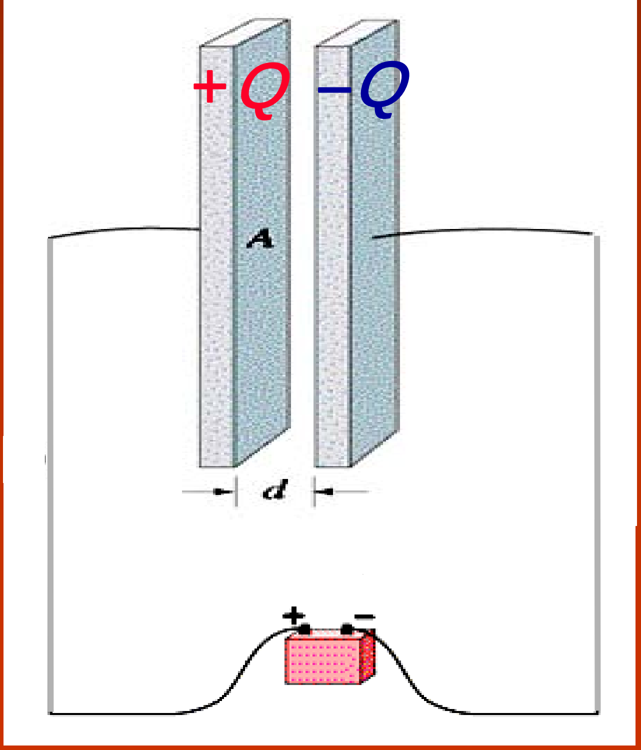
Clicker Session –
Capacitors and Dielectrics

ConcepTest 25.1 Capacitors

Capacitor C_1 is connected across a battery of 5 V. An identical capacitor C_2 is connected across a battery of 10 V. Which one has the most charge?

1) C_1
2) C_2
3) both have the same charge
4) it depends on other factors

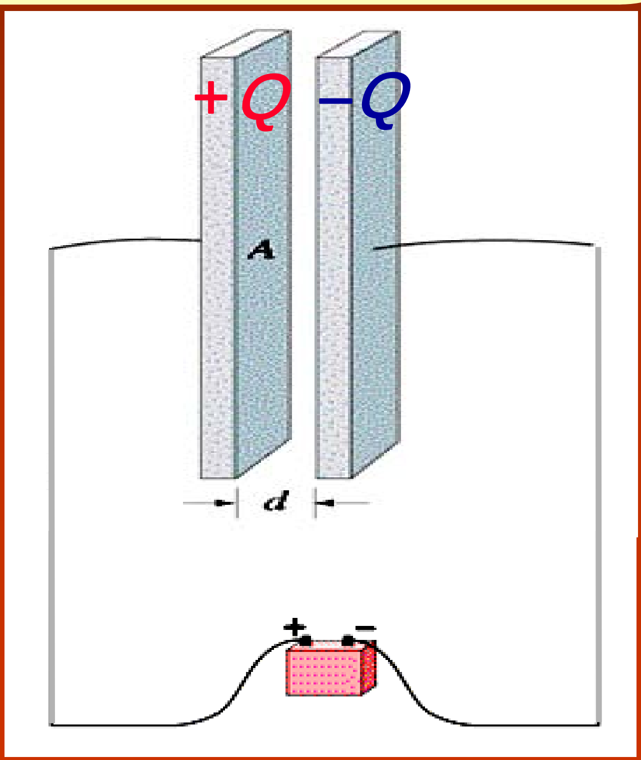


ConcepTest 25.1 Capacitors

Capacitor C_1 is connected across a battery of 5 V. An identical capacitor C_2 is connected across a battery of 10 V. Which one has the most charge?

