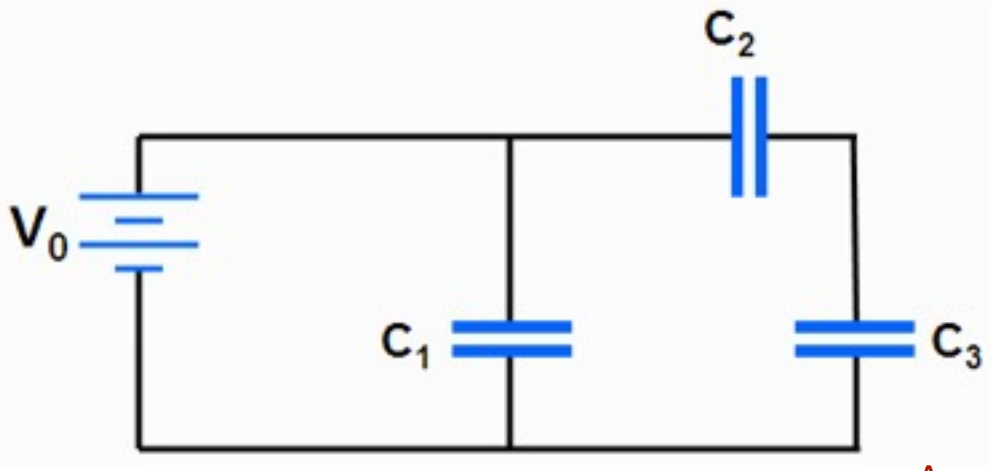

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- ☐ $Q_2 = Q_3$
- ☐ $V_2 = V_3$
- ☐ $V_0 = V_1$
- NO ☐ $V_1 < V_2$
- ☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3$ → $V_1 > V_2$

(A)	(B)	(C)	(D)
$Q_1 = Q_2$	$Q_1 = Q_2$	$Q_1 \neq Q_2$	$Q_1 \neq Q_2$
$V_1 < V_2$	$V_1 \not< V_2$	$V_1 < V_2$	$V_1 \not< V_2$

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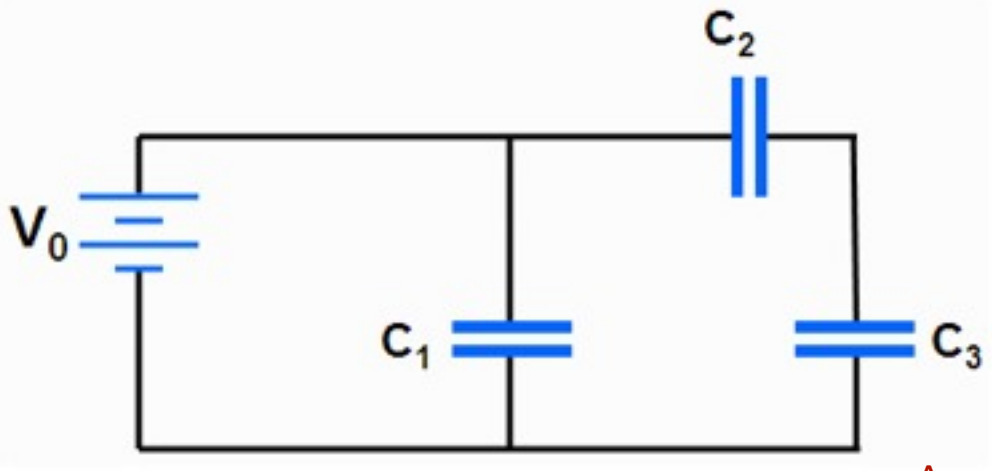

To simplify,
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- ☐ $Q_1 = Q_2$
- ☐ $Q_2 = Q_3$
- ☐ $V_2 = V_3$
- ☐ $V_0 = V_1$
- NO ☐ $V_1 < V_2$
- ☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3$

$Q_2 = Q_3$

→ $V_1 > V_2$

(A)	(B)	(C)	(D)
$Q_1 = Q_2$ $V_1 < V_2$	$Q_1 = Q_2$ $V_1 \not< V_2$	$Q_1 \neq Q_2$ $V_1 < V_2$	$Q_1 \neq Q_2$ $V_1 \not< V_2$

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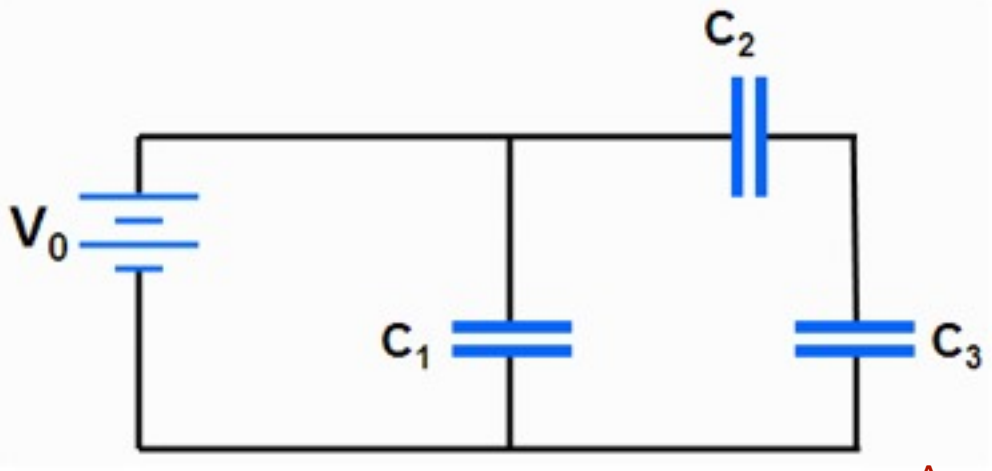


To simplify,
Assume $C_1 = C_2 = C_3$

Check all of the following that apply in the general case for all values of the capacitors:

- ☐ $Q_1 = Q_2$
- ☐ $Q_2 = Q_3$
- ☐ $V_2 = V_3$
- ☐ $V_0 = V_1$
- NO ☐ $V_1 < V_2$
- ☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3$ → $V_1 > V_2$

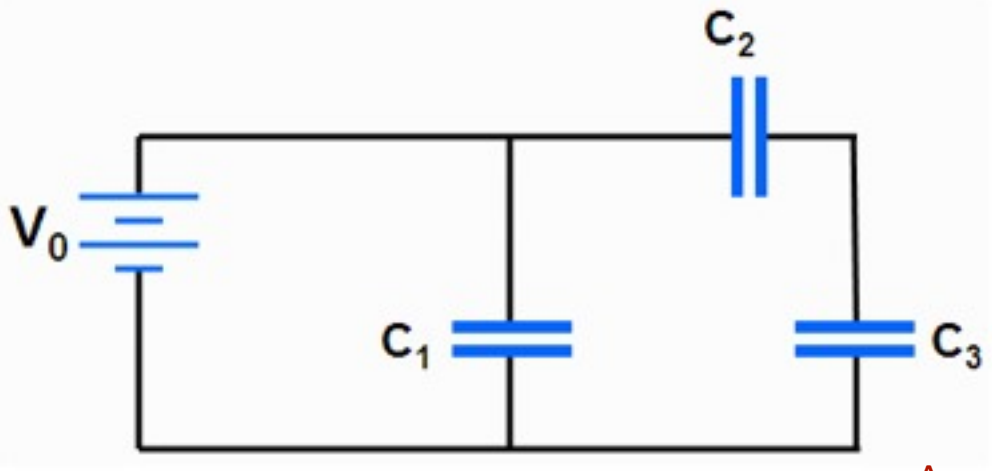
$Q_2 = Q_3$

$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} + \frac{Q_2}{C_3}$

(A)	(B)	(C)	(D)
$Q_1 = Q_2$	$Q_1 = Q_2$	$Q_1 \neq Q_2$	$Q_1 \neq Q_2$
$V_1 < V_2$	$V_1 \not< V_2$	$V_1 < V_2$	$V_1 \not< V_2$

Clicker Question: Capacitor Network

7) A circuit consists of three unequal capacitors C_1, C_2, and C_3 which are connected to a battery of voltage V_0. The capacitors obtain charges Q_1, Q_2, Q_3, and have voltages across their plates V_1, V_2, and V_3. C_{eq} is the equivalent capacitance of the circuit.



To simplify,
Assume $C_1 = C_2 = C_3$

Check all of the following that apply in the general case for all values of the capacitors:

NO ☐ $Q_1 = Q_2$
☐ $Q_2 = Q_3$
☐ $V_2 = V_3$
☐ $V_0 = V_1$
NO ☐ $V_1 < V_2$
☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3$ → $V_1 > V_2$

$Q_2 = Q_3$

$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} + \frac{Q_2}{C_3}$ → $Q_2 = \frac{C_2 C_3}{C_1(C_2 + C_3)} Q_1$

(A) $Q_1 = Q_2$, $V_1 < V_2$

(B) $Q_1 = Q_2$, $V_1 \not< V_2$

(C) $Q_1 \neq Q_2$, $V_1 < V_2$

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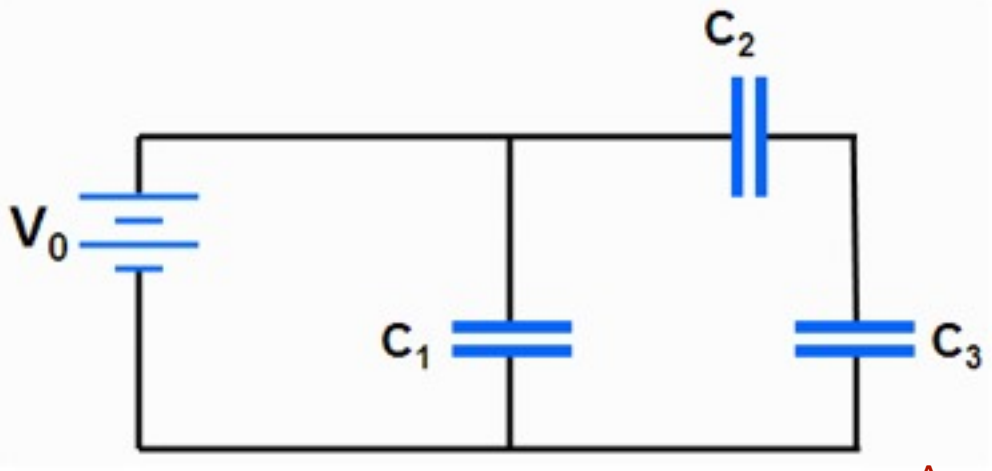

To simplify,
Assume $C_1 = C_2 = C_3$

Check all of the following that apply in the general case for all values of the capacitors:

NO ☐ $Q_1 = Q_2$
☐ $Q_2 = Q_3$
☐ $V_2 = V_3$
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NO ☐ $V_1 < V_2$
☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3$ → $V_1 > V_2$

$Q_2 = Q_3$

$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} + \frac{Q_2}{C_3}$ → $Q_2 = \frac{C_2 C_3}{C_1(C_2 + C_3)} Q_1$

(A) $Q_1 = Q_2$, $V_1 < V_2$

(B) $Q_1 = Q_2$, $V_1 \not< V_2$

(C) $Q_1 \neq Q_2$, $V_1 < V_2$

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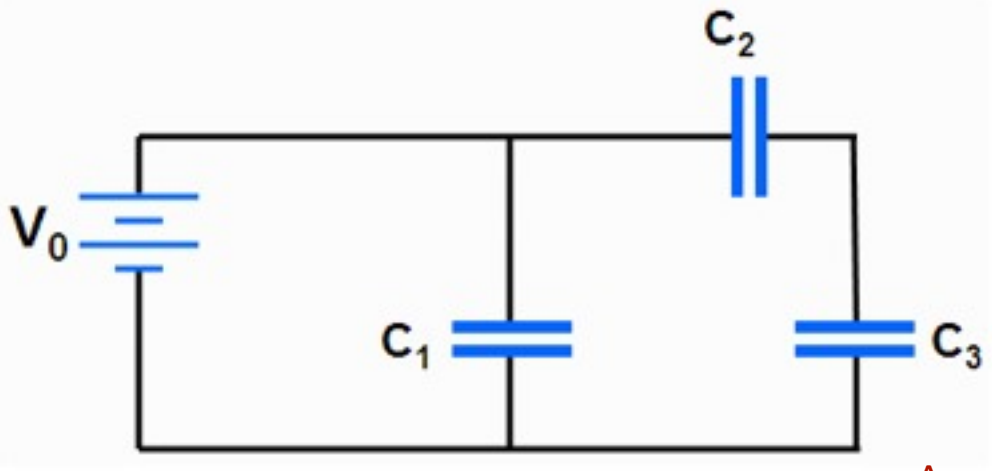
Clicker Question: Capacitor Network

7) A circuit consists of three unequal capacitors C_1, C_2, and C_3 which are connected to a battery of voltage V_0. The capacitors obtain charges Q_1, Q_2, Q_3, and have voltages across their plates V_1, V_2, and V_3. C_{eq} is the equivalent capacitance of the circuit.



To simplify,
Assume $C_1 = C_2 = C_3$

Check all of the following that apply in the general case for all values of the capacitors:

NO ☐ $Q_1 = Q_2$
YES ☐ $Q_2 = Q_3$
NO ☐ $V_2 = V_3$
YES ☐ $V_0 = V_1$
NO ☐ $V_1 < V_2$
YES ☐ $C_{eq} > C_1$

$V_1 = V_2 + V_3 \rightarrow V_1 > V_2$

$Q_2 = Q_3$

$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} + \frac{Q_2}{C_3} \rightarrow Q_2 = \frac{C_2 C_3}{C_1(C_2 + C_3)} Q_1$

(A) $Q_1 = Q_2$, $V_1 < V_2$

(B) $Q_1 = Q_2$, $V_1 \not< V_2$

(C) $Q_1 \neq Q_2$, $V_1 < V_2$

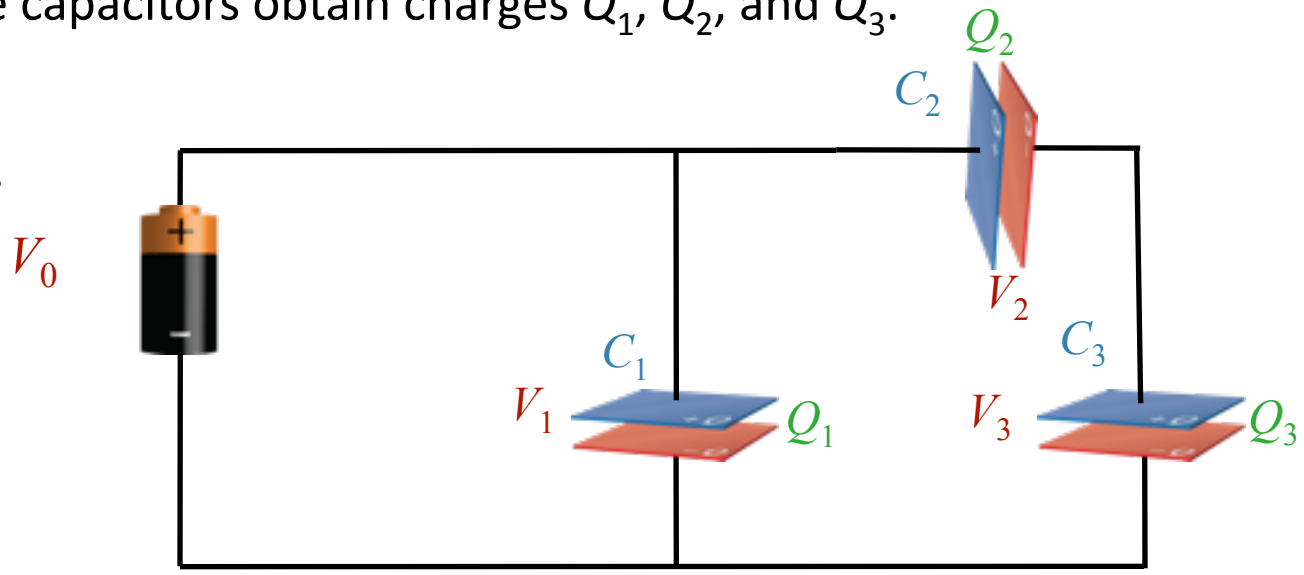
(D) $Q_1 \neq Q_2$, $V_1 \not< V_2$

CheckPoint: Capacitor Network

A circuit consists of three unequal capacitors C_1, C_2, and C_3 which are connected to a battery of voltage V_0. The capacitance of C_2 is twice that of C_1. The capacitance of C_3 is three times that of C_1. The capacitors obtain charges Q_1, Q_2, and Q_3.

Compare Q_1, Q_2, and Q_3.

A. $Q_1 > Q_3 > Q_2$
B. $Q_1 > Q_2 > Q_3$
C. $Q_1 > Q_2 = Q_3$
D. $Q_1 = Q_2 = Q_3$
E. $Q_1 < Q_2 = Q_3$



CheckPoint: Capacitor Network

A circuit consists of three unequal capacitors C_1, C_2, and C_3 which are connected to a battery of voltage V_0. The capacitance of C_2 is twice that of C_1. The capacitance of C_3 is three times that of C_1. The capacitors obtain charges Q_1, Q_2, and Q_3.

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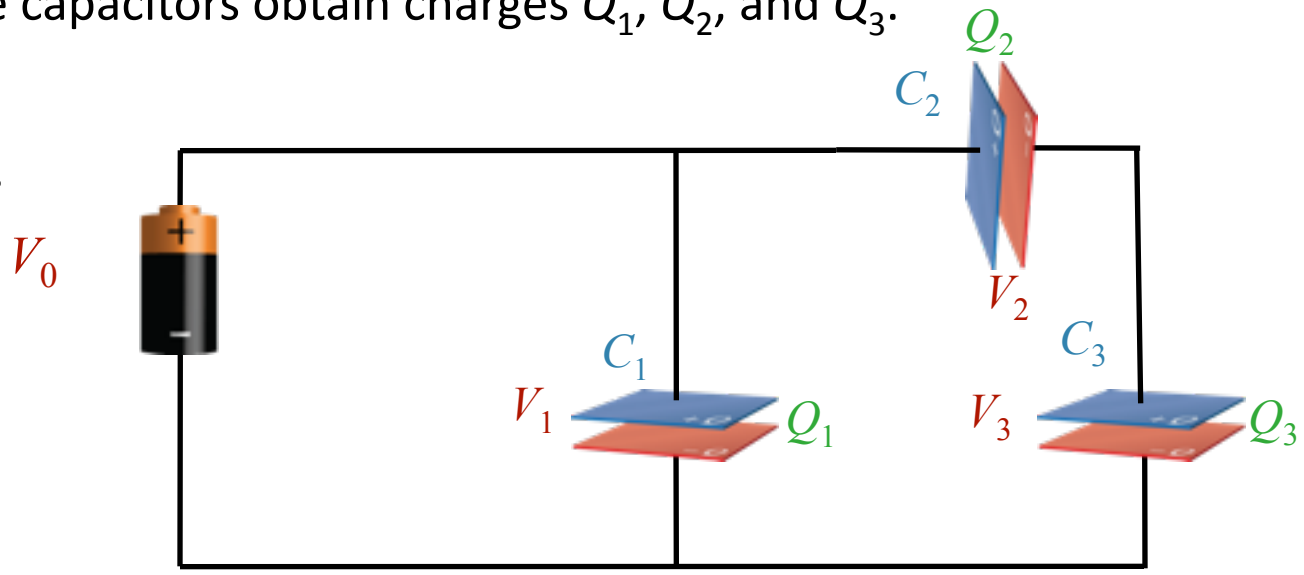

