Mar 6

Get Clickers, kits, and stopwatch

Minilab: Charging and Discharging a Capacitor

Fade Away

Clicker Questions:

Effect of size combinations:
What happens to the capacitance if the area of a capacitor doubles?

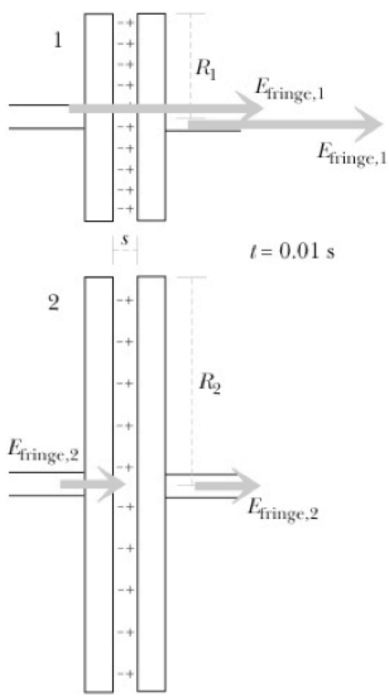
A. **doubles**
B. **halves**
C. ~~**stays the same**~~

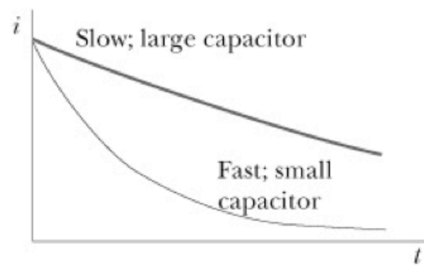
$$Q = C\Delta V$$

$$\Delta V = Ed = \frac{Q/A}{\epsilon_0} d$$

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

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


1
R_1
$E_{fringe,1}$
$E_{fringe,1}$
s
$t = 0.01$ s
2
R_2
$E_{fringe,2}$
$E_{fringe,2}$


i
Slow; large capacitor
Fast; small capacitor
t

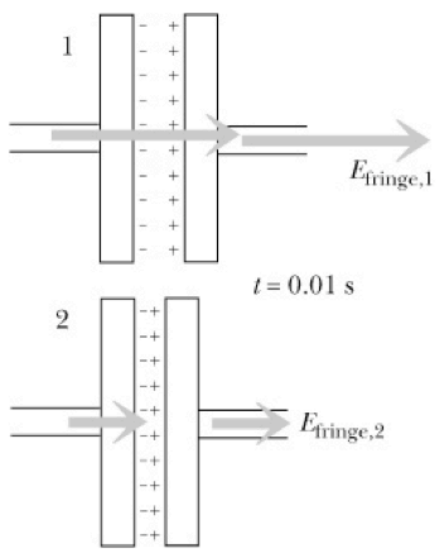
What happens to the capacitance if the separation of a capacitor is cut in half?

A. doubles

B. halves

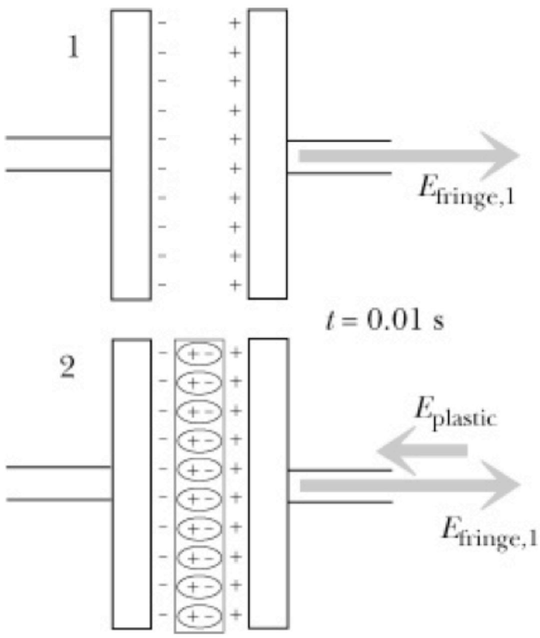
C. stays the same

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


1
$E_{fringe,1}$
$t = 0.01$ s
2
$E_{fringe,2}$

What happens to the capacitance if a dielectric is inserted into a capacitor?

A. Goes up
B. Goes down
C. stays the same



Net E field is smaller

$E \sim \Delta V$

$Q = C\Delta V$

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

bigger (C) smaller (ΔV)

Discussion: Definition of Resistance

Micro Analysis

looking at fundamental behavior

Hard to measure directly

no electron mobility meter

Macro Analysis

measure contributions of fundamental quantities

Easy to measure

(current, volt, ...)