1) C_1
2) C_2
3) both have the same charge
4) it depends on other factors

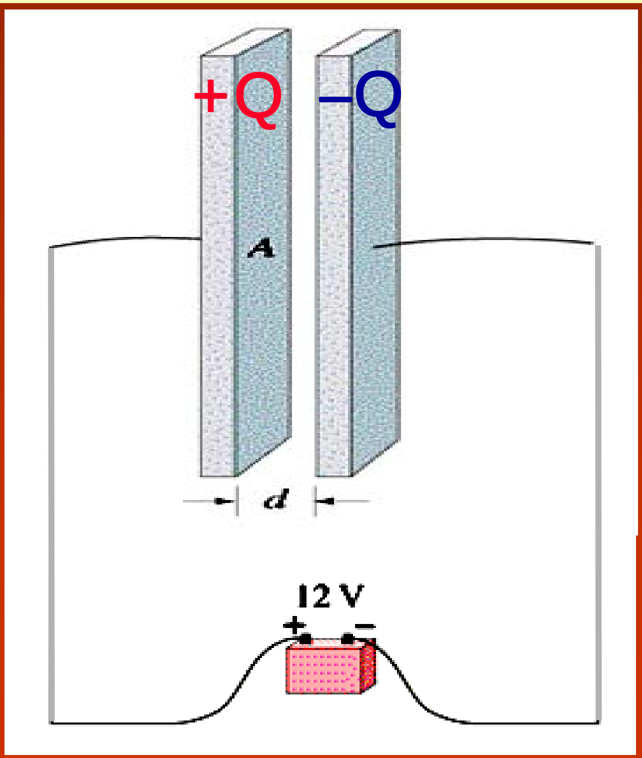
Since $Q = C V$ and the two capacitors are identical, the one that is connected to the **greater voltage** has the **most charge**, which is C_2 in this case.



ConcepTest 25.2a Varying Capacitance I

What must be done to a capacitor in order to increase the amount of charge it can hold (for a constant voltage)?

1) increase the area of the plates
2) decrease separation between the plates
3) decrease the area of the plates
4) either (1) or (2)
5) either (2) or (3)

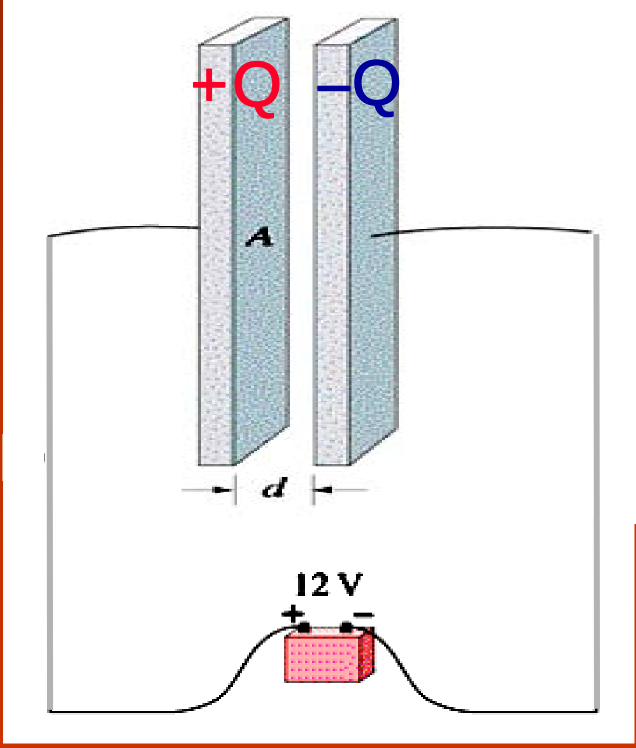


ConcepTest 25.2a Varying Capacitance I

What must be done to a capacitor in order to increase the amount of charge it can hold (for a constant voltage)?

1) increase the area of the plates
2) decrease separation between the plates
3) decrease the area of the plates
4) either (1) or (2)
5) either (2) or (3)

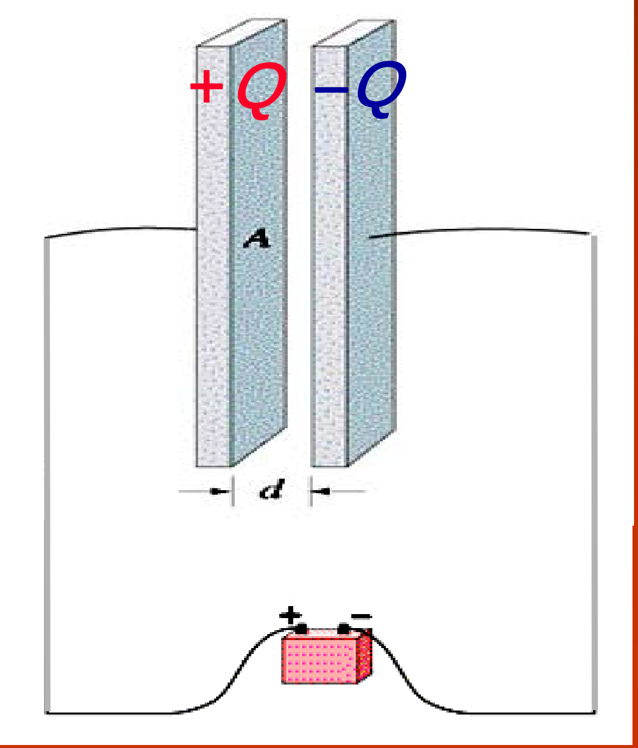
Since $Q = C V$, in order to increase the charge that a capacitor can hold at constant voltage, one has to **increase its capacitance**. Since the capacitance is given by $C = \varepsilon_0 \frac{A}{d}$, that can be done by either **increasing A** or **decreasing d**.