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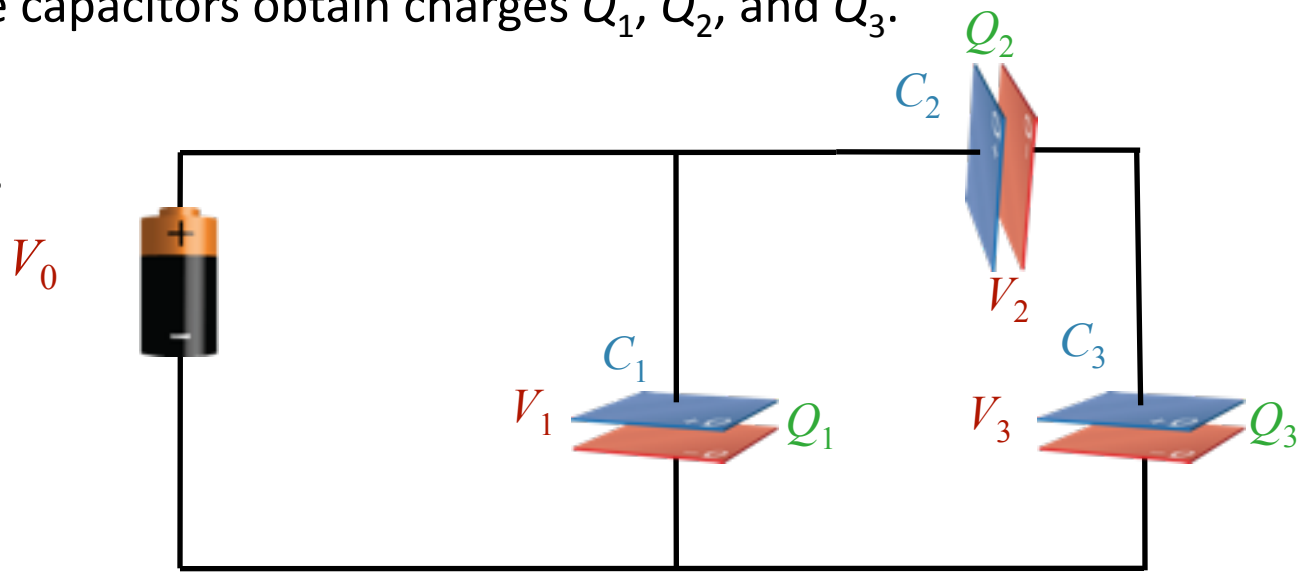
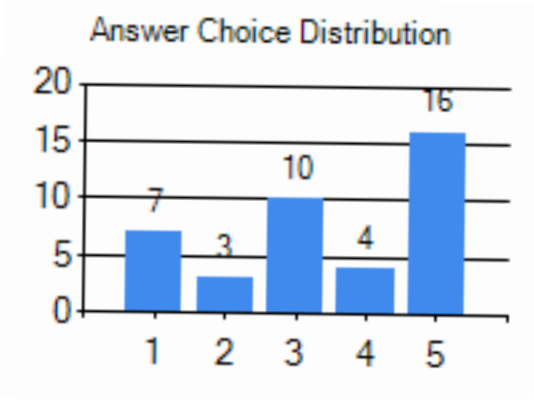
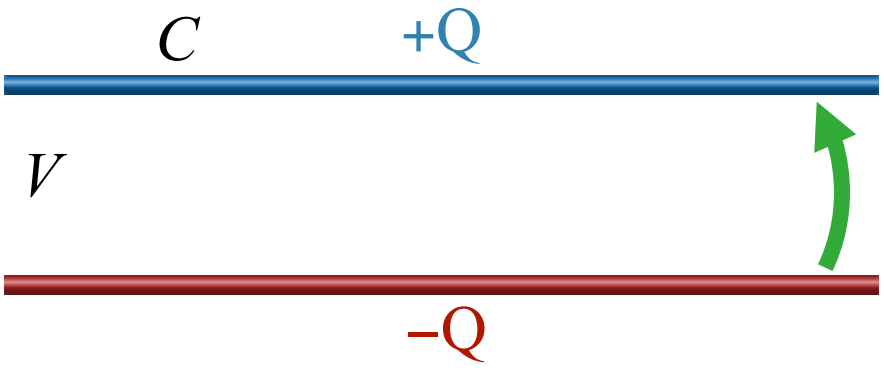




Energy in a Capacitor

In Prelecture 7 we calculated the work done to move charge Q from one plate to another:



$$U = {}^{1}/_{2}QV$$

This is potential energy waiting to be used…

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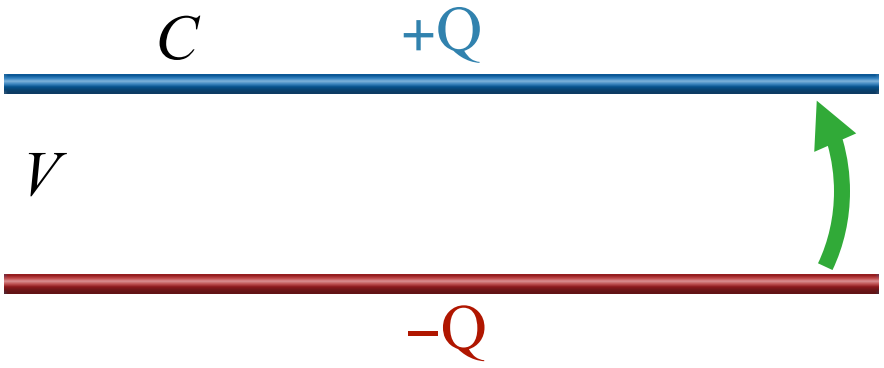

$$U = {}^1/_2 QV$$
$$= {}^1/_2 CV^2$$
$$= {}^1/_2 Q^2/C$$

Since $Q = VC$

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Messing with Capacitors

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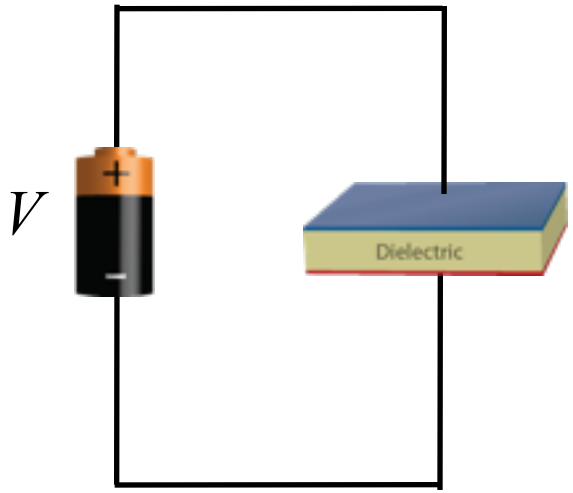
If connected to a battery V stays constant



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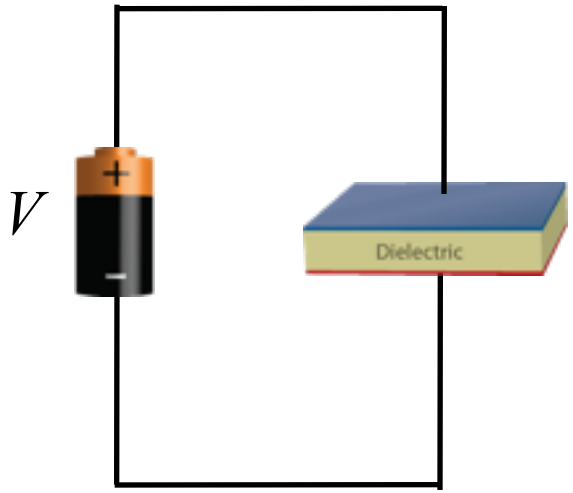

$$V_1 = V$$

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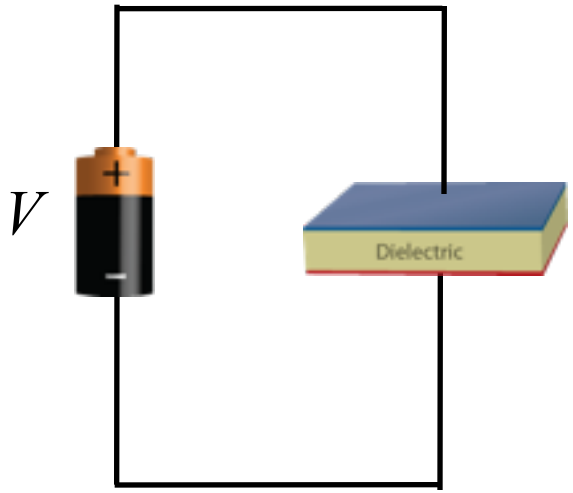

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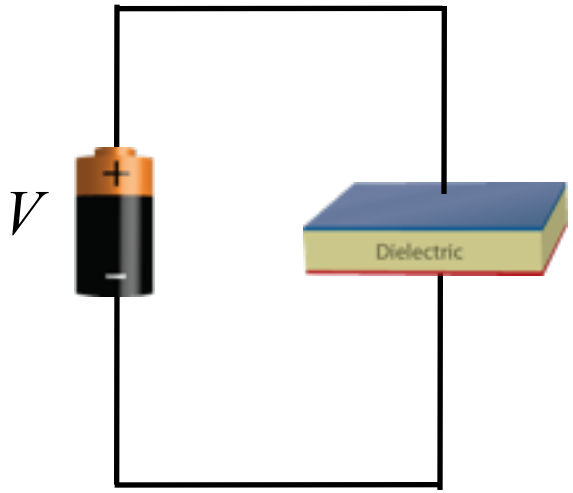

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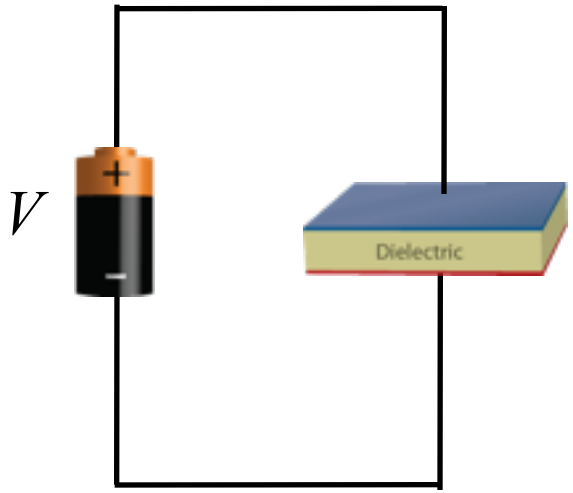

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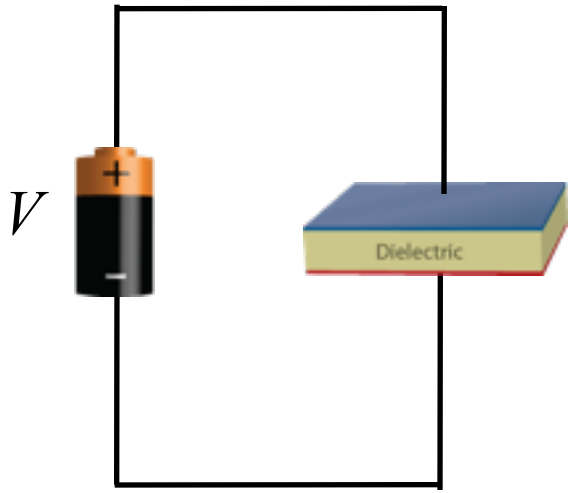

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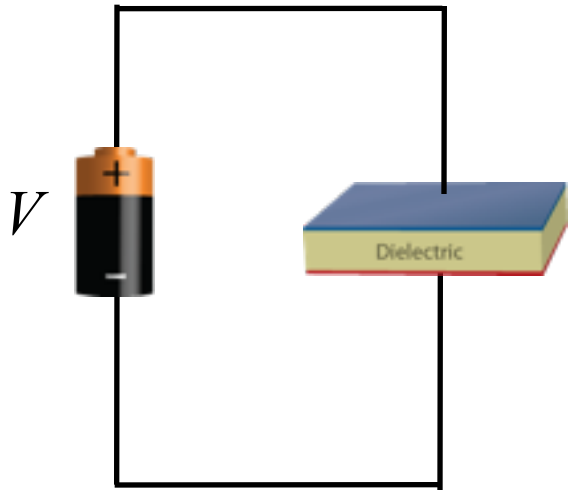

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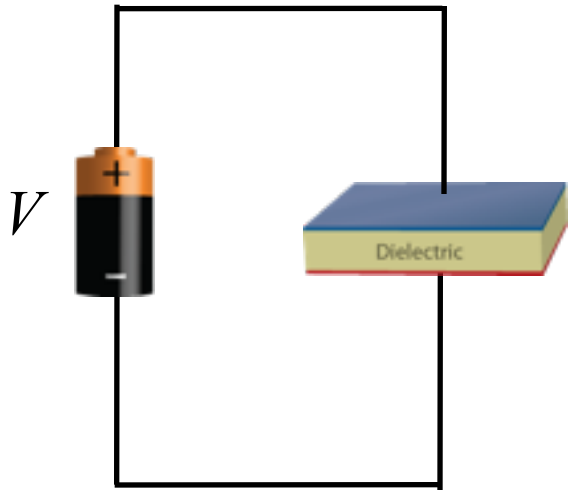

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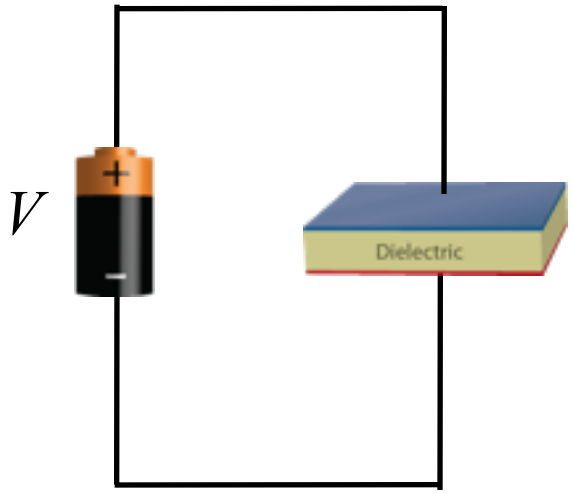

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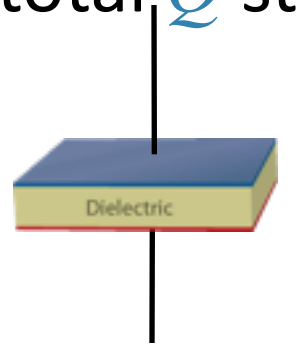
If isolated then total Q stays constant



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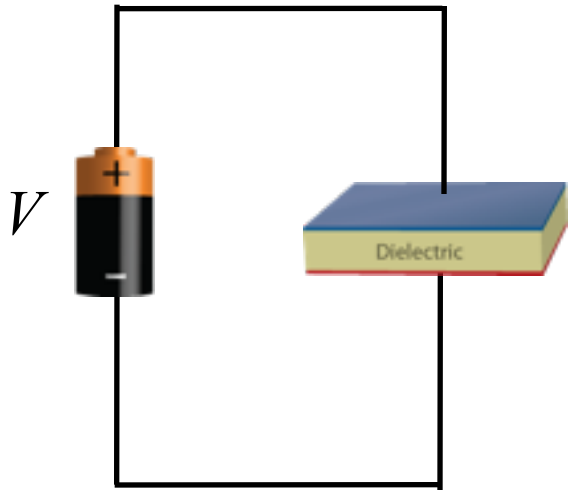

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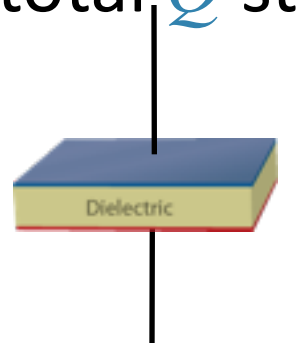

$$Q_1 = Q$$

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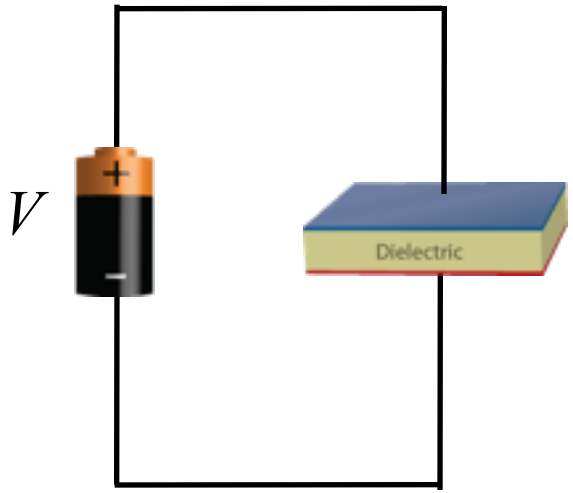

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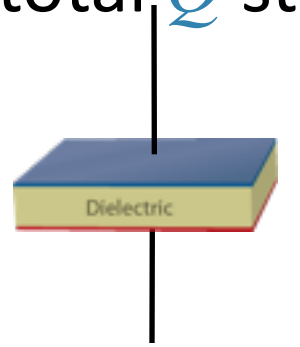

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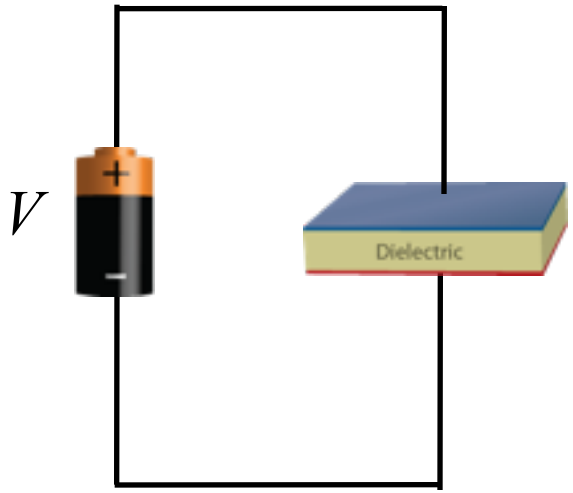

$$V_1 = V$$
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$$Q_1 = C_1 V_1 = \kappa C V = \kappa Q$$

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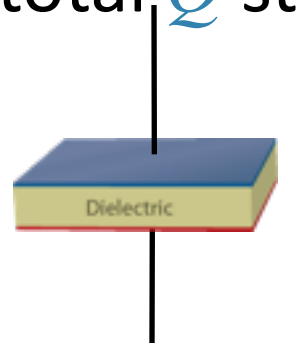

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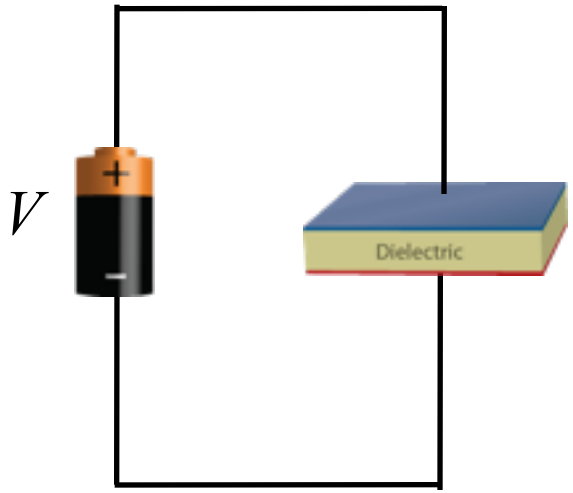

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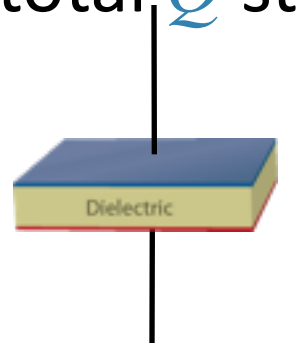

$$Q_1 = Q$$
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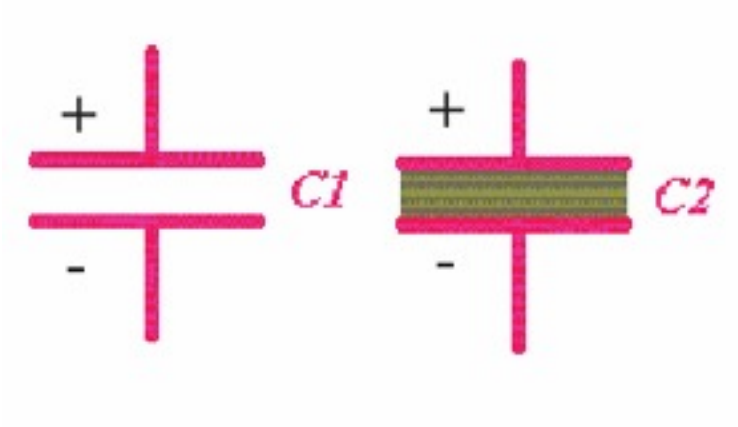
$$\rightarrow V_1 = Q_1/C_1 = Q/\kappa C = V/\kappa$$

CheckPoint: Capacitors and Dielectrics 1

Two identical parallel plate capacitors are given the same charge Q, after which they are disconnected from the battery. After C_2 has been charged and disconnected, it is filled with a dielectric.



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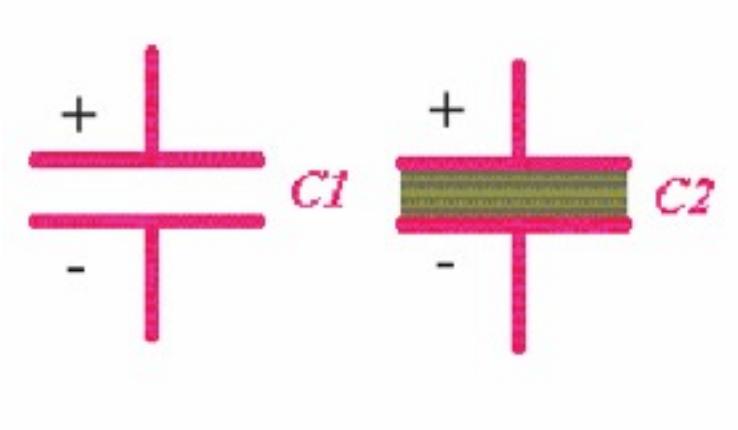

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"The little brown thing is stopping the pikachus from reaching the other side."