Micro

$$I = |q| n A u E = (|q| n u)(AE)$$

($|q| n u$: prop of material; AE: external parameters)

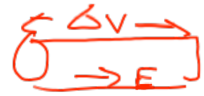
$$J = \text{current density} = \frac{I}{A} = \frac{(|q| n u) AE}{A} = (|q| n u) E$$

($|q| n u = \sigma$)

$$\vec{J} = \sigma \vec{E}$$

↳ Ohm's law

Macroscopic view   Resistor in uniform field



$$\Delta V = -\int \vec{E}\cdot d\vec{l} \qquad |\vec{E}| = \frac{|\vec{J}|}{\sigma}$$

$$= -EL = -\frac{J}{\sigma}L = -\frac{I/A}{\sigma}L$$

$$|\Delta V| = \left(\frac{L}{\sigma A}\right) I$$

↳ define to be resistance $\quad R = \frac{L}{\sigma A}$

$\Delta V = IR$ → only true for Ohmic resistors

Non-ohmic:

- Capacitor: $\Delta V \not\propto I \Rightarrow Q \propto \Delta V$
- bulbs: temp changes conductivity
- battery: $\Delta V \sim$ const, I is not

Semiconductors
diodes

Micro

$\bar{V} = uE$

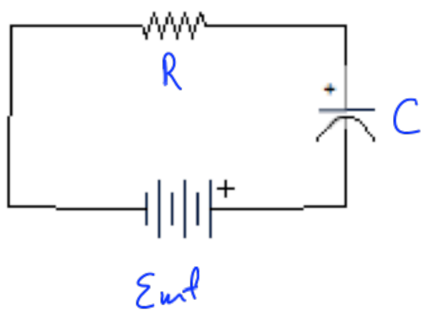
$i = nAuE$

macro

$\vec{J} = \sigma \vec{E}$

$I = \frac{\Delta V}{R}$ ohmic resistors

Discussion: RC circuit



$$\Delta V = 0$$

$$+\mathcal{E}mf - \frac{Q}{C} - IR = 0$$

$$I = \frac{\mathcal{E}mf - Q/C}{R} = \frac{dQ}{dt}$$

$$\frac{dQ}{dt} = \frac{C\mathcal{E}mf - Q}{RC}$$

$$\frac{dt}{RC} = \frac{dQ}{C\mathcal{E}mf - Q}$$

$$-\frac{t}{RC} + \text{const} = \ln\left(C\mathcal{E}mf - Q\right)$$

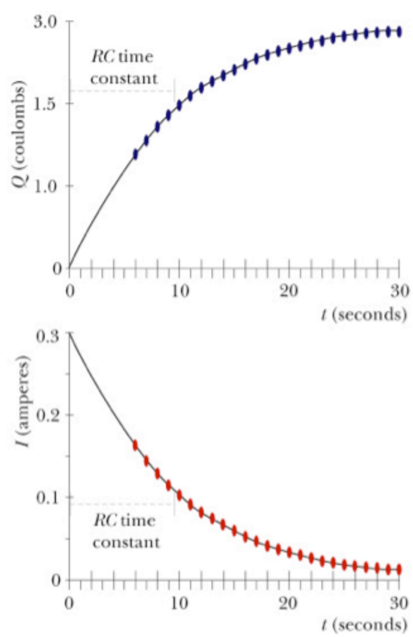
$$\rightarrow C\mathcal{E}mf - Q = Ae^{-t/RC}$$

$$Q = C\mathcal{E}mf - Ae^{-t/RC}$$

$$t = 0 \quad Q = 0 \Rightarrow A = C\mathcal{E}mf$$

$$Q = C\mathcal{E}mf\left(1 - e^{-t/RC}\right)$$

$$I = \frac{dQ}{dt} = \frac{\mathcal{E}mf}{R} e^{-t/RC}$$



RC is time Const

$$I = \frac{\varepsilon_{mf}}{R} e^{-t/RC}$$

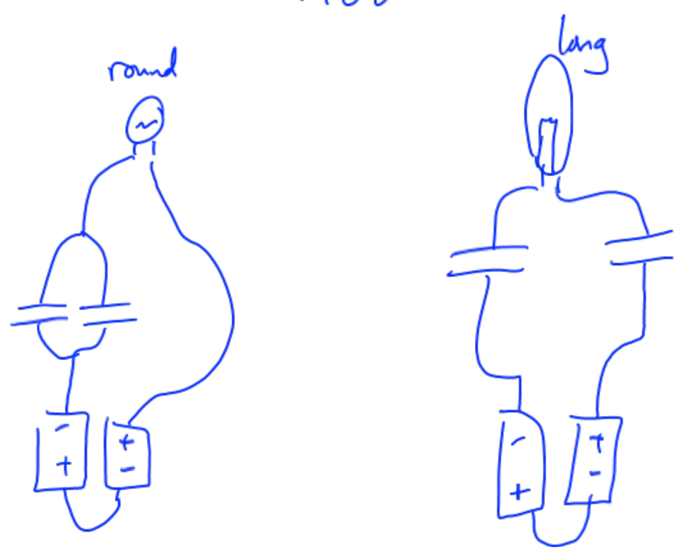
when $t = RC$

$$I = \frac{\varepsilon_{mf}}{R} e^{-1} = I_0 e^{-1}$$

$$e^{-1} \approx 0{,}37$$

Tangible: 2 Capacitors and Isolated Bulb

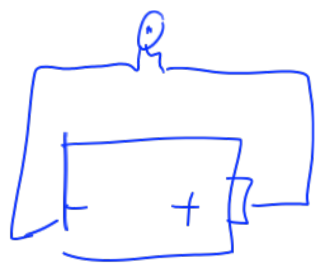
Hold It



Clicker questions:

Battery in series with bulb. When you disconnect the battery, what happens to the bulb?

A. stays lit
B. turns off
C. goes dim
D. brightens



Battery, bulb and capacitor in parallel. When you disconnect the battery, what happens to the bulb?

- **A. stays lit**
- **B. turns off**
- **C. goes dim**
- **D. brightens**

Tangible: Usefulness of a Capacitor

Figure 19.12