ConcepTest 25.2b Varying Capacitance II

A parallel-plate capacitor initially has a voltage of **400 V** and ***stays connected to the battery***. If the plate spacing is now **doubled,** what happens?

1) the voltage decreases
2) the voltage increases
3) the charge decreases
4) the charge increases
5) both voltage and charge change

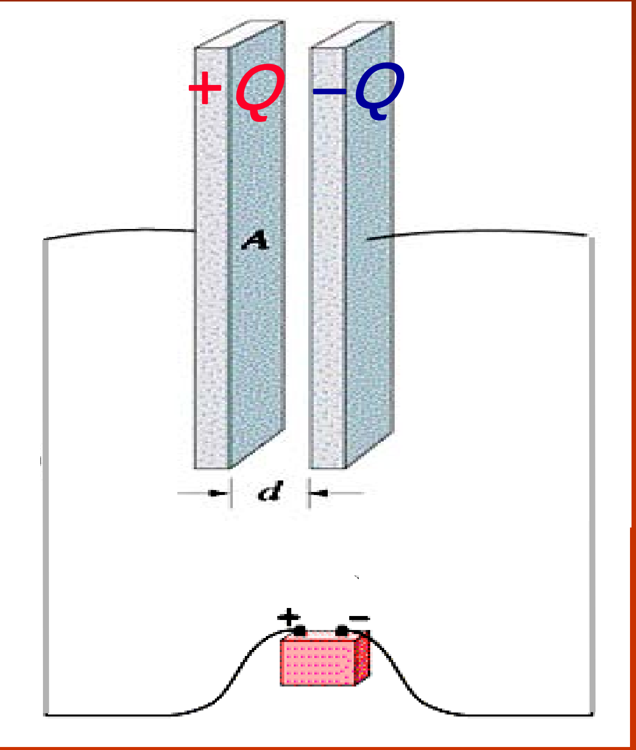


ConcepTest 25.2b Varying Capacitance II

A parallel-plate capacitor initially has a voltage of 400 V and *stays connected to the battery*. If the plate spacing is now doubled, what happens?

1) the voltage decreases
2) the voltage increases
3) the charge decreases
4) the charge increases
5) both voltage and charge change

Since the battery stays connected, the voltage must remain constant ! Since $C = \varepsilon_0 \frac{A}{d}$ when the spacing d is doubled, the capacitance C is halved. And since $Q = C V$, that means the **charge must decrease**.

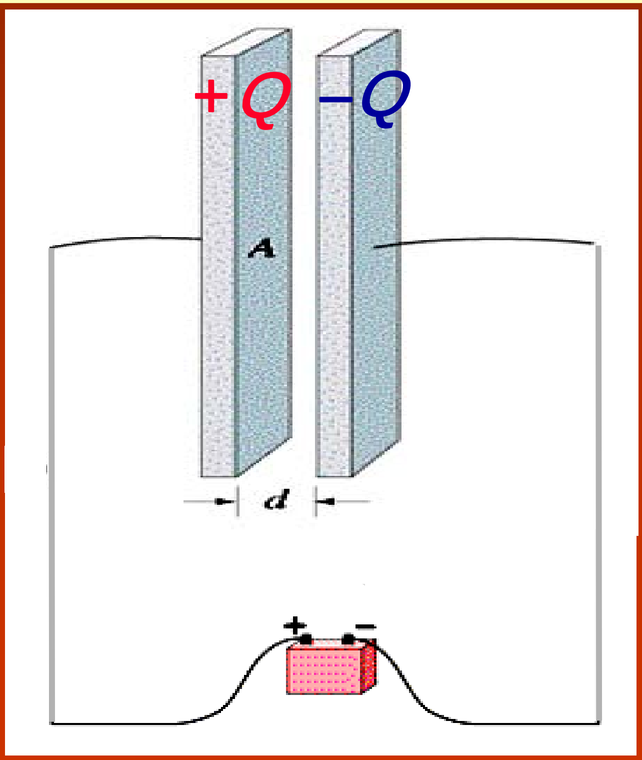


Follow-up: How do you increase the charge?