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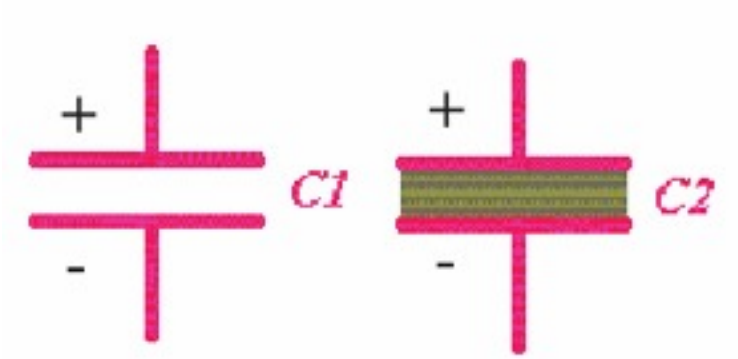

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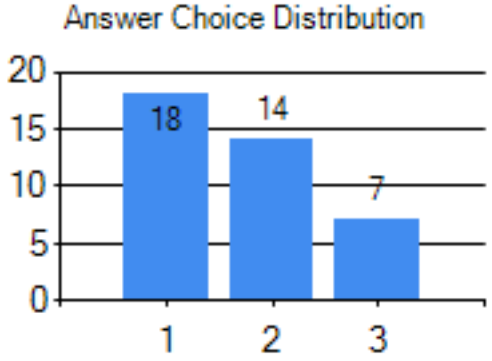

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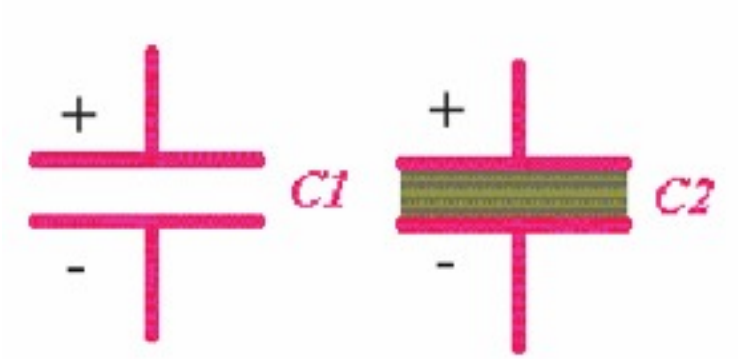

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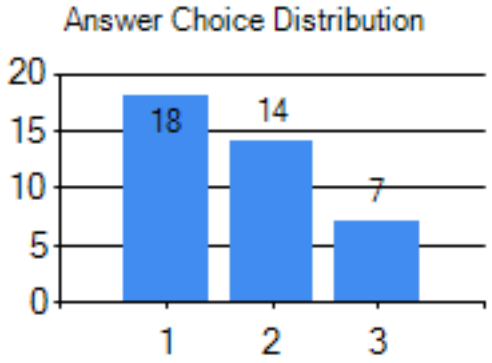

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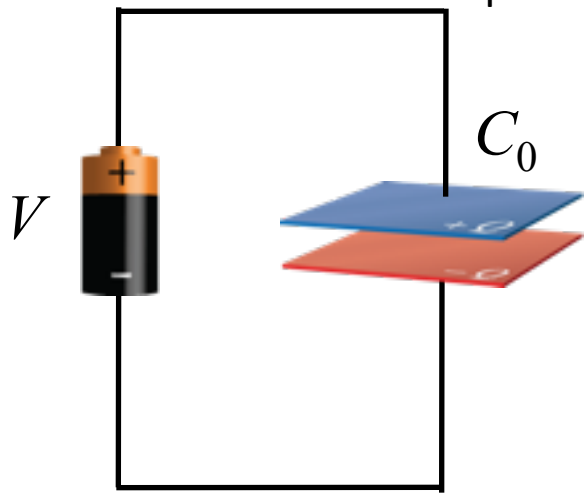

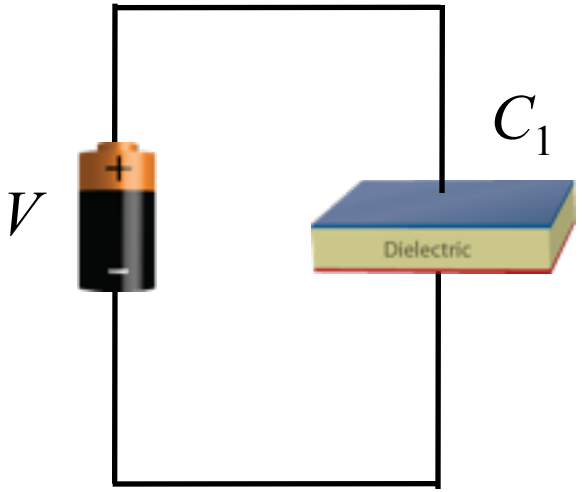

A) $U_1 < U_0$

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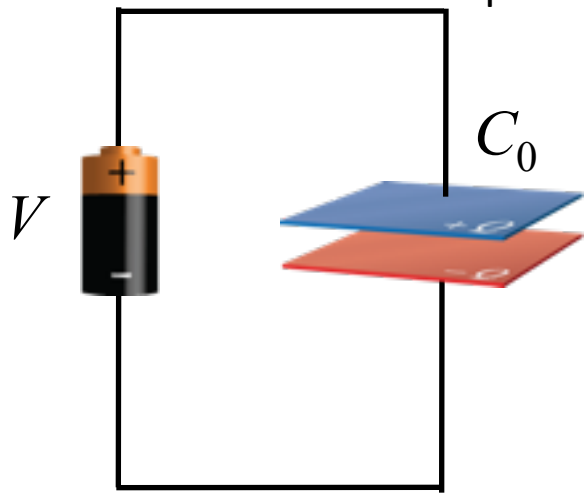

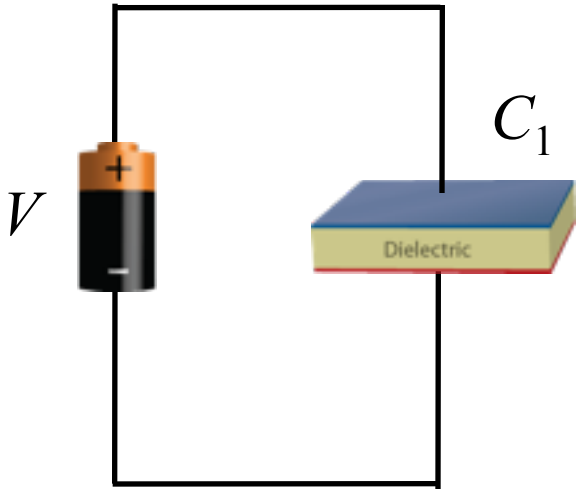

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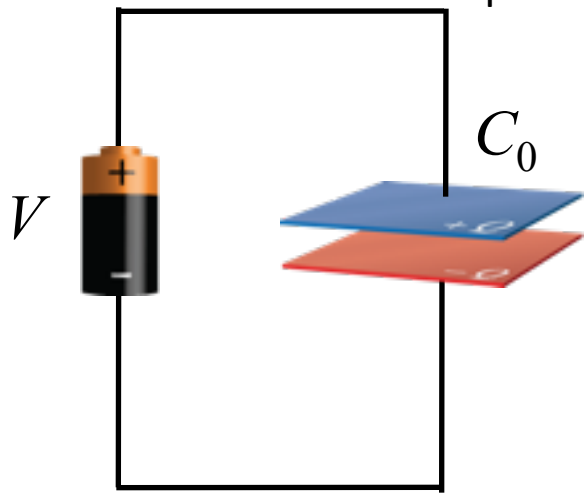

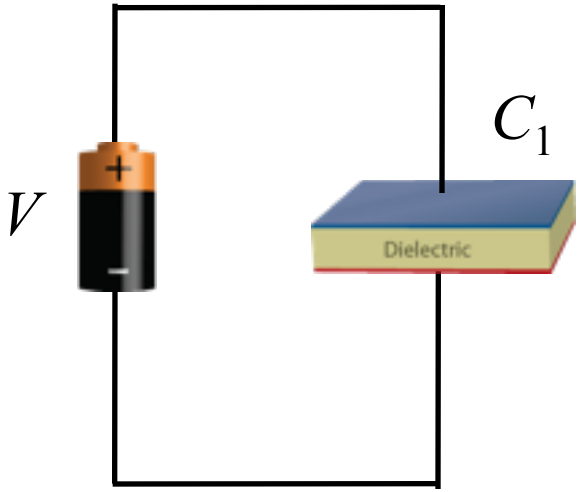

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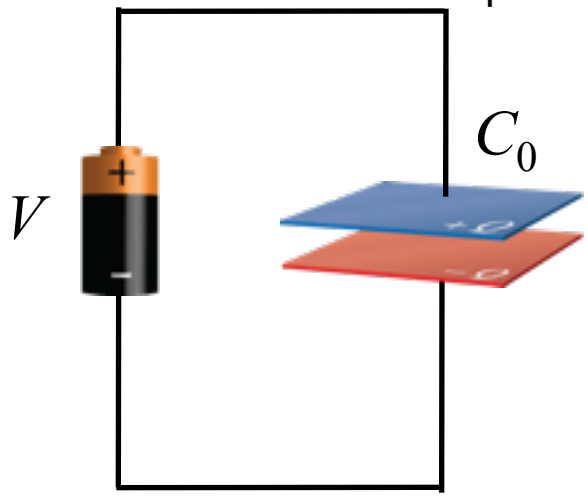

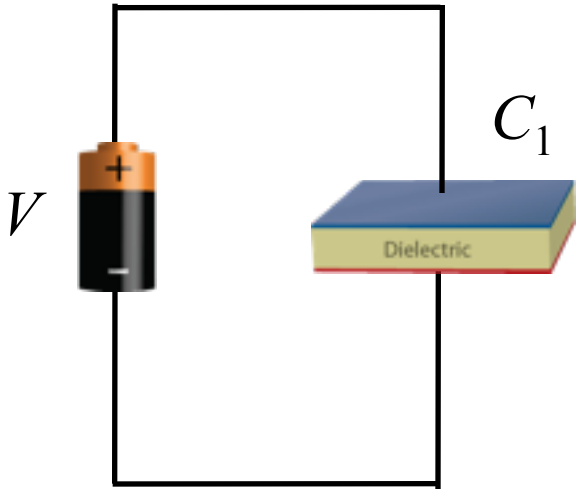

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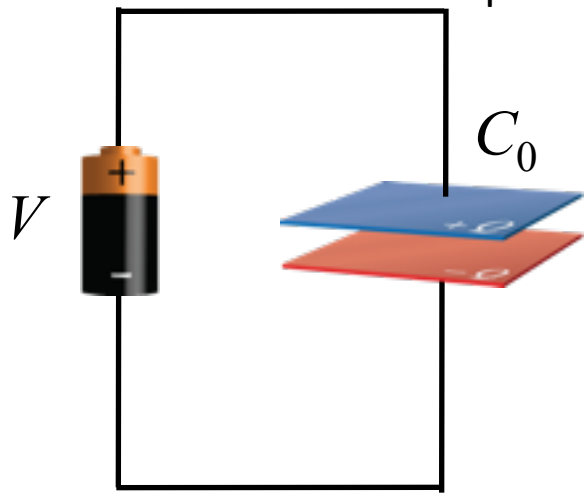

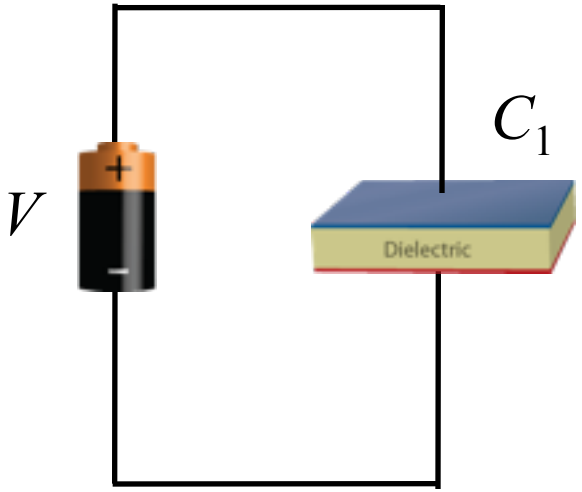

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→ Potential Energy goes UP

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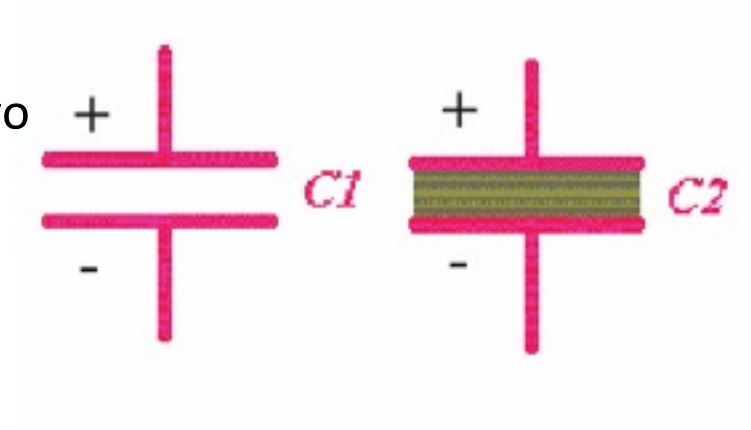

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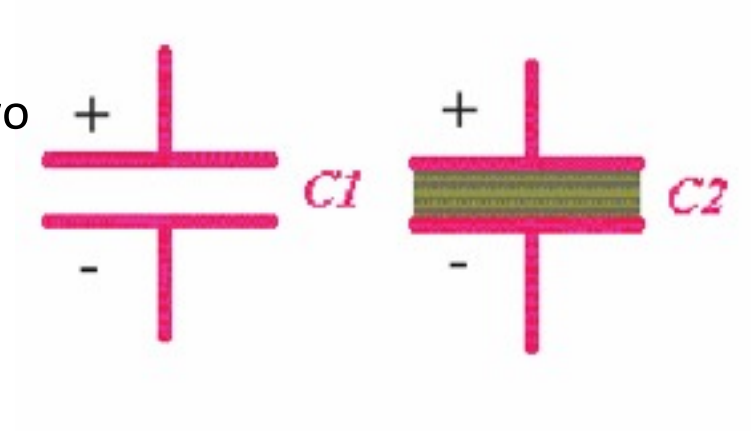

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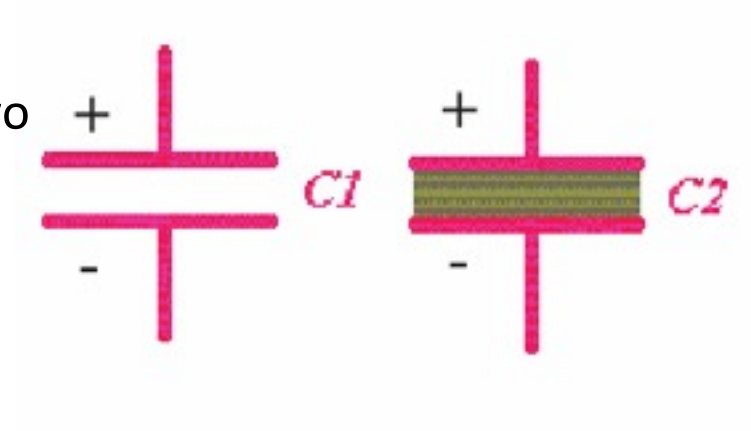

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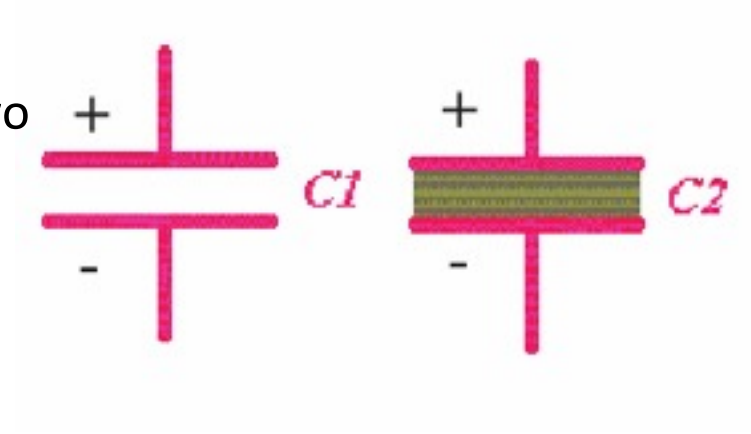
" If the electric field goes down, then so does the potential energy of the second system.."

"Dielectrics don't affect potential."

"U = QV. Since voltage remains constant and charge increases, potential energy must also increase."

CheckPoint: Capacitors and Dielectrics 2

Two identical parallel plate capacitors are given the same charge Q, after which they are disconnected from the battery. After C_2 has been charged and disconnected, it is filled with a dielectric.



Compare the potential energy stored by the two capacitors.

A. $U_1 > U_2$

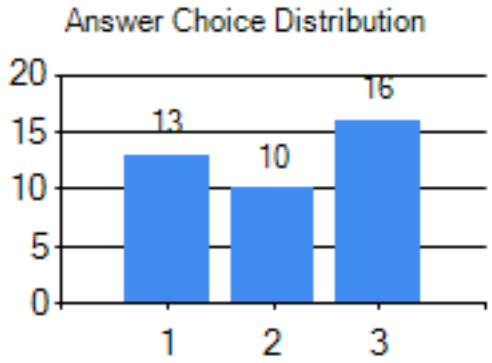
B. $U_1 = U_2$

C. $U_1 < U_2$

" If the electric field goes down, then so does the potential energy of the second system.."

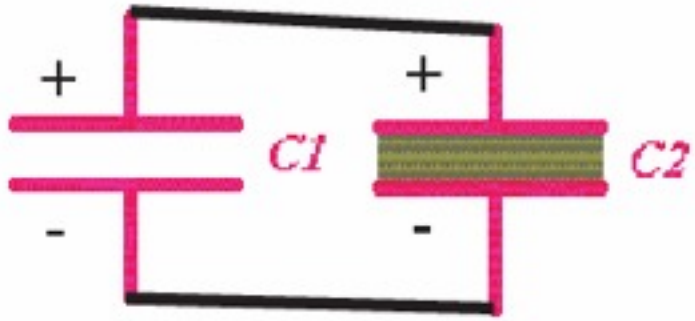
"Dielectrics don't affect potential."

"U = QV. Since voltage remains constant and charge increases, potential energy must also increase."



CheckPoint: Capacitors and Dielectrics 3

The two capacitors are now connected to each other by wires as shown. How will the charge redistribute itself, if at all?



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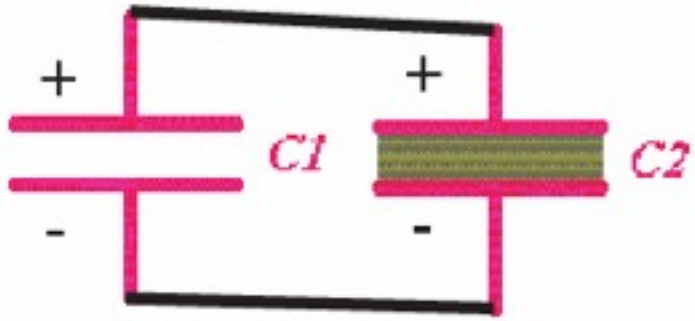

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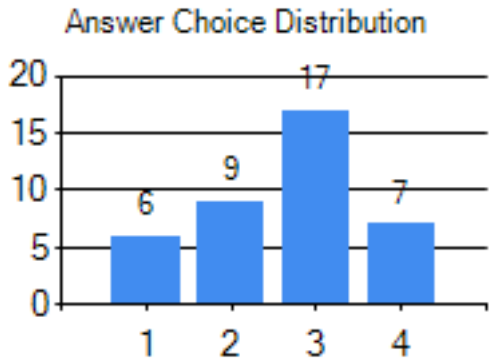

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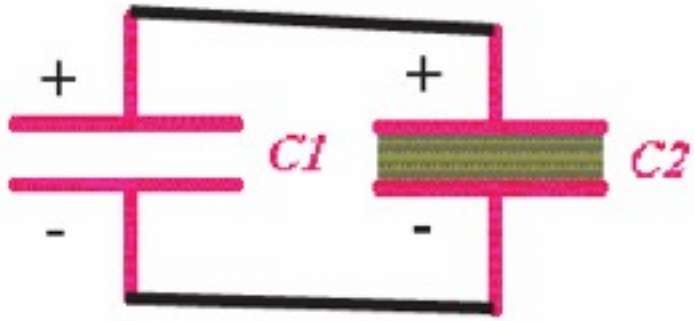

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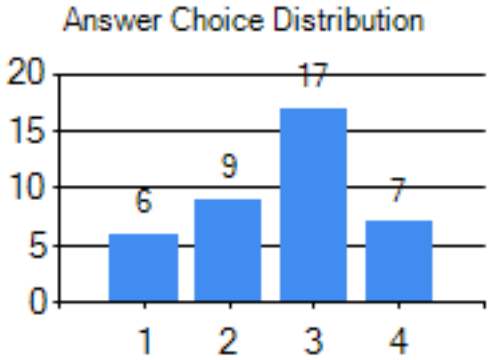

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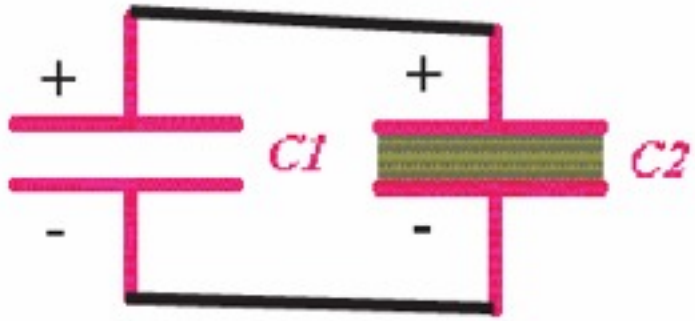

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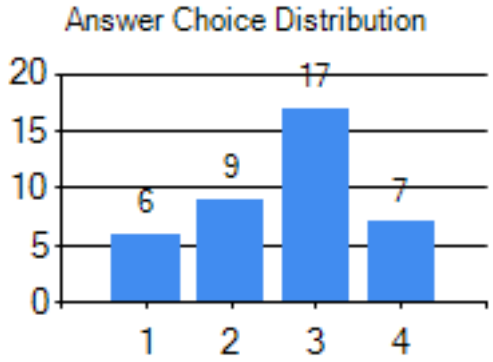