ConcepTest 25.2c Varying Capacitance III

A parallel-plate capacitor initially has a potential difference of **400 V** and is then disconnected from the charging battery. If the plate spacing is now **doubled** (without changing *Q*), what is the new value of the voltage?

1) 100 V
2) 200 V
3) 400 V
4) 800 V
5) 1600 V

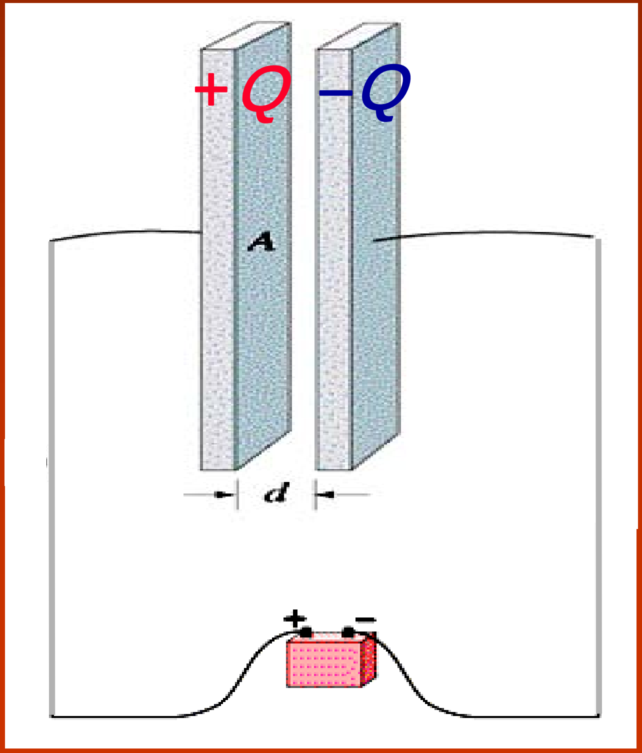


ConcepTest 25.2c Varying Capacitance III

A parallel-plate capacitor initially has a potential difference of **400 V** and is then disconnected from the charging battery. If the plate spacing is now **doubled** (without changing Q), what is the new value of the voltage?

1) 100 V
2) 200 V
3) 400 V
4) 800 V
5) 1600 V

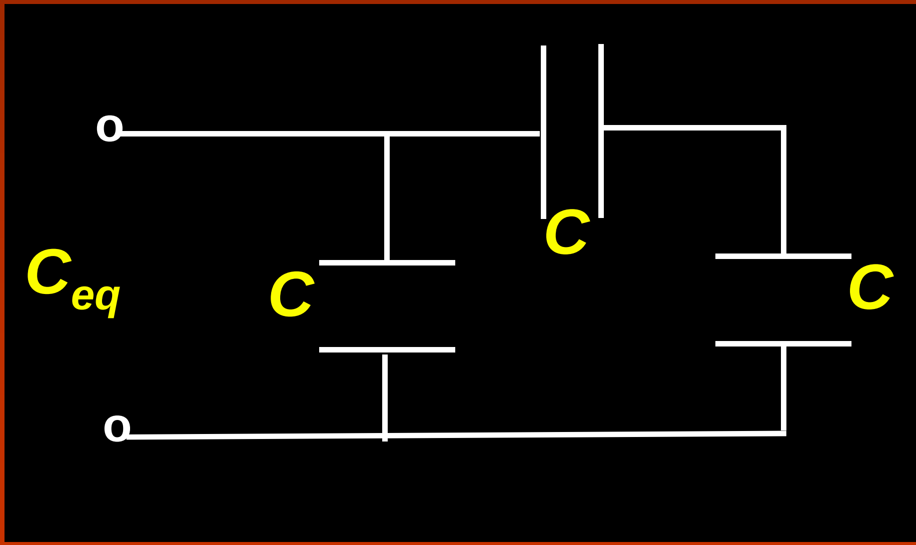
Once the battery is disconnected, Q has to remain constant, since no charge can flow either to or from the battery. Since $C = \varepsilon_0 \frac{A}{d}$ when the spacing d is doubled, the capacitance C is halved. And since $Q = C V$, that means the **voltage must double**.