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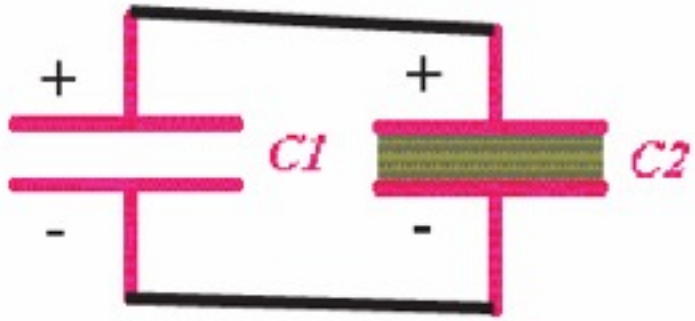

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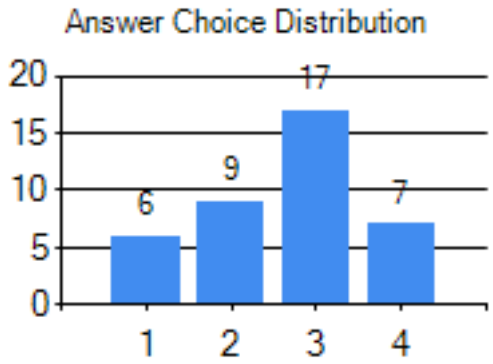

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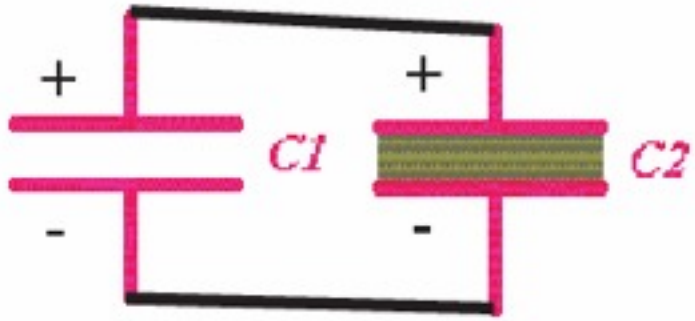

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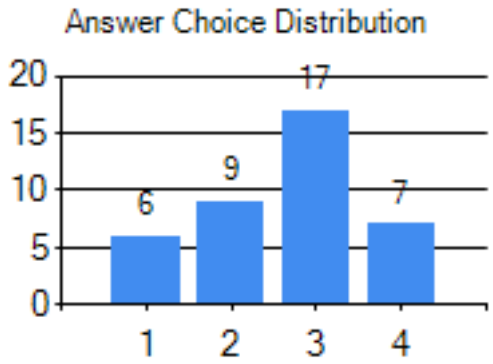

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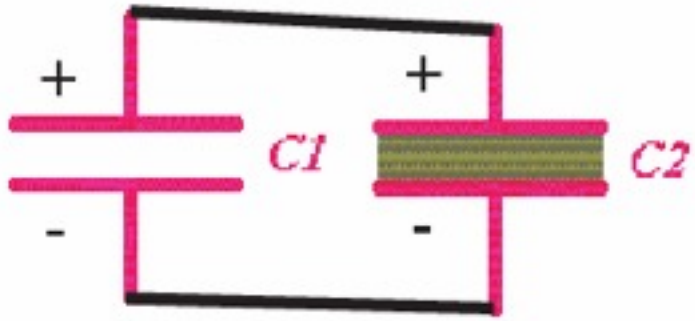

V must be the same !

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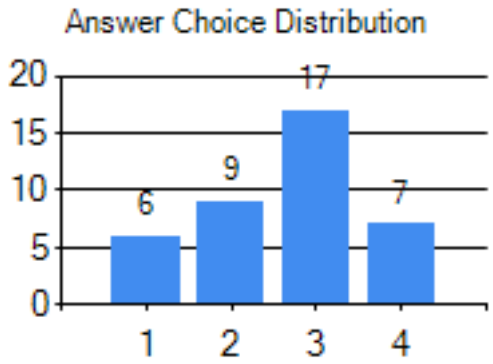

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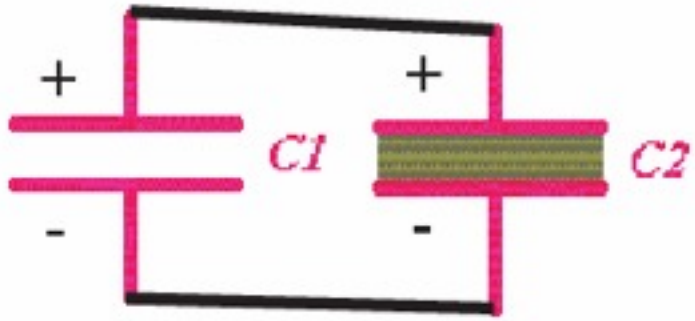

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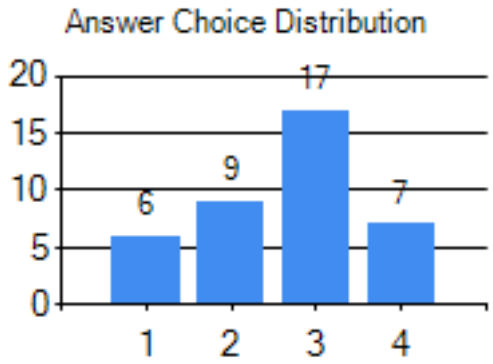
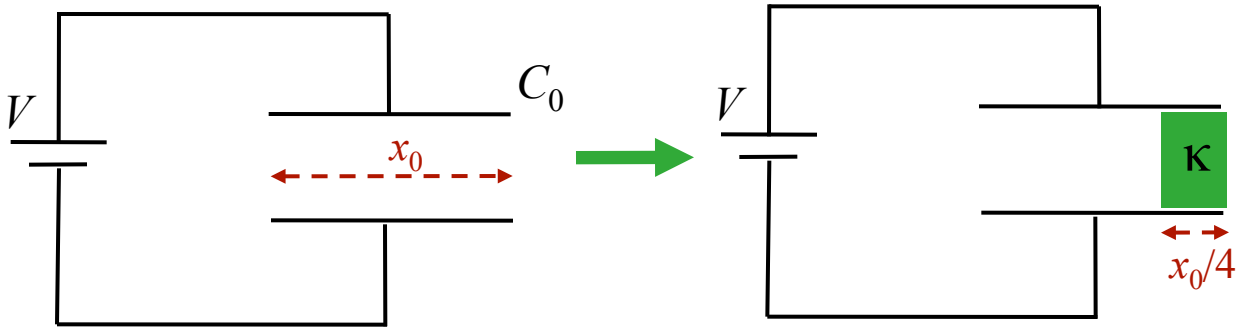


Calculation



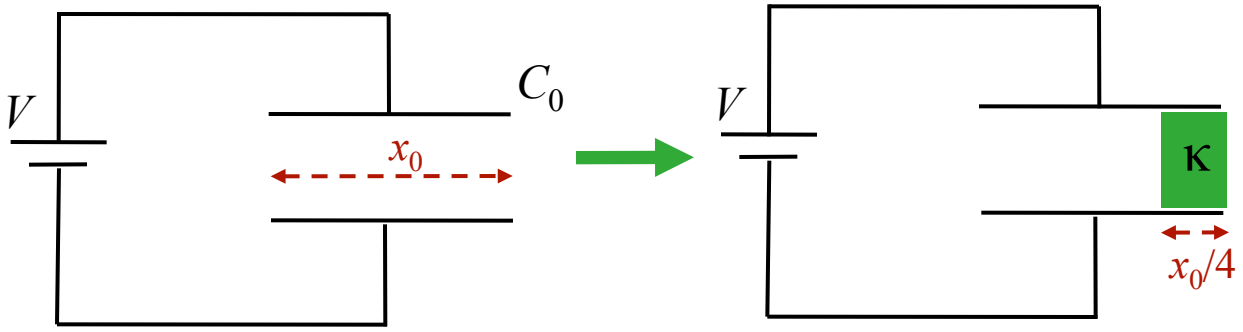
An air-gap capacitor, having capacitance C_0 and width x_0 is connected to a battery of voltage V.

A dielectric (κ) of width $x_0/4$ is inserted into the gap as shown.

What is Q_f, the final charge on the capacitor?

Conceptual Analysis:

Calculation



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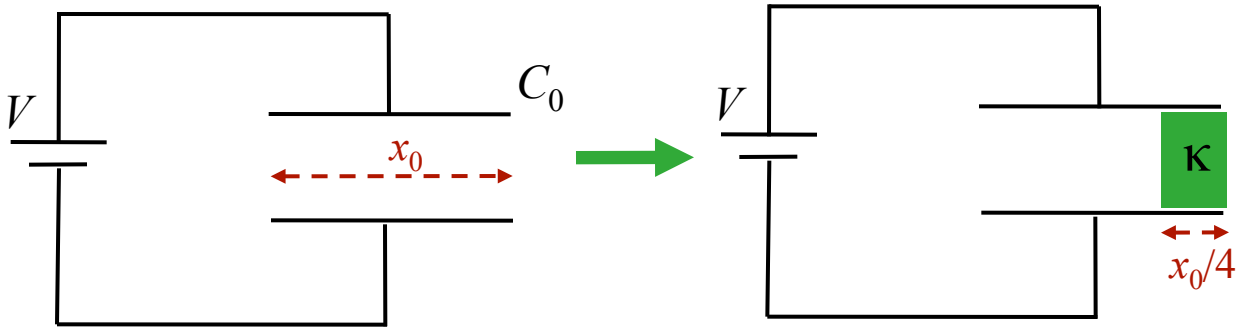

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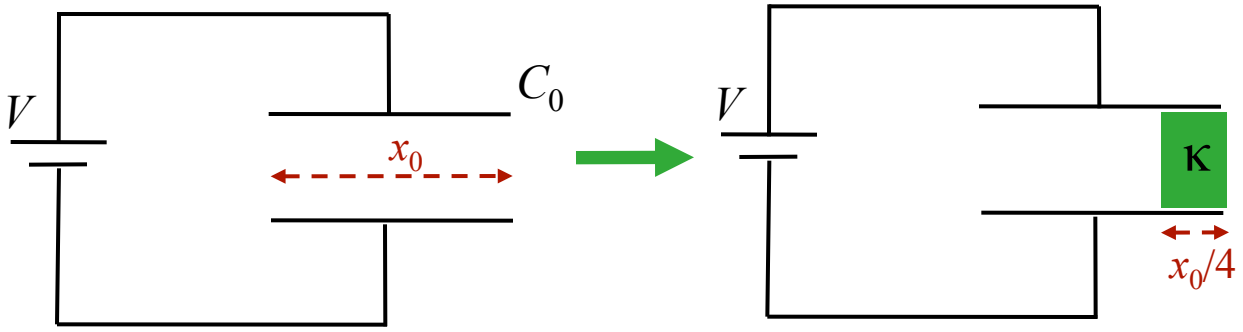
What changes when the dielectric added?

A) Only C B) only Q C) only V D) C and Q E) V and Q

Calculation



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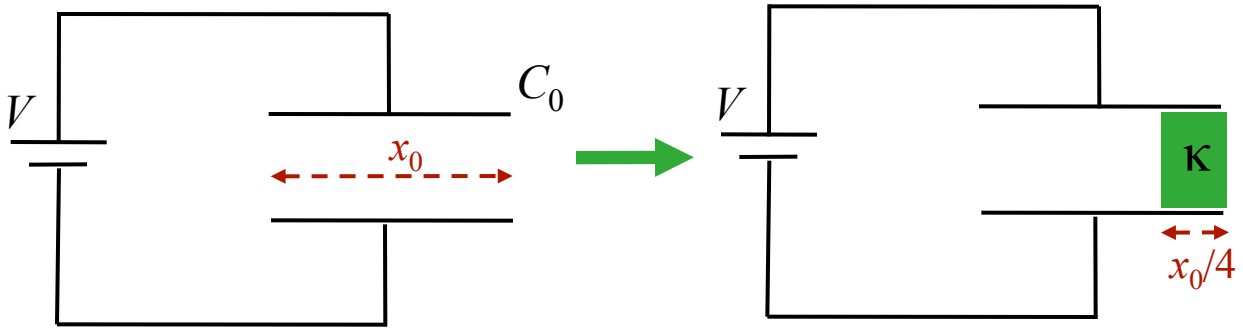

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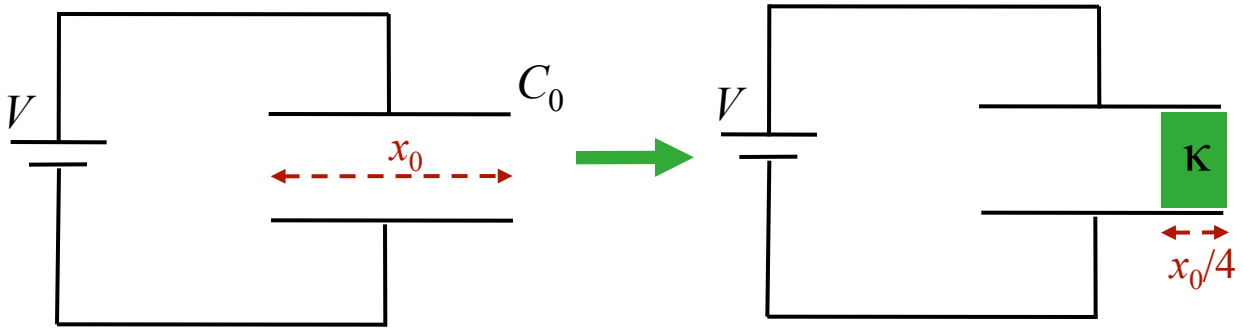
Adding dielectric changes the physical capacitor → C changes

Calculation



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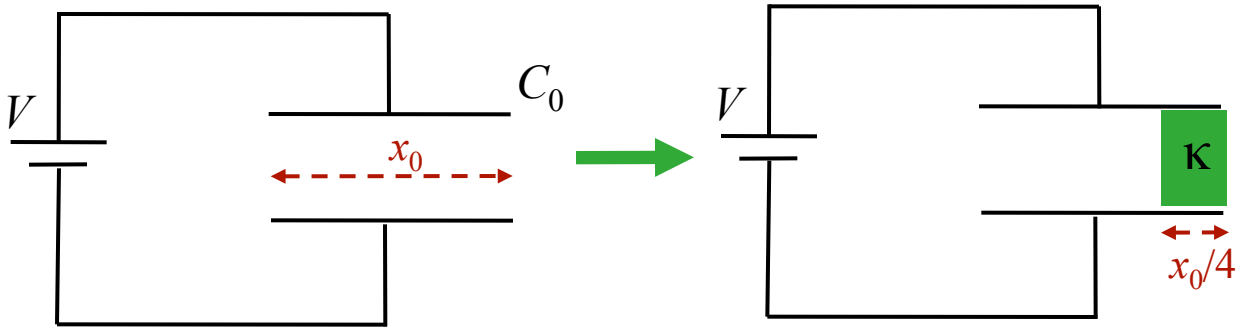
Adding dielectric changes the physical capacitor → C changes

V does not change and C changes → Q changes

Calculation



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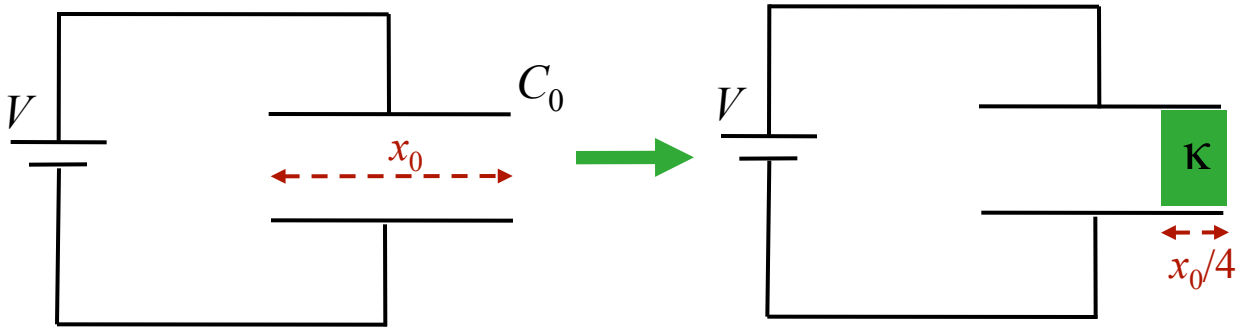

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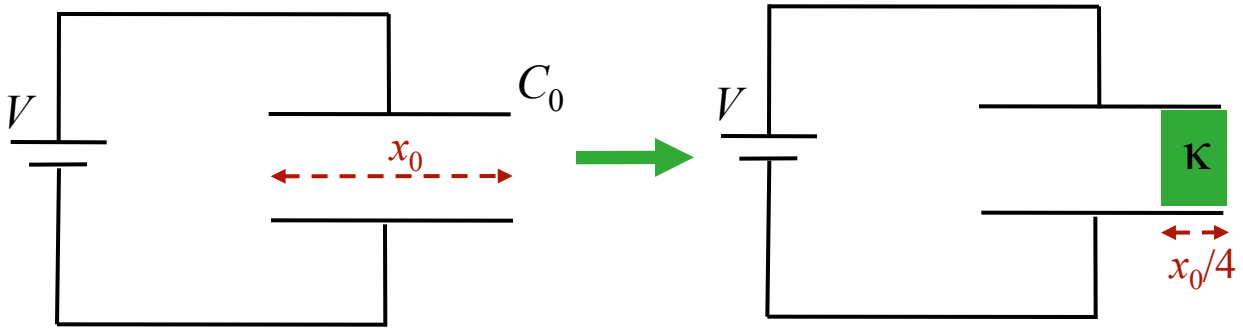

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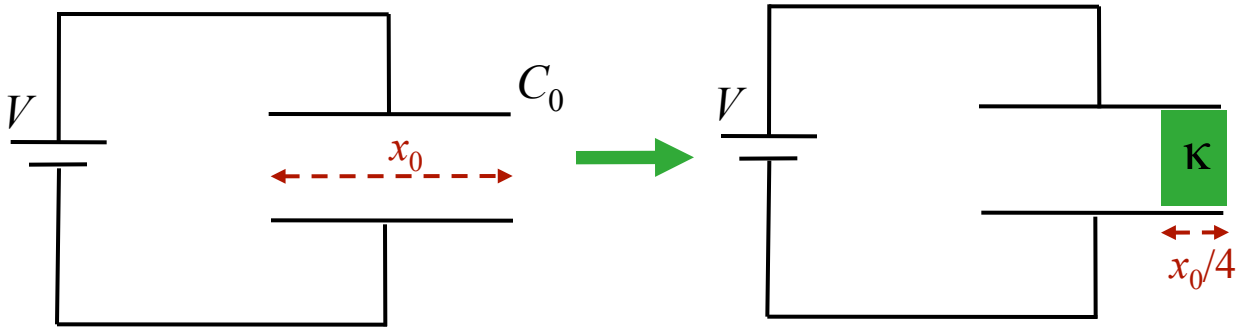
Strategic Analysis:

- Calculate new capacitance C

Calculation



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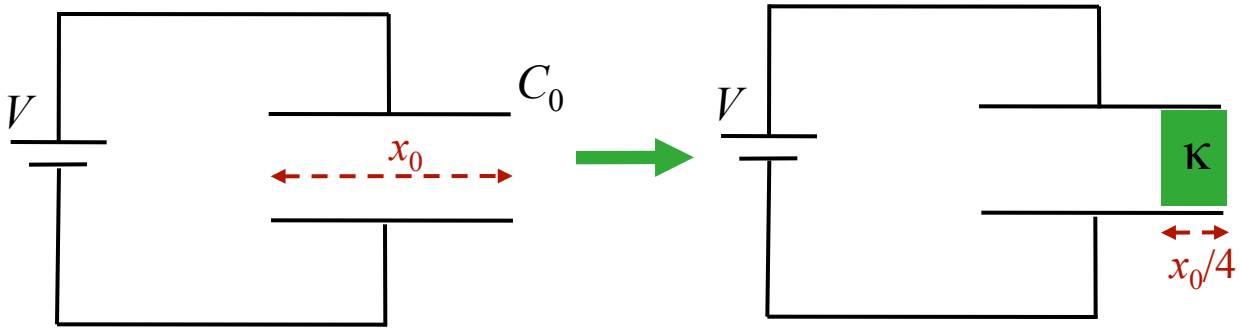
Strategic Analysis:

- Calculate new capacitance C
- Apply definition of capacitance to determine Q

Calculation



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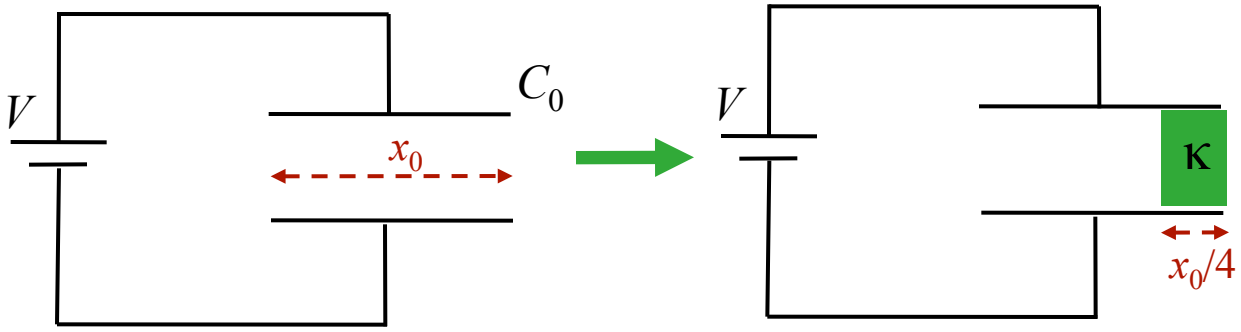
Calculation



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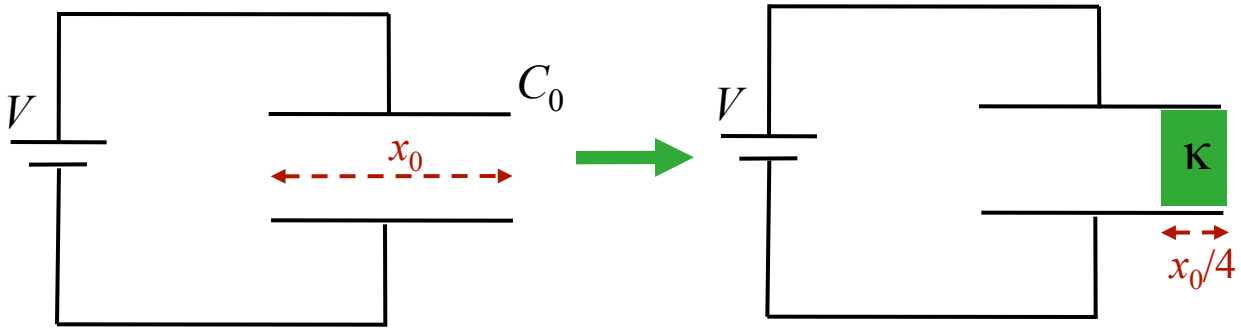
To calculate C, let's first look at:

A) $V_{left} < V_{right}$ B) $V_{left} = V_{right}$ C) $V_{left} > V_{right}$

Calculation



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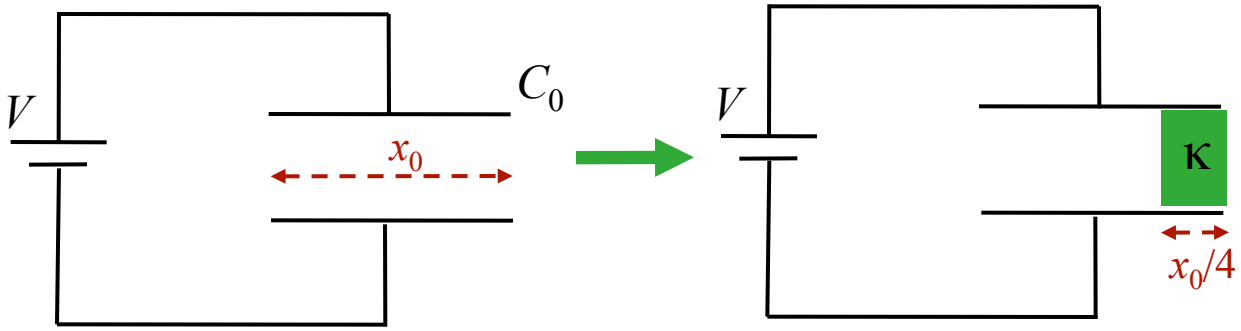

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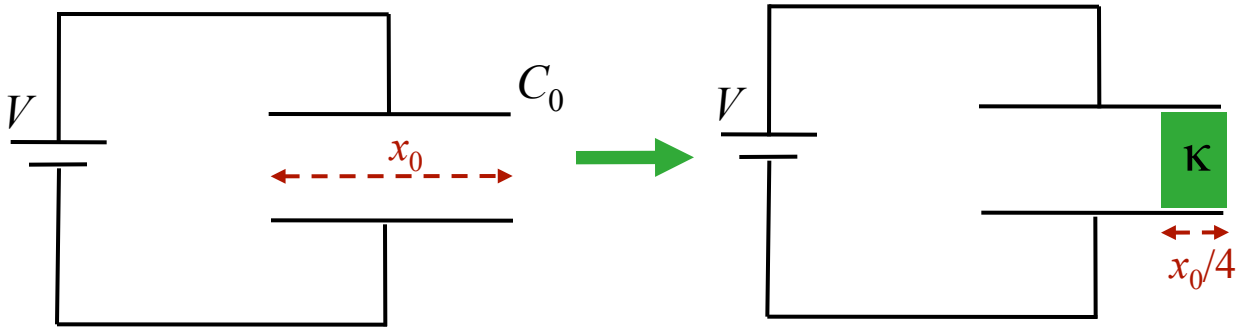
The conducting plate is an equipotential !

Calculation



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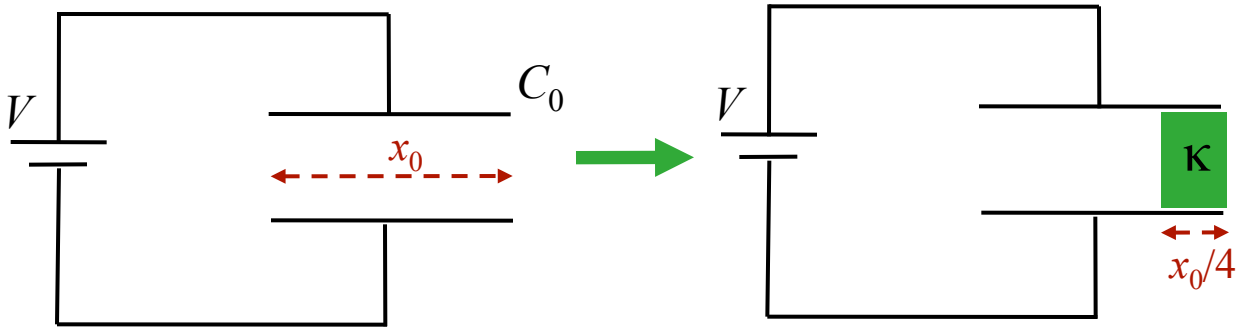

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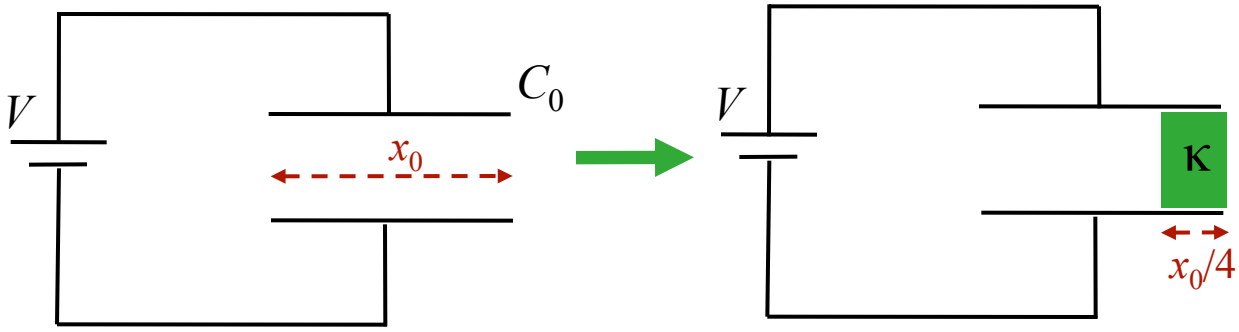
Can consider capacitor to be two capacitances, C_1 and C_2, in parallel

Calculation



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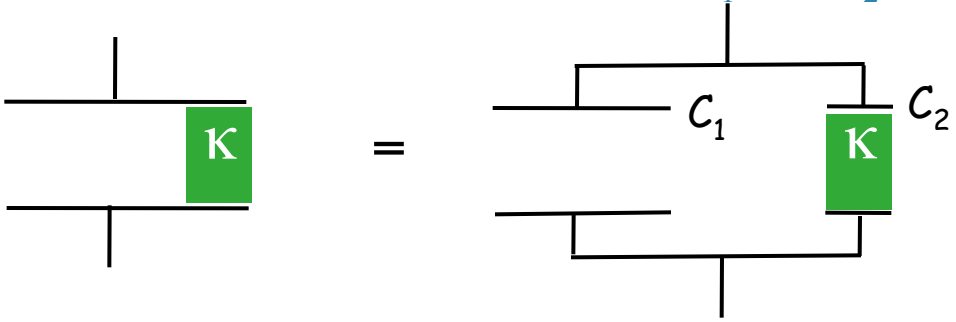
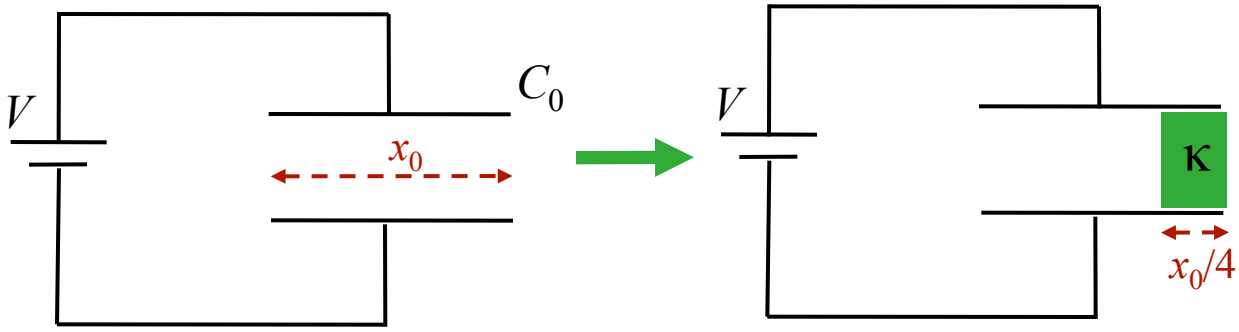


Calculation



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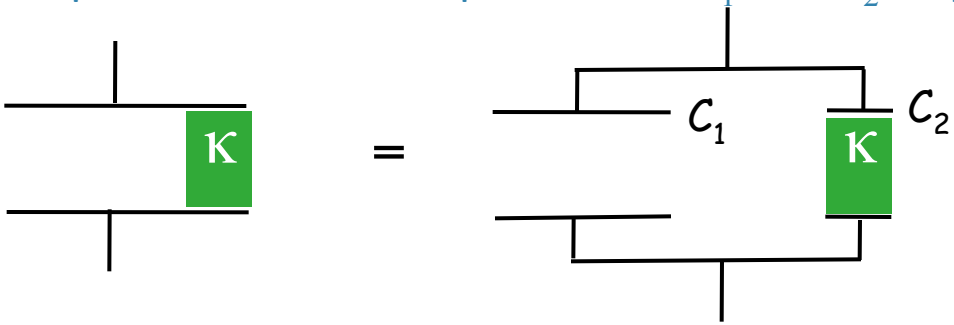
What is Q_f, the final charge on the capacitor?

Can consider capacitor to be two capacitances, C_1 and C_2, in parallel



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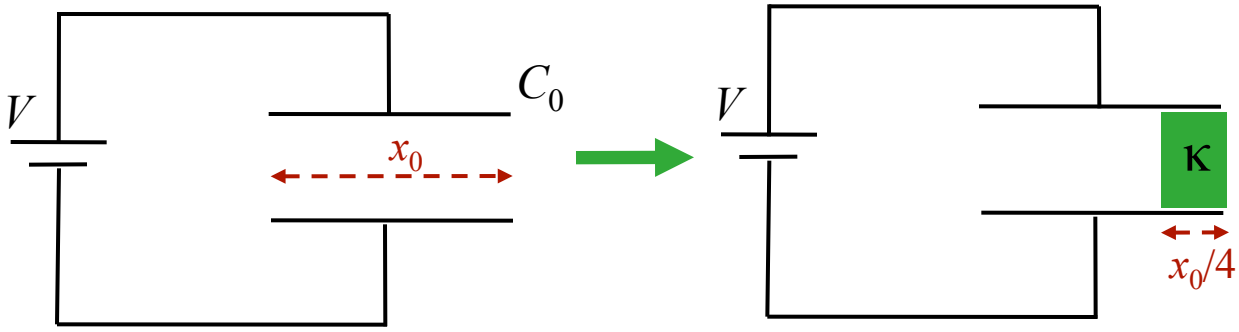

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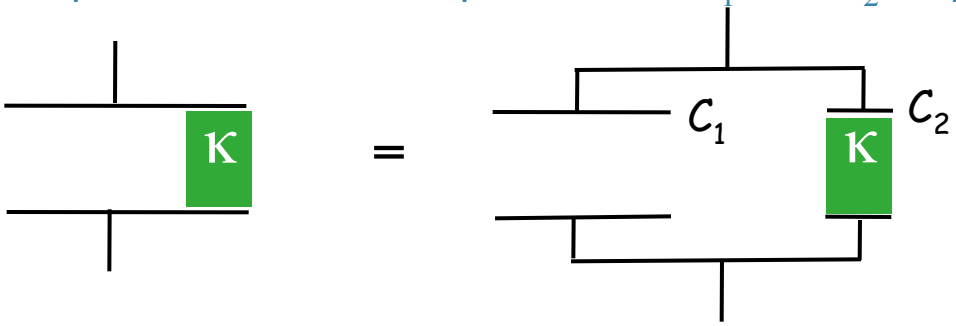

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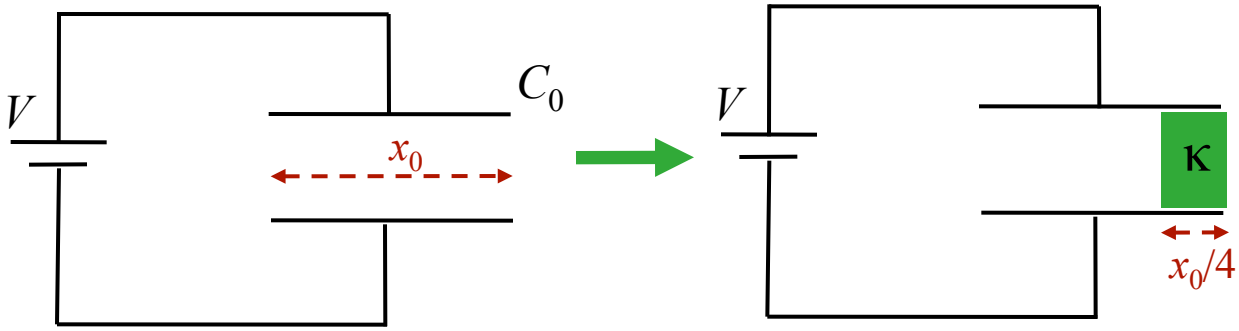

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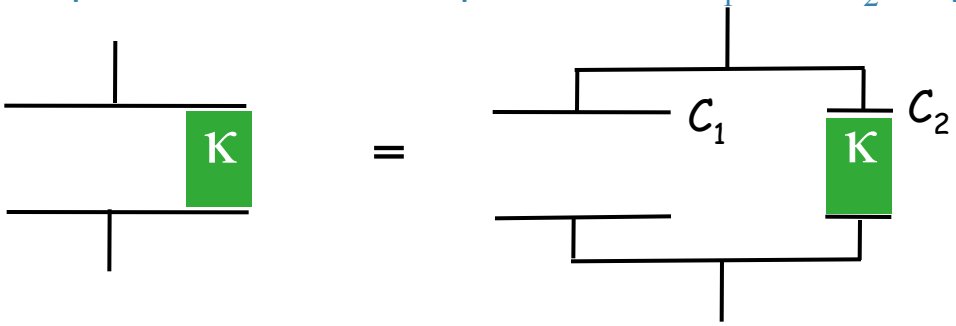

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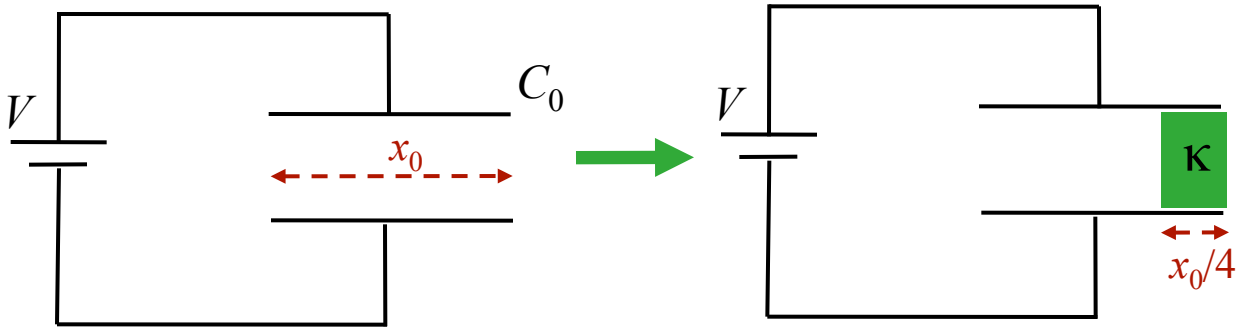

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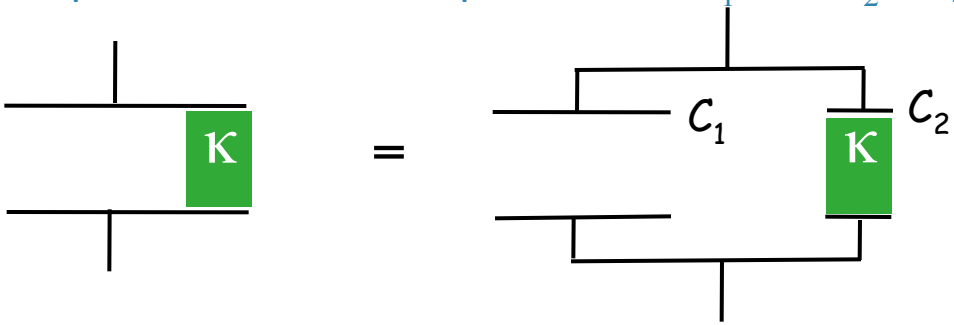

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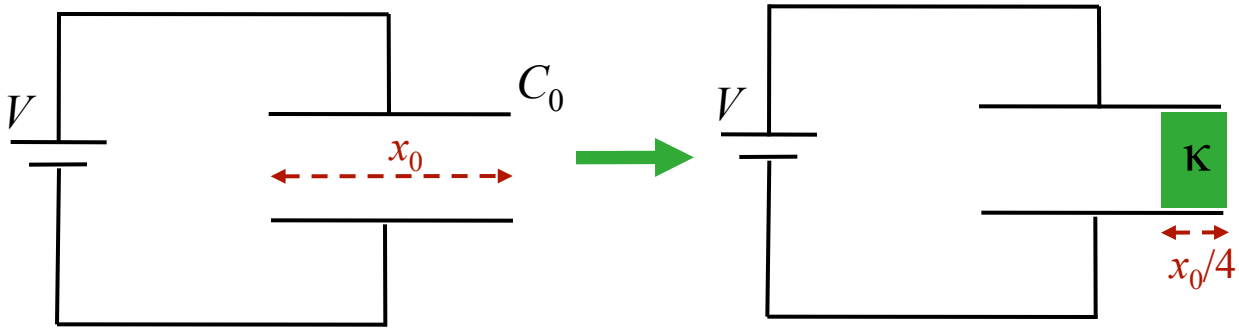

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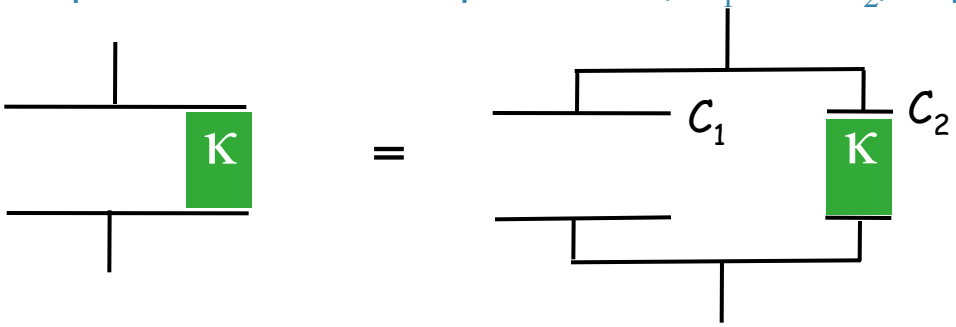

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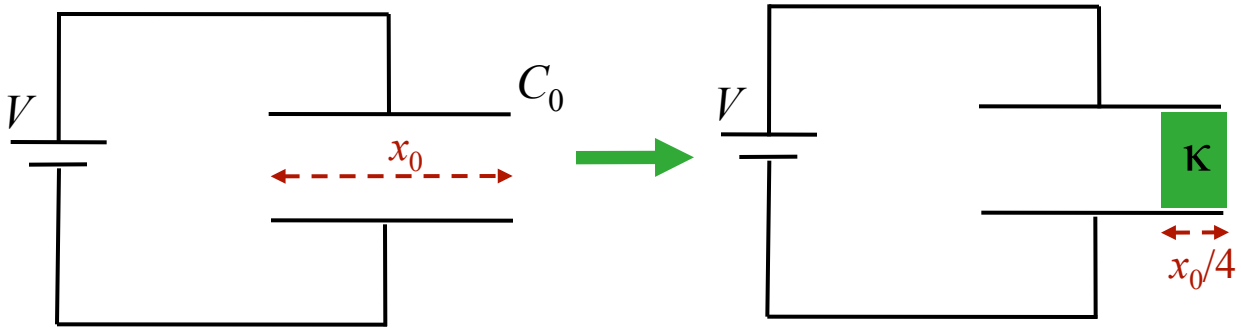
$\Rightarrow C_1 = {}^3/_4 (\varepsilon_0 A_0/d_0)$