ConcepTest 25.3a Capacitors I

What is the equivalent capacitance, C_{eq} , of the combination below?

1) C_{eq} = 3/2 C
2) C_{eq} = 2/3 C
3) C_{eq} = 3 C
4) C_{eq} = 1/3 C
5) C_{eq} = 1/2 C

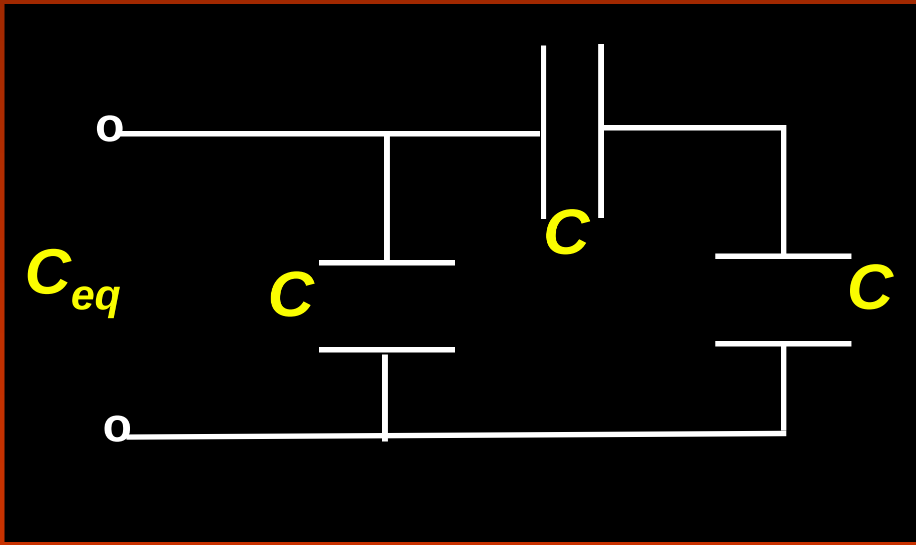


ConcepTest 25.3a Capacitors I

What is the equivalent capacitance, C_{eq} , of the combination below?

1) C_{eq} = 3/2 C
2) C_{eq} = 2/3 C
3) C_{eq} = 3 C
4) C_{eq} = 1/3 C
5) C_{eq} = 1/2 C

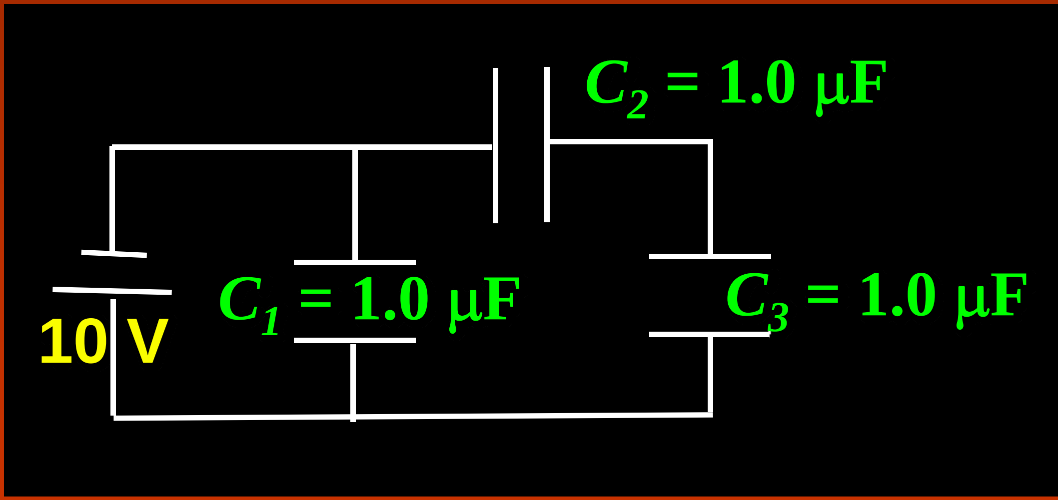
The 2 equal capacitors in series add up as inverses, giving 1/2 C. These are parallel to the first one, which add up directly. Thus, the total equivalent capacitance is 3/2 C.



ConcepTest 25.3b Capacitors II

How does the voltage V_1 across the first capacitor (C_1) compare to the voltage V_2 across the second capacitor (C_2)?

1) $V_1 = V_2$
2) $V_1 > V_2$
3) $V_1 < V_2$
4) all voltages are zero

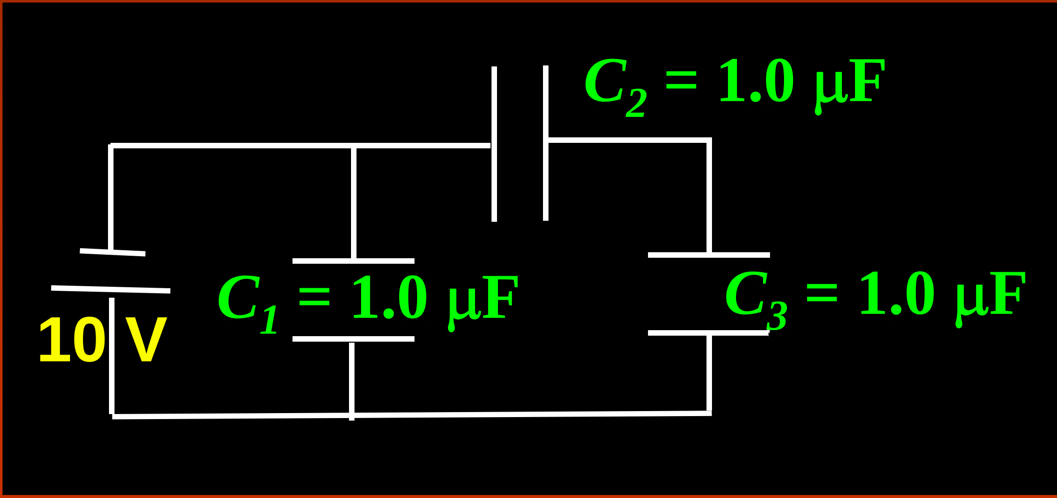


ConcepTest 25.3b Capacitors II

How does the voltage V_1 across the first capacitor (C_1) compare to the voltage V_2 across the second capacitor (C_2)?

1) $V_1 = V_2$
2) $V_1 > V_2$
3) $V_1 < V_2$
4) all voltages are zero

The voltage across C_1 is 10 V. The combined capacitors C_2+C_3 are parallel to C_1. The voltage across C_2+C_3 is also 10 V. Since C_2 and C_3 are in series, their voltages add. Thus the voltage across C_2 and C_3 each has to be 5 V, which is less than V_1.

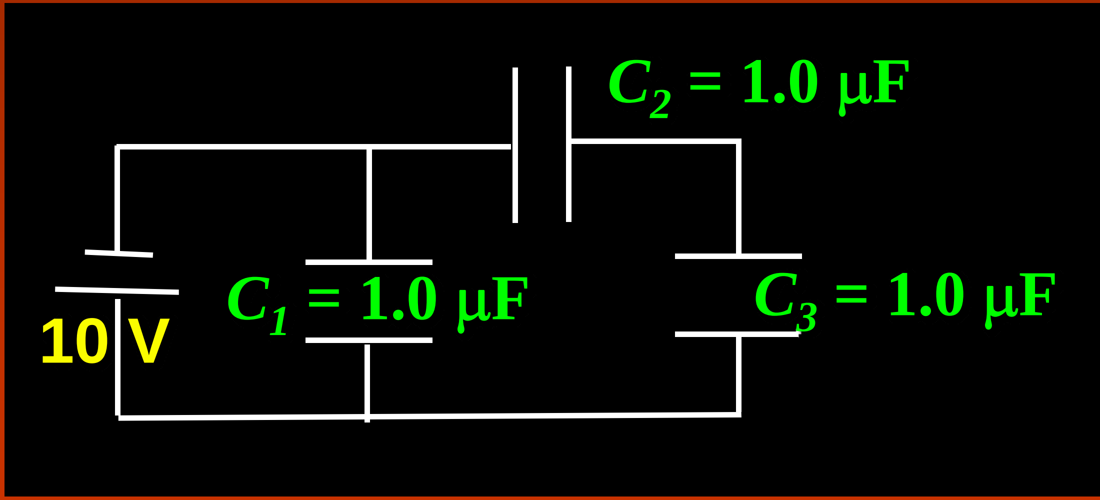


Follow-up: What is the current in this circuit?