Calculation



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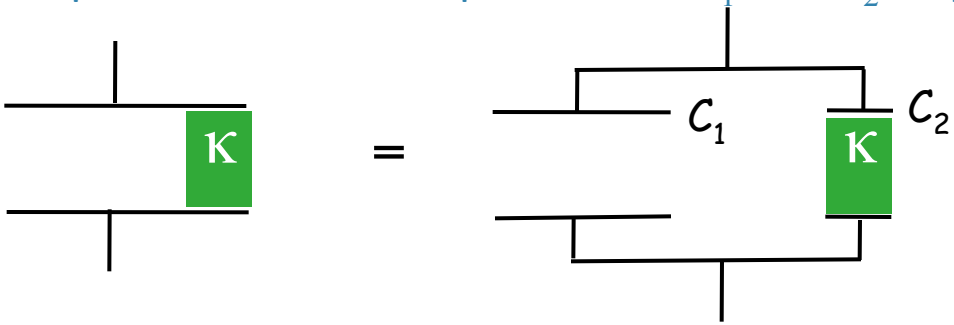

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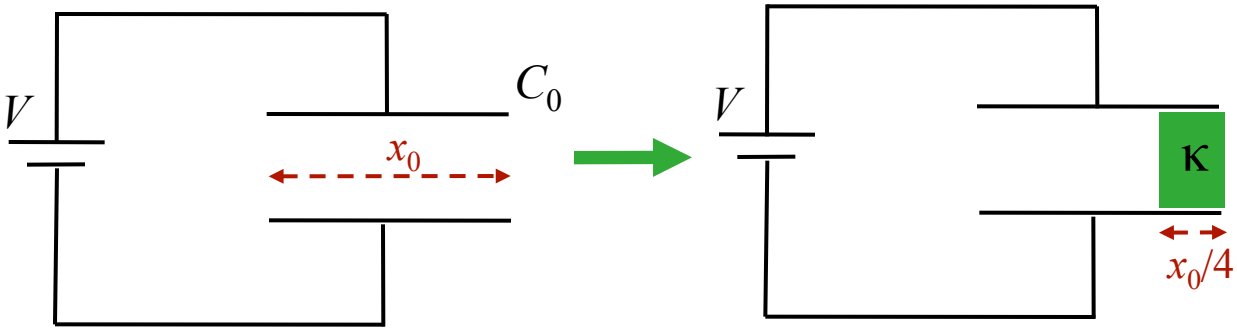
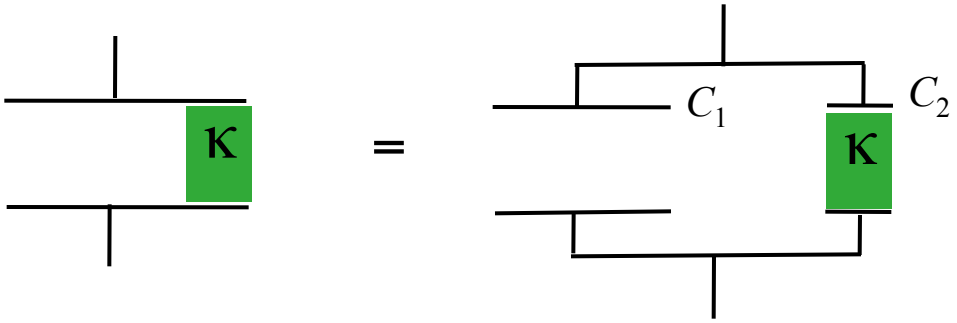
$A = {}^3/_4 A_0$, $d = d_0$ → $C_1 = {}^3/_4 (\varepsilon_0 A_0/d_0)$ → $C_1 = {}^3/_4 C_0$

Calculation





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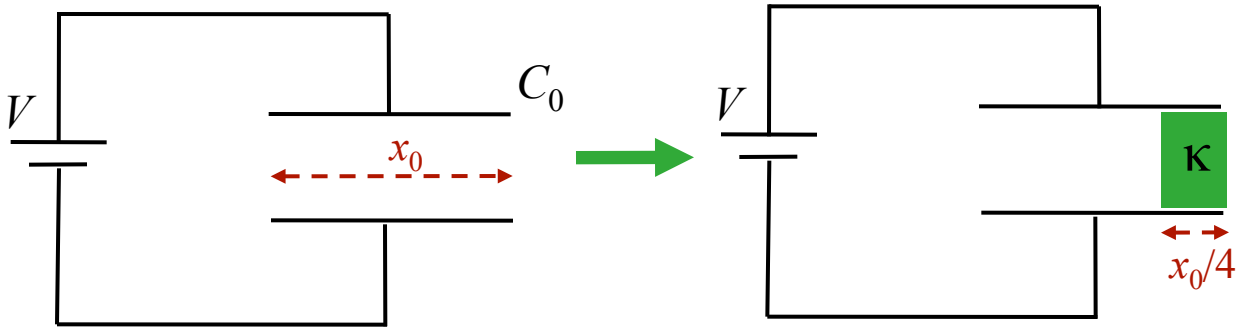
What is Q_f, the final charge on the capacitor?

$C_1 = {}^3/_4 C_0$

Calculation



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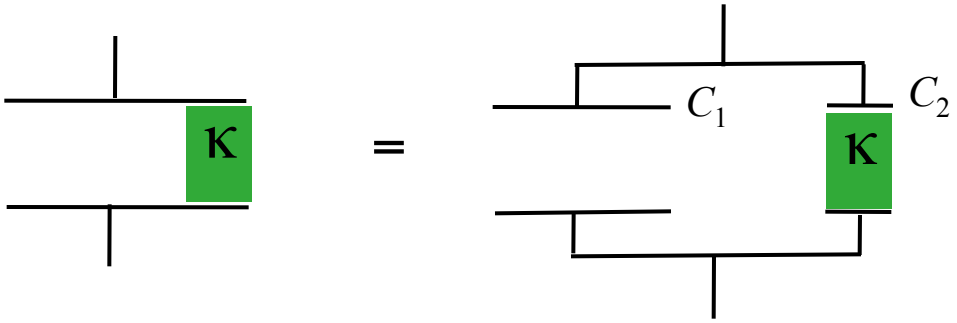


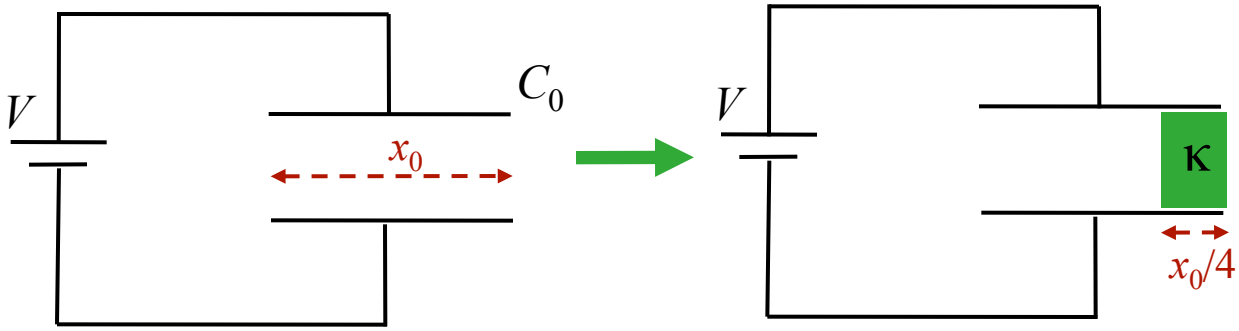
$C_1 = {}^3/_4 C_0$

What is Q_f, the final charge on the capacitor?

What is C_2 ?

A) $C_2 = \kappa C_0$ B) $C_2 = {}^3/_4 \kappa C_0$ C) $C_2 = {}^4/_3 \kappa C_0$ D) $C_2 = {}^1/_4 \kappa C_0$

Calculation



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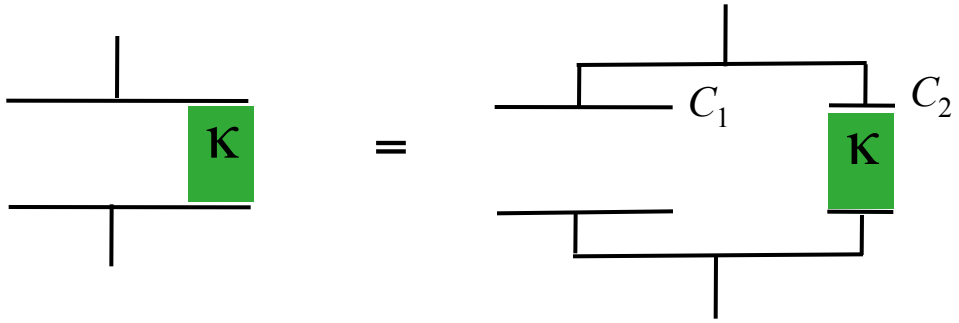

$C_1 = {}^3/_4 C_0$

What is Q_f, the final charge on the capacitor?

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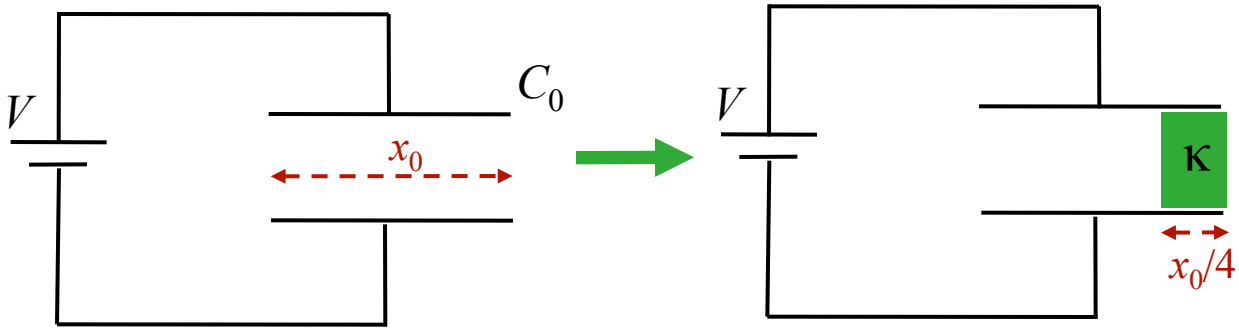

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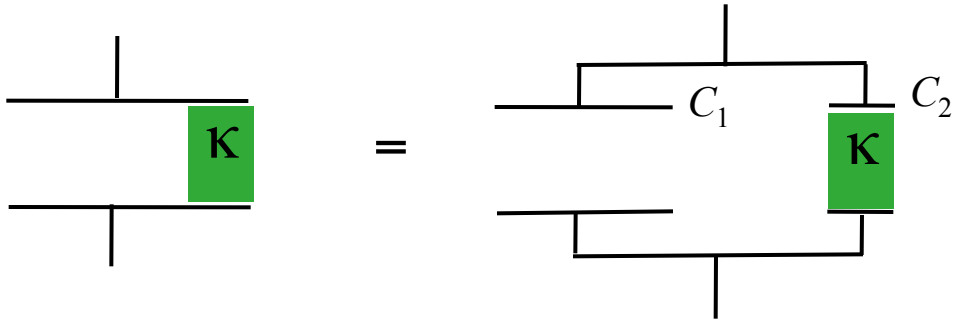


$C_1 = {}^3/_4 C_0$

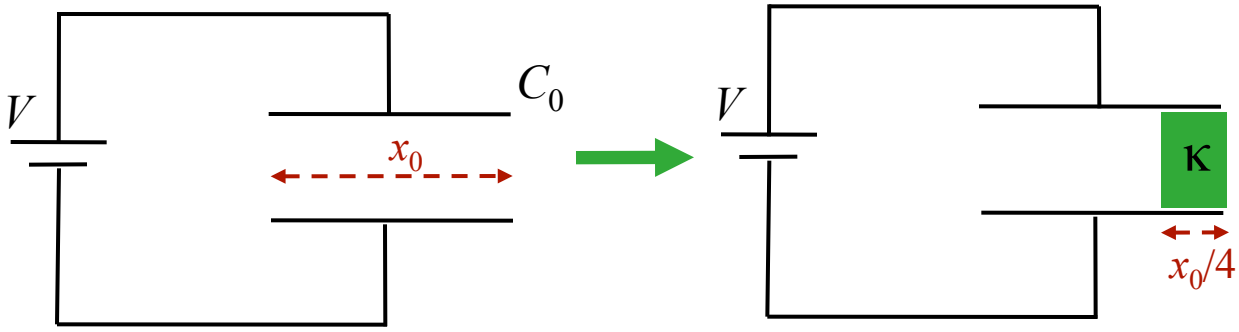
What is Q_f, the final charge on the capacitor?

What is C_2 ?

A) $C_2 = \kappa C_0$ B) $C_2 = {}^3/_4\, \kappa C_0$ C) $C_2 = {}^4/_3\, \kappa C_0$ D) $C_2 = {}^1/_4\, \kappa C_0$

In general. For parallel plate capacitor filled with dielectric: $C = \kappa \varepsilon_0 A/d$

Calculation



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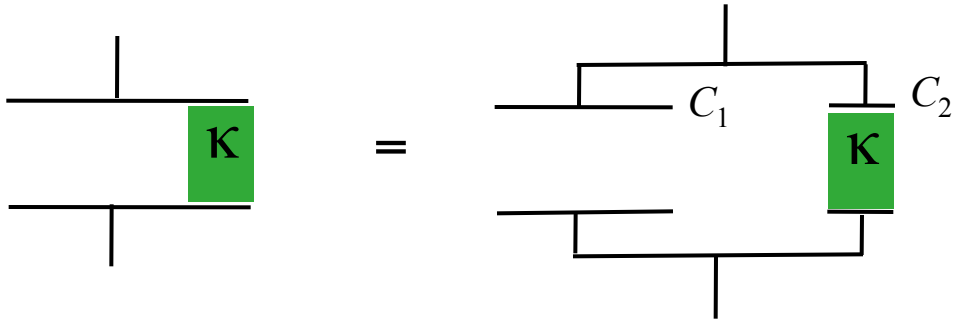

$C_1 = {}^3/_4 C_0$

What is Q_f, the final charge on the capacitor?

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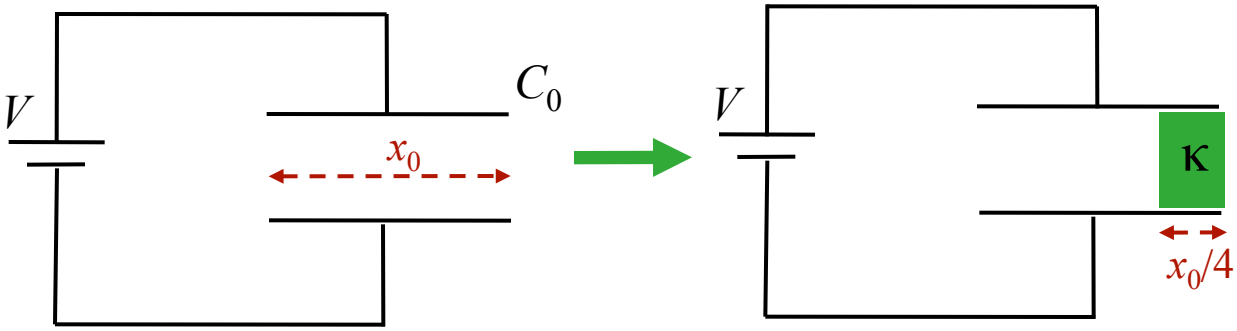
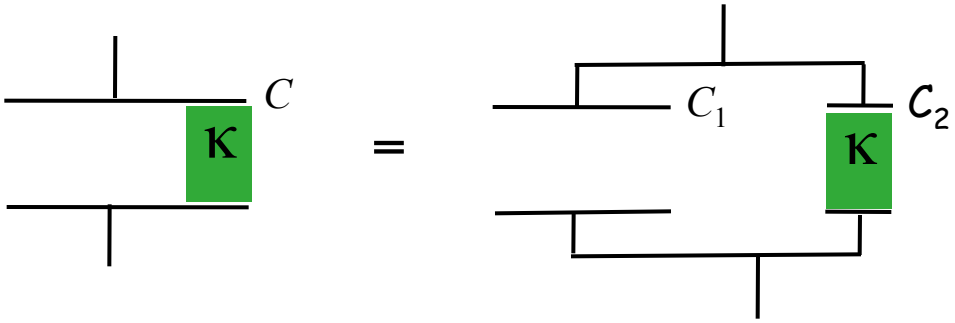
In general. For parallel plate capacitor filled with dielectric: $C = \kappa\varepsilon_0 A/d$

$A = {}^1/_4 A_0$, $d = d_0$ → $C = {}^1/_4(\kappa\varepsilon_0 A_0/d_0)$ → $C_2 = {}^1/_4\, \kappa C_0$

Calculation





$C_1 = {}^3/_4 C_0$

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An air-gap capacitor, having capacitance C_0 and width x_0 is connected to a battery of voltage V.

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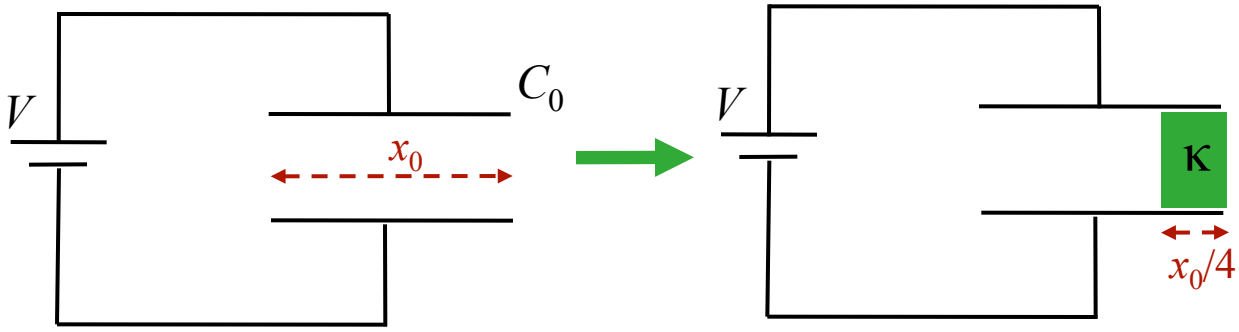

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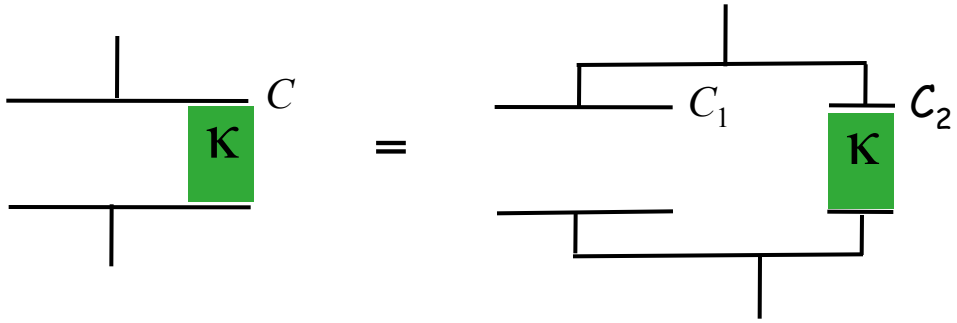
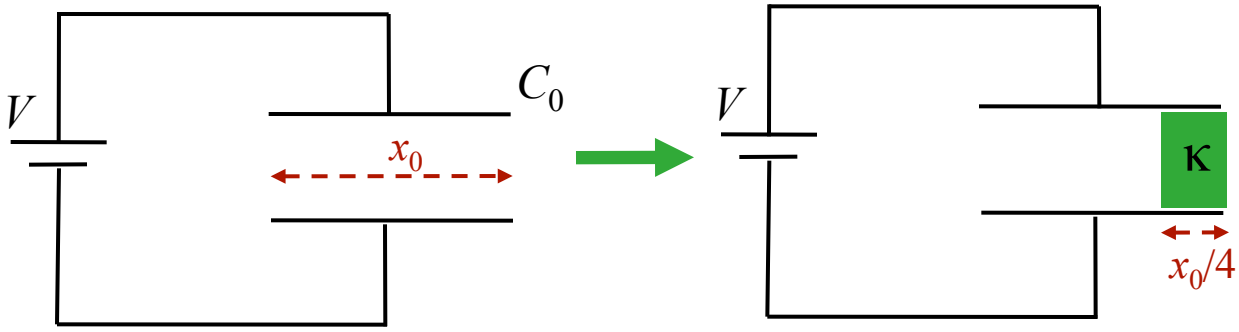


$C_1 = {}^3/_4 C_0$ $C_2 = {}^1/_4 \kappa C_0$

What is C?