ConcepTest 25.3c Capacitors III

How does the charge Q_1 on the first capacitor (C_1) compare to the charge Q_2 on the second capacitor (C_2)?

1) $Q_1 = Q_2$
2) $Q_1 > Q_2$
3) $Q_1 < Q_2$
4) all charges are zero

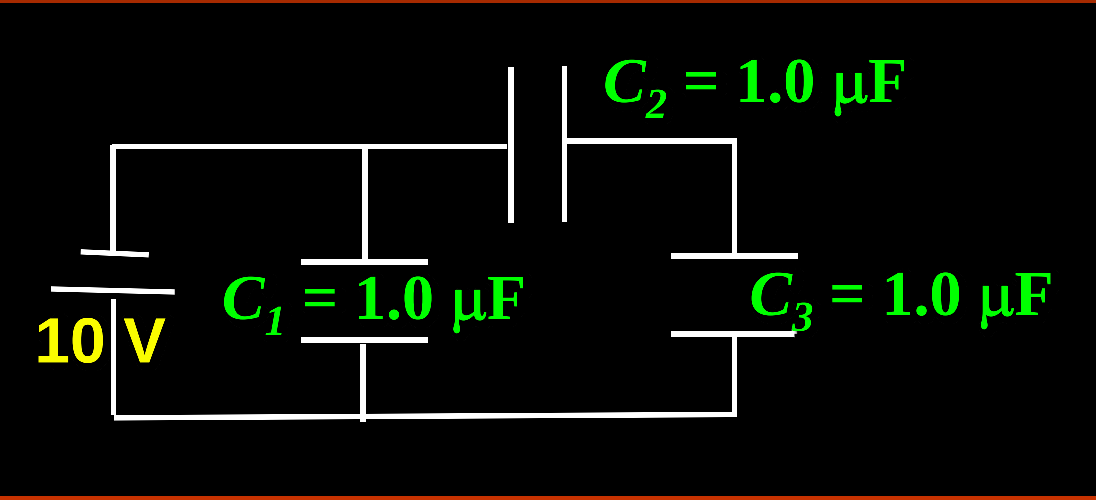


ConcepTest 25.3c Capacitors III

How does the charge Q_1 on the first capacitor (C_1) compare to the charge Q_2 on the second capacitor (C_2)?

1) $Q_1 = Q_2$
2) $Q_1 > Q_2$
3) $Q_1 < Q_2$
4) all charges are zero

We already know that the voltage across C_1 is 10 V and the voltage across C_2 and C_3 each is 5 V. Since $Q = CV$ and C is the same for all the capacitors, then since $V_1 > V_2$ therefore $Q_1 > Q_2$.



ConcepTest 25.4 Capacitors III

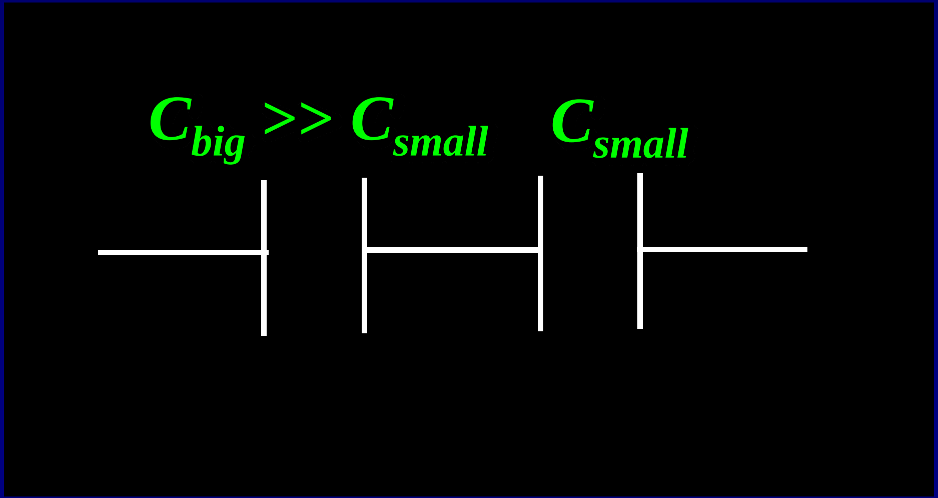
A very large capacitor **(C_{big})** is in series with a very small capacitor **(C_{small})** . The equivalent capacitance of this combination will be -

a) slightly greater than the capacitance of **(C_{big})**,

b) slightly less than the capacitance of **(C_{big})**,

c) slightly greater than the capacitance of **(C_{small})** , or

d) slightly less than the capacitance of **(C_{small})** .



ConcepTest 25.4 Capacitors III

A very large capacitor (C_{big}) is in series with a very small capacitor (C_{small}). The equivalent capacitance of this combination will be -

a) slightly greater than the capacitance of (C_{big}),

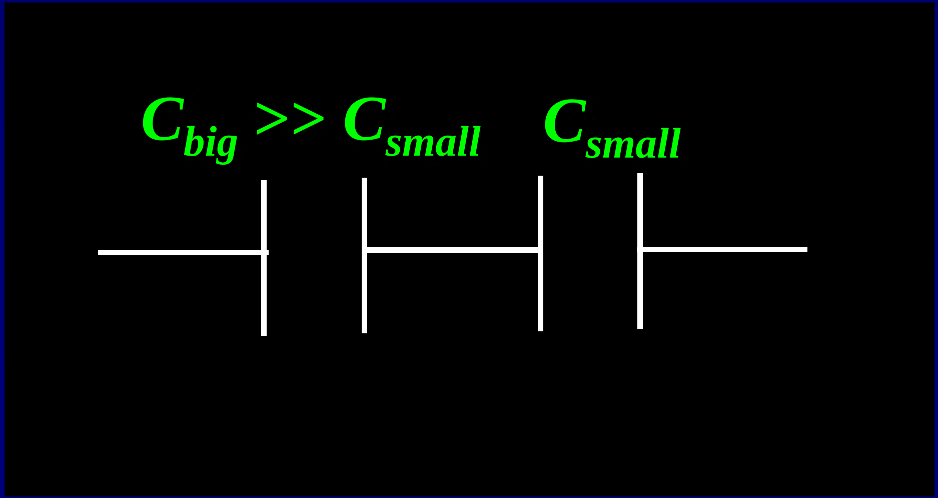
b) slightly less than the capacitance of (C_{big}),

c) slightly greater than the capacitance of (C_{small}), or

d) slightly less than the capacitance of (C_{small}).

$$\frac{1}{C_{eq}} = \frac{1}{C_{big}} + \frac{1}{C_{small}} \quad \text{or}$$

$$C_{eq} = \frac{C_{big}C_{small}}{C_{big} + C_{small}} = \frac{C_{small}}{1 + C_{small}/C_{big}}$$



ConcepTest 25.5 Capacitors III

The volume enclosed by the plates of a parallel plate capacitor is given by the equation Volume = *Ad*. If one doubles the area, *A*, of the plates and reduces the plate separation, *d*, by a factor of two so that the volume remains the same, the capacitance will

a) decrease by a factor of 4,

b) decrease by a factor of 2,

c) remain constant,

d) increase by a factor of 2, or

e) increase by a factor of 4.

ConcepTest 25.3c Capacitors III

The volume enclosed by the plates of a parallel plate capacitor is given by the equation Volume = Ad. If one doubles the area, A, of the plates and reduces the plate separation, d, by a factor of two so that the volume remains the same, the capacitance will

a) decrease by a factor of 4,

b) decrease by a factor of 2,

c) remain constant,

d) increase by a factor of 2, or

e) increase by a factor of 4.

Because the capacitance is determined by $C = \varepsilon_o A/d$, doubling the plate area and decreasing the plate separation by a factor of two will increase the capacitance by a factor of 4.

ConcepTest 25.6 Energy Storage

Which of the following statements is *false*?

a) In the process of charging a capacitor, an electric field is produced between its plates.

b) The work required to charge a capacitor can be thought of as the work required to create the electric field between its plates.

c) The energy density in the space between the plates of a capacitor is directly proportional to the first power of the electric field.

d) The potential difference between the plates of a capacitor is directly proportional to the electric field.

e) None of these is false.

ConcepTest 25.6 Energy Storage

Which of the following statements is *false*?

a) In the process of charging a capacitor, an electric field is produced between its plates.

b) The work required to charge a capacitor can be thought of as the work required to create the electric field between its plates.

c) The energy density in the space between the plates of a capacitor is directly proportional to the first power of the electric field.

d) The potential difference between the plates of a capacitor is directly proportional to the electric field.

e) None of these is false.