A) $C = C_1 + C_2$ B) $C = C_1 + \kappa C_2$ C) $C = \left(\frac{1}{C_1} + \frac{1}{C_2} \right)^{-1}$

Calculation



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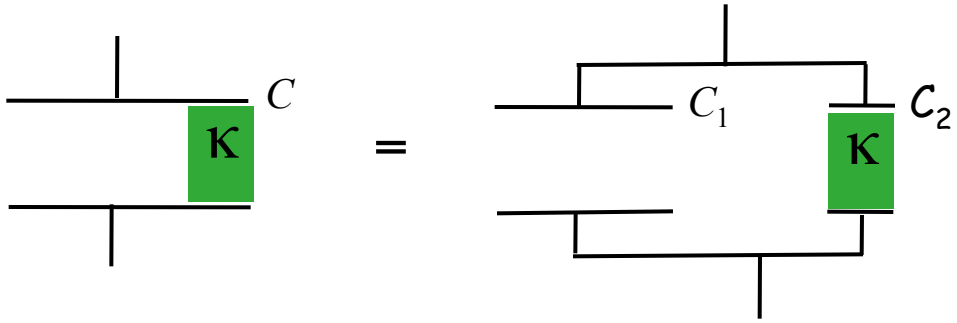

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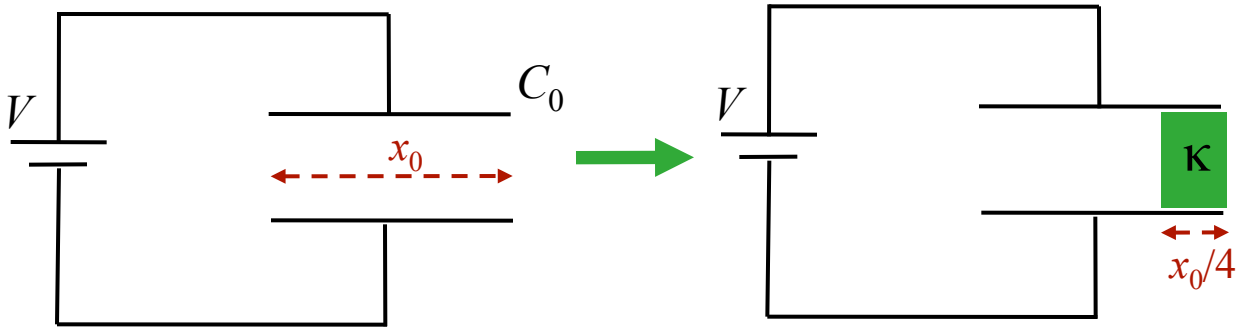

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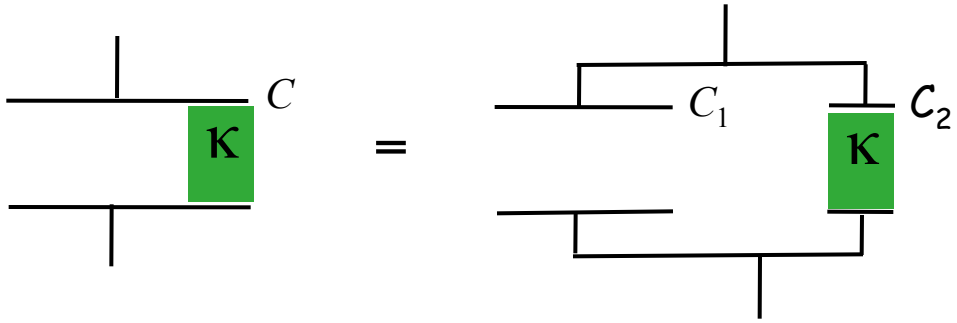

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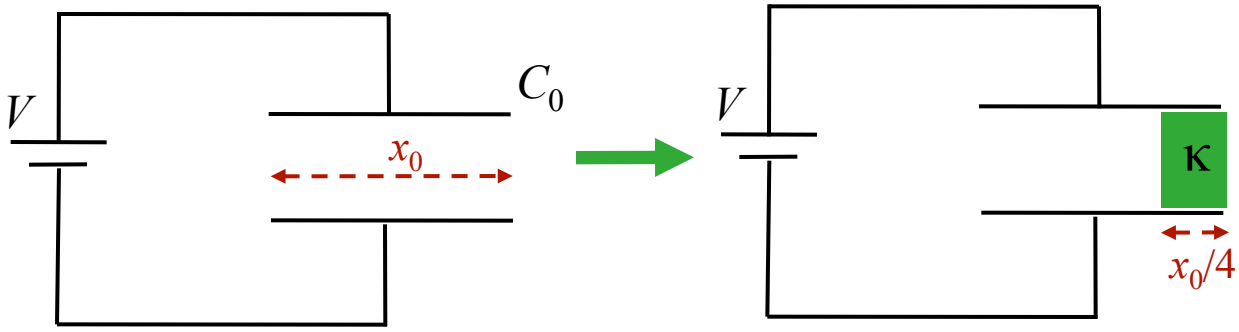

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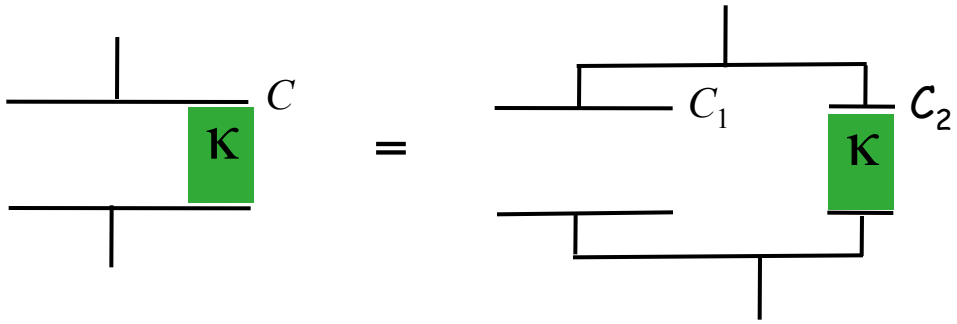

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$$\rightarrow C = C_0 \left({}^3/_4 + {}^1/_4 \kappa \right)$$

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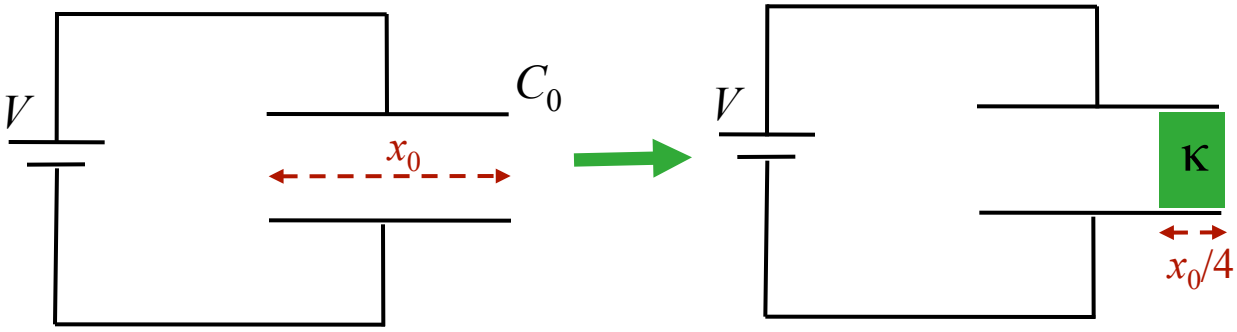

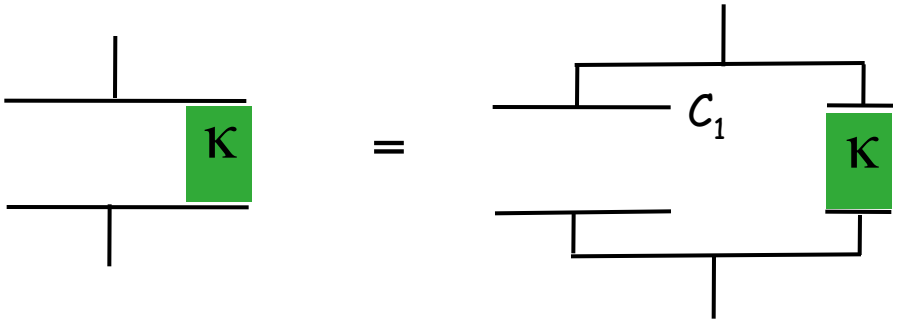

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$$C = C_0\ ({}^3/_4 + {}^1/_4\ \kappa)$$

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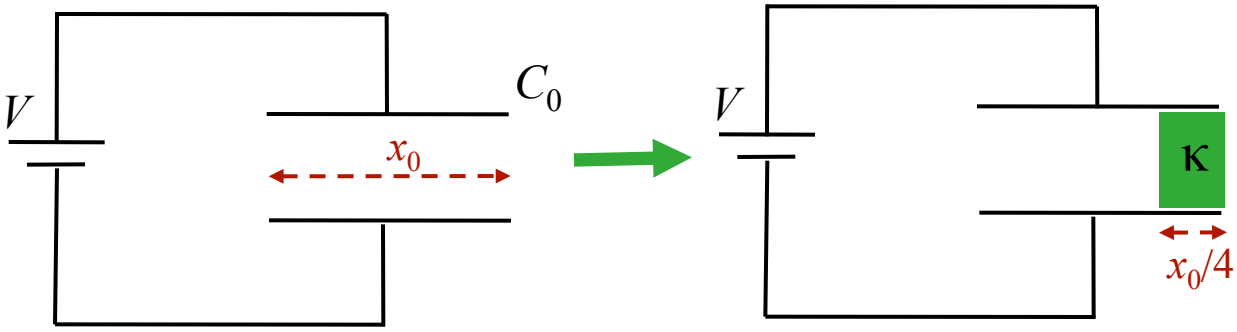

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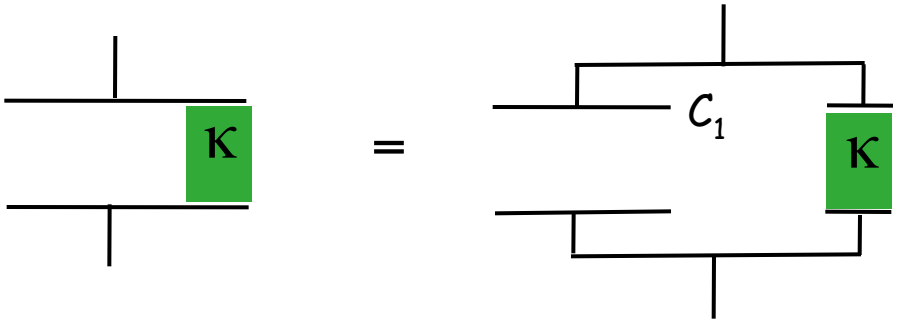


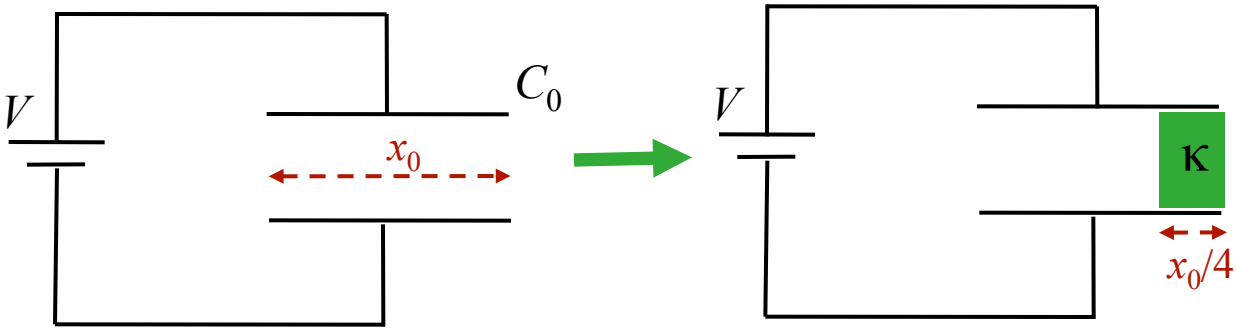
What is Q_f, the final charge on the capacitor?

$C_1 = {}^3/_4 C_0$ $\quad$ $C_2 = {}^1/_4\ \kappa\ C_0$

$\rightarrow\ C = C_0\ ({}^3/_4 + {}^1/_4\ \kappa)$

What is Q?

Calculation



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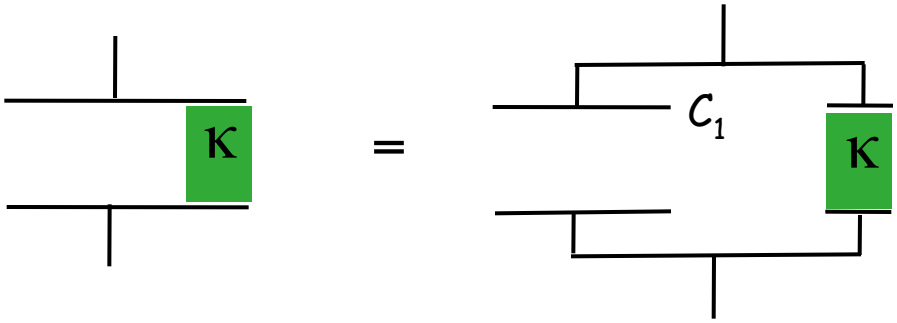


What is Q_f, the final charge on the capacitor?

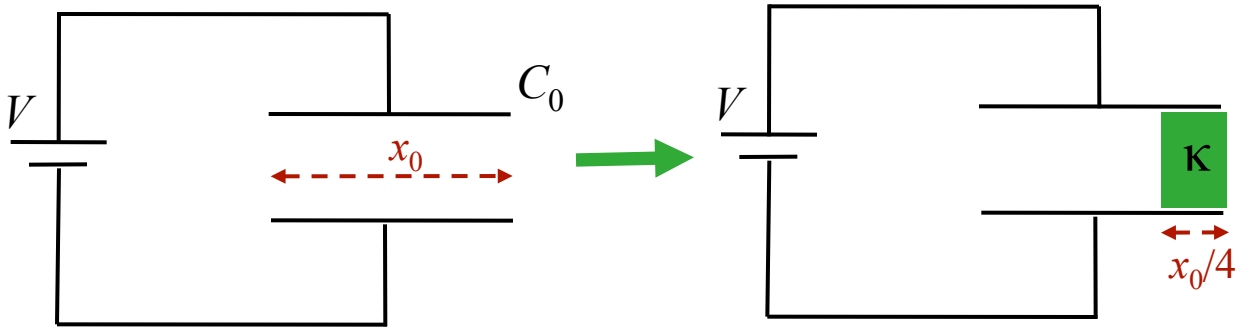
$C_1 = {}^3/_4 C_0$ $\qquad$ $C_2 = {}^1/_4\ \kappa\ C_0$

$\rightarrow\ C = C_0\ ({}^3/_4 + {}^1/_4\ \kappa)$

What is Q?

$$C \equiv \frac{Q}{V}$$

Calculation



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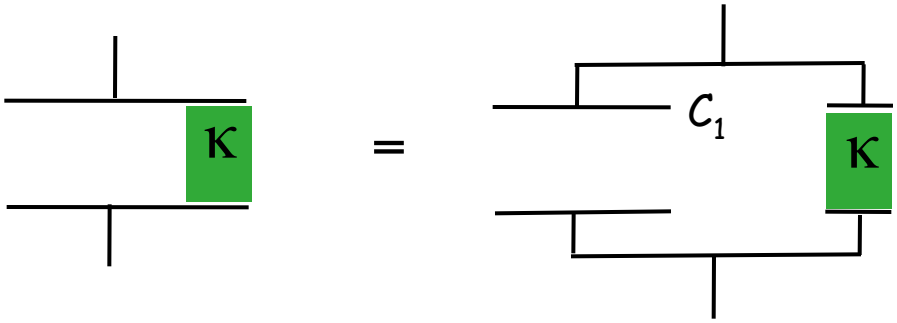

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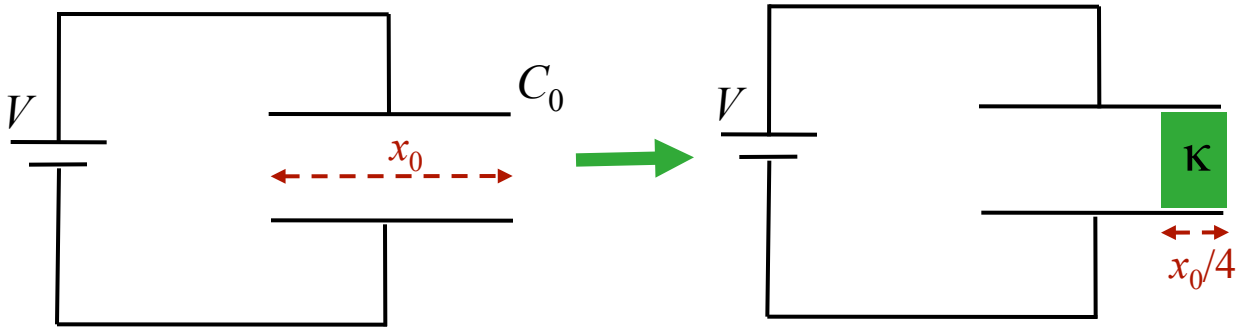

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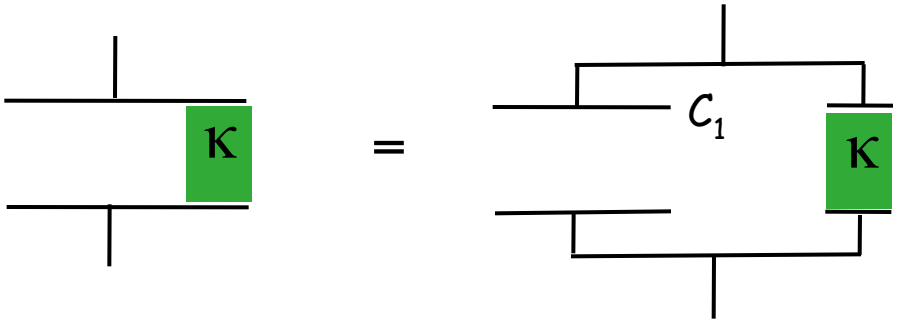

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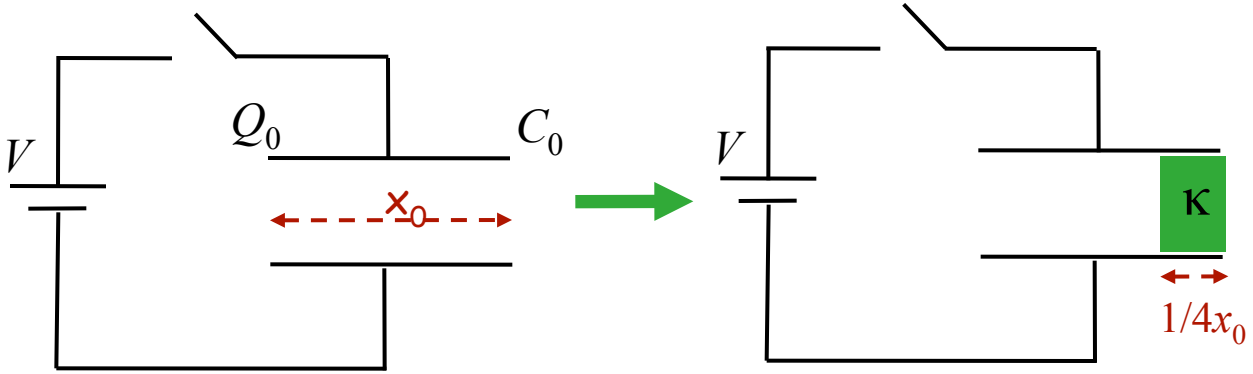
$$Q_f = VC_0\left(\frac{3}{4} + \frac{1}{4}\kappa\right)$$

Different Problem



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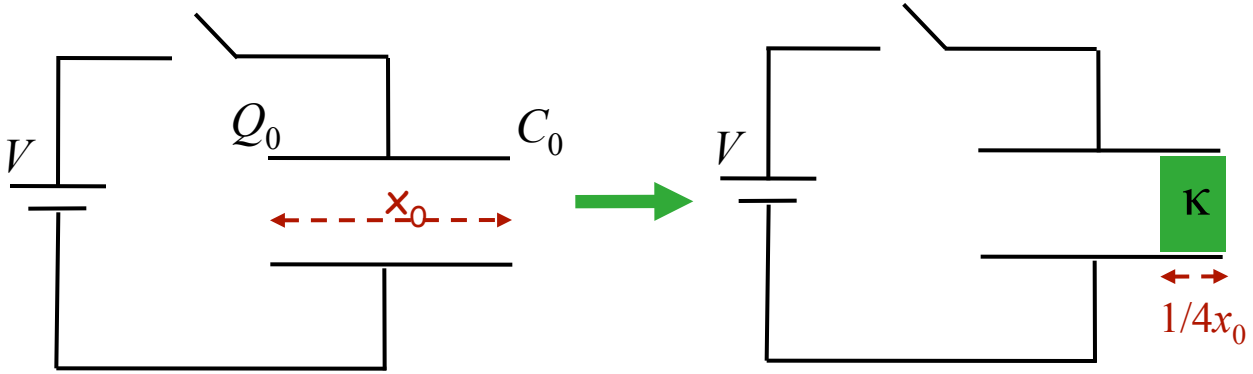
What is V_f, the final voltage on the capacitor?

Different Problem



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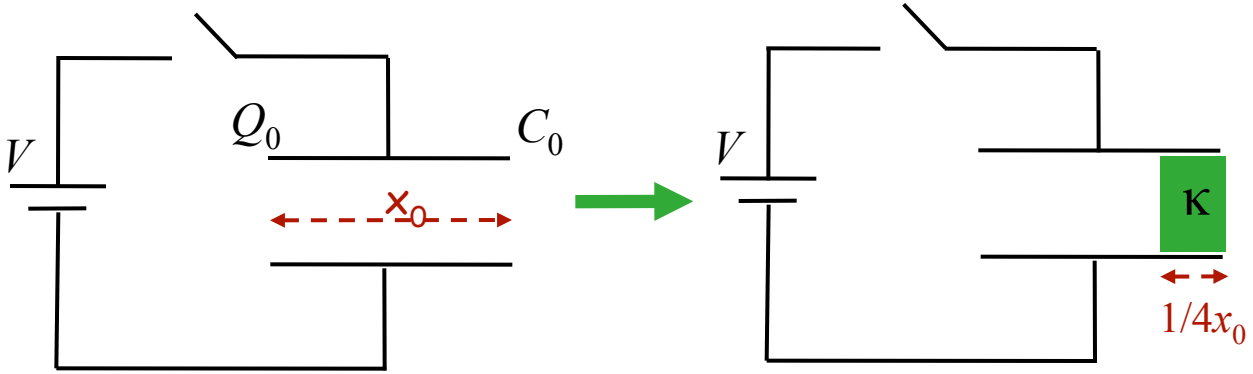
A) $V_f < V$ B) $V_f = V$ C) $V_f > V$

Different Problem



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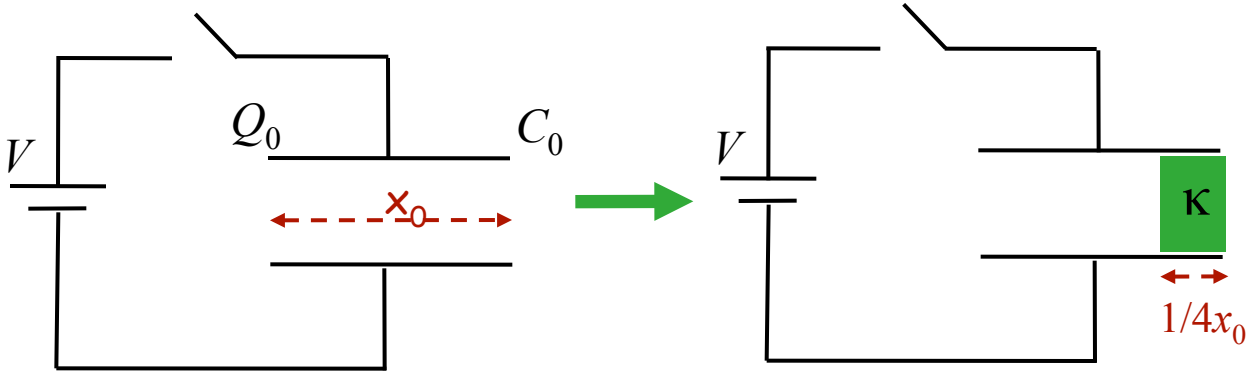

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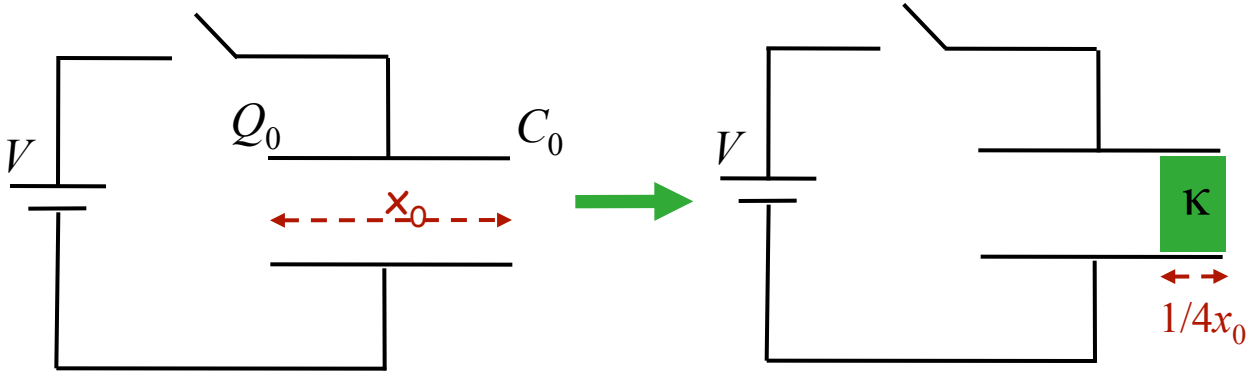
Different Problem



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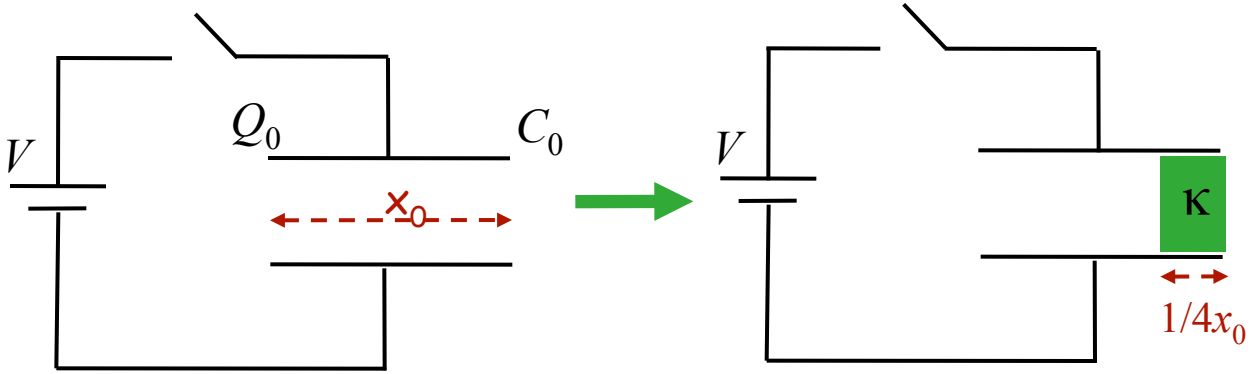

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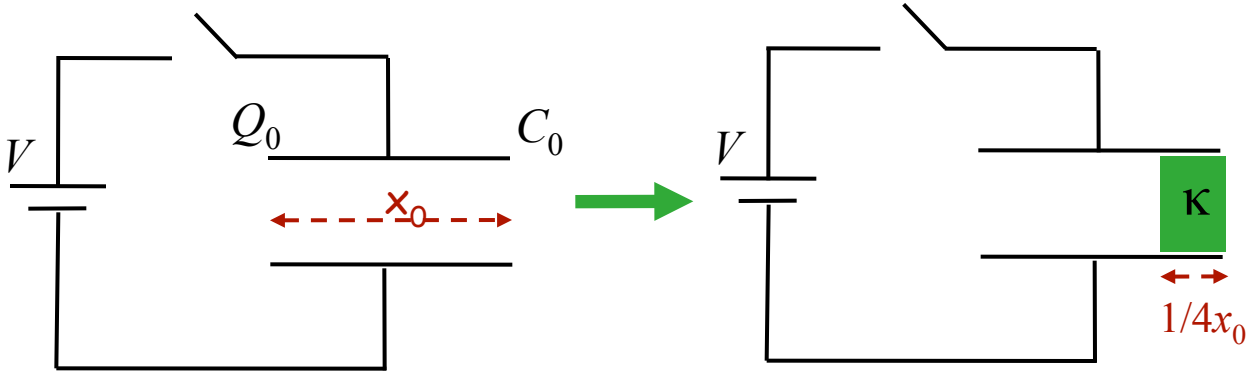

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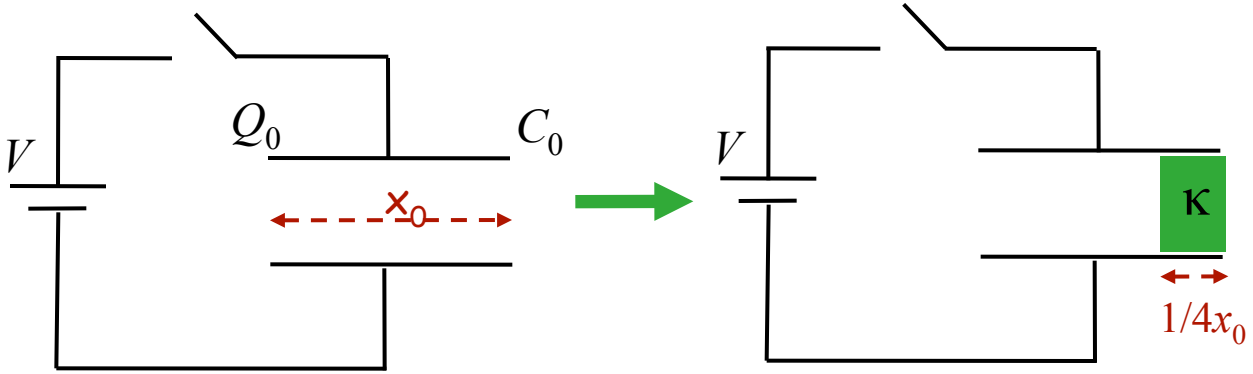

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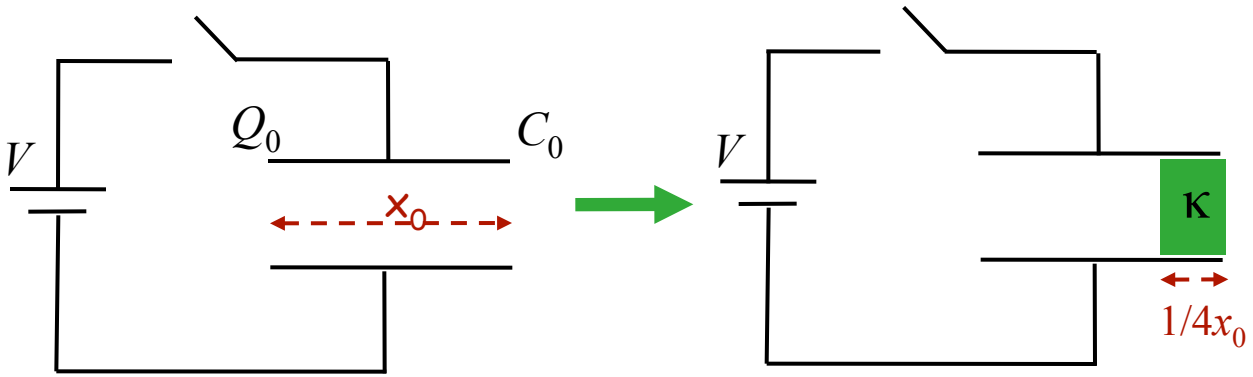
→ $V_f = Q/C = V/\left({}^3/_4 + {}^1/_4\ \kappa\right)$

Different Problem



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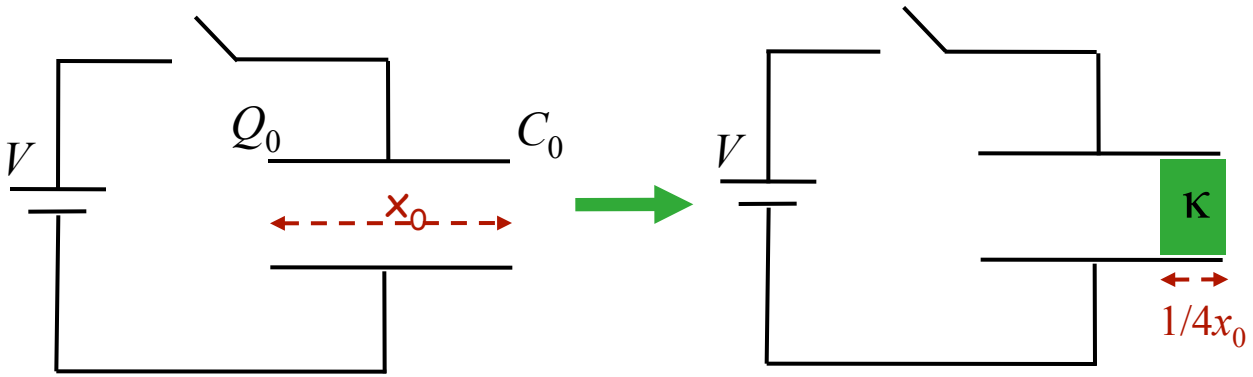

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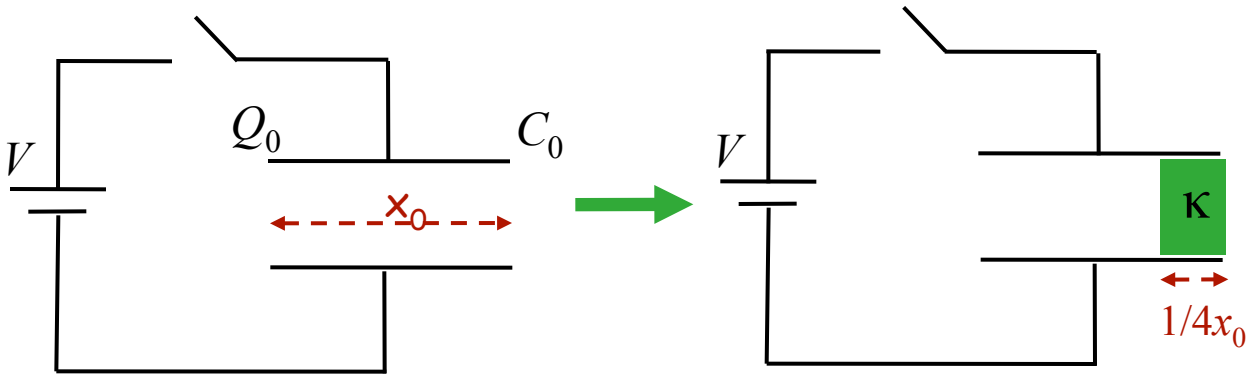
Different Problem



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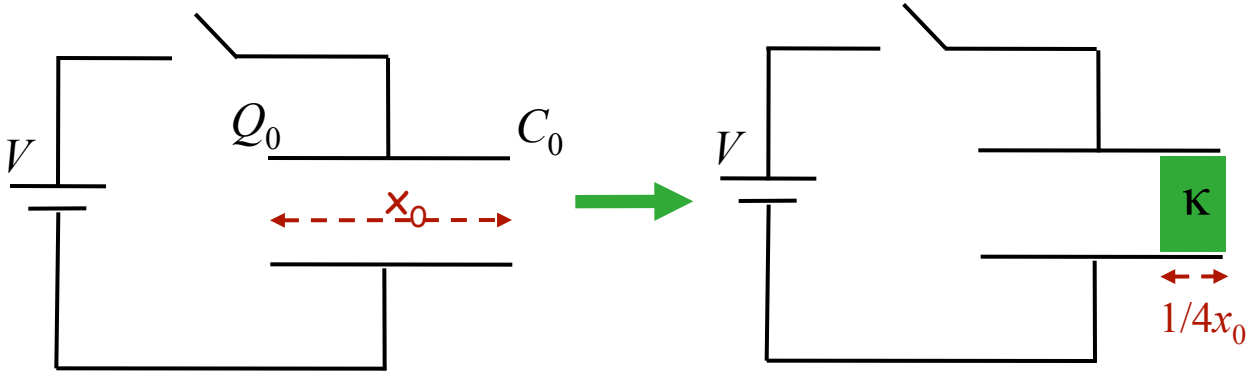

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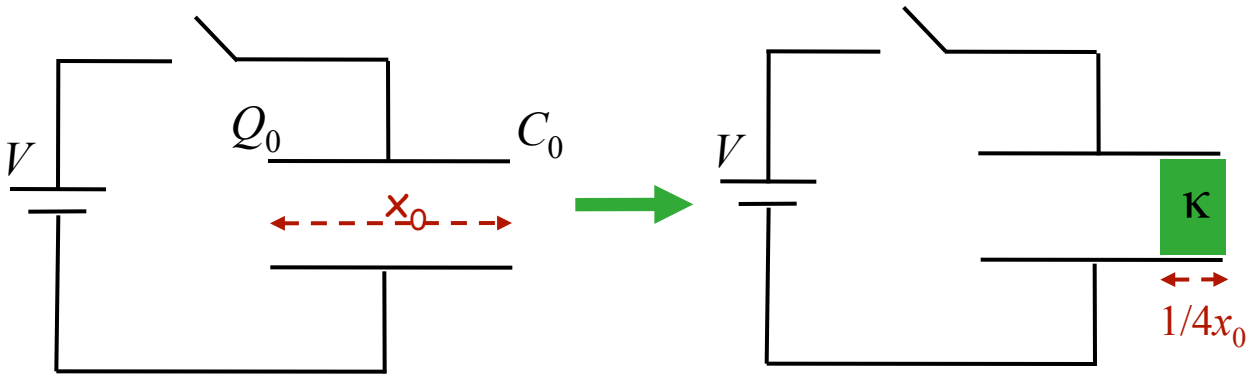

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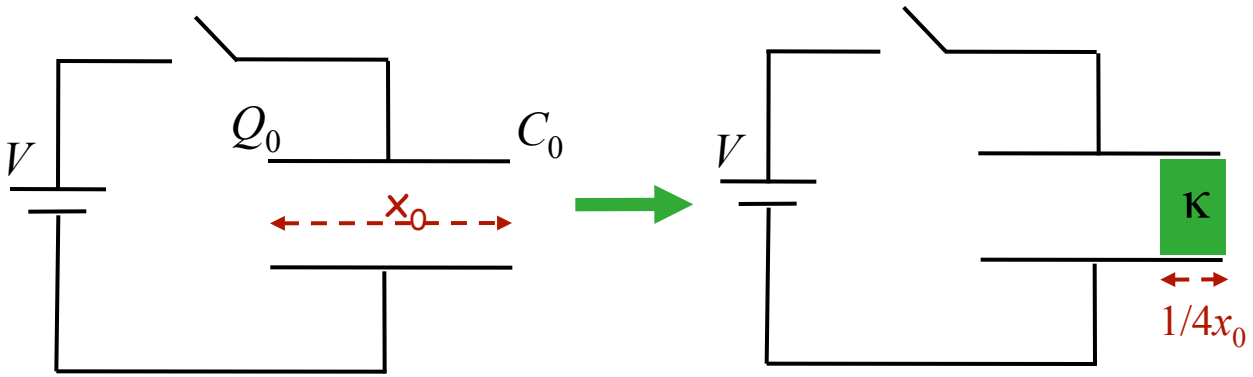

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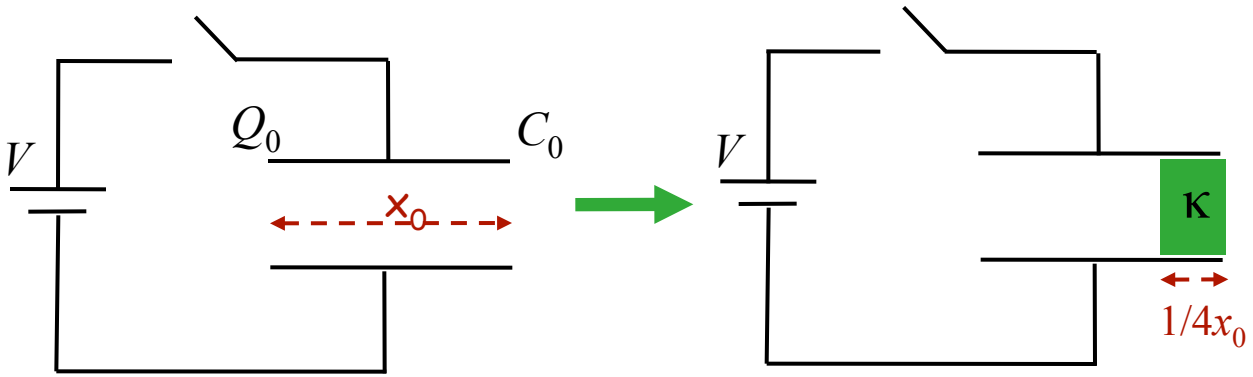
Q remained same

Different Problem



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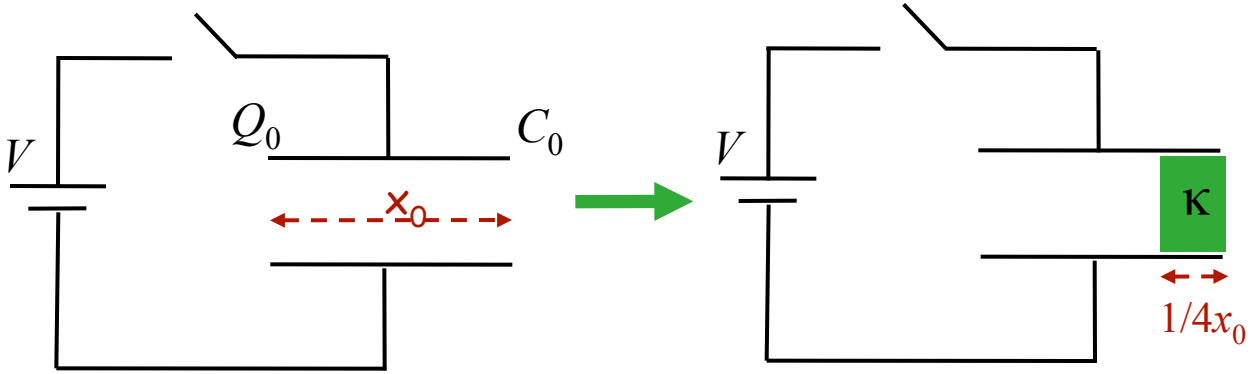

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