Electricity and Magnetism

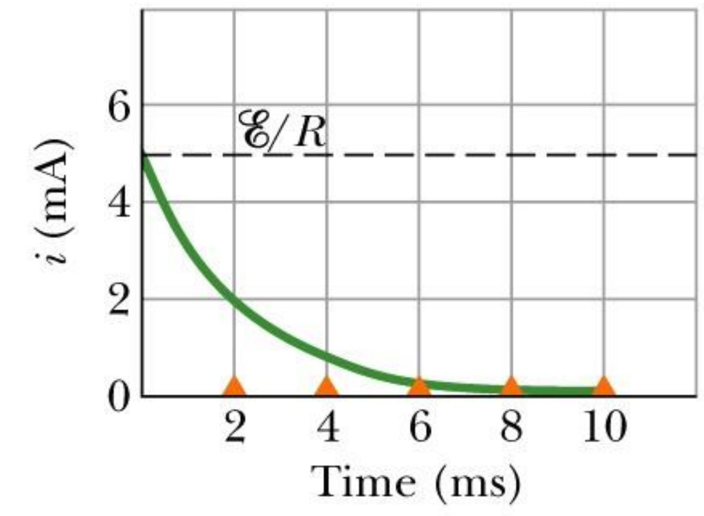
- Physics 259 – L02
- Lecture 36

Chapter 27

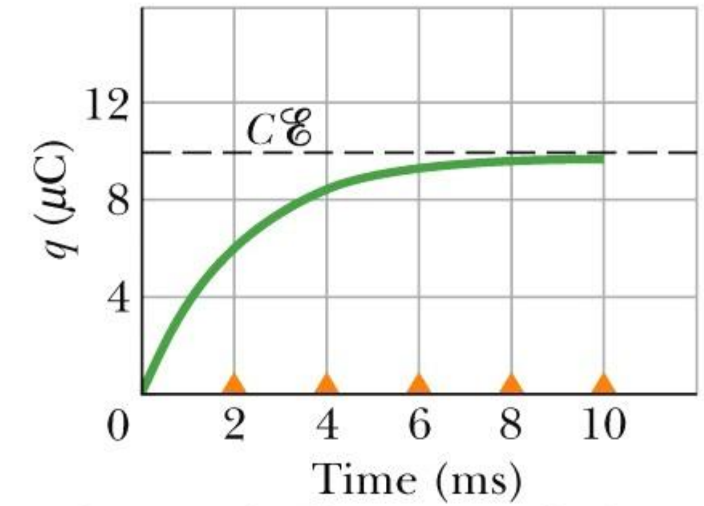
27 Circuits

Case 1: Charging a capacitor

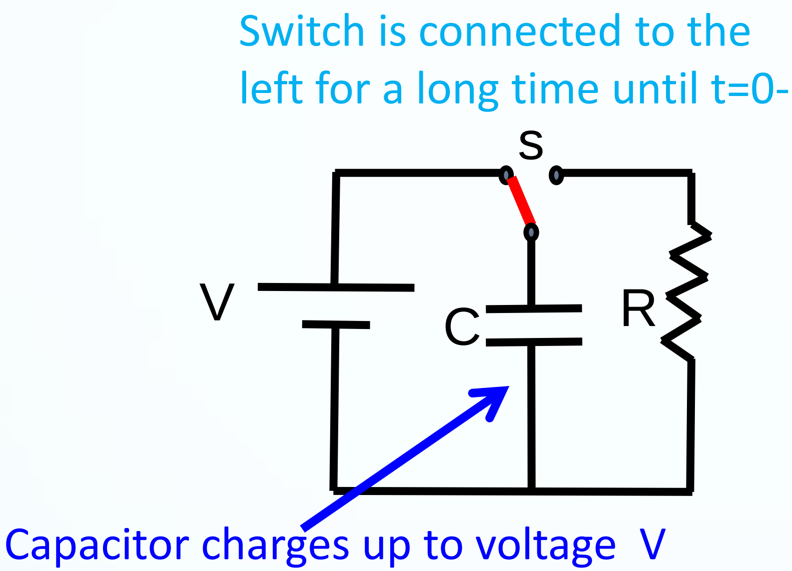
$$i = i_0 e^{-t/RC}$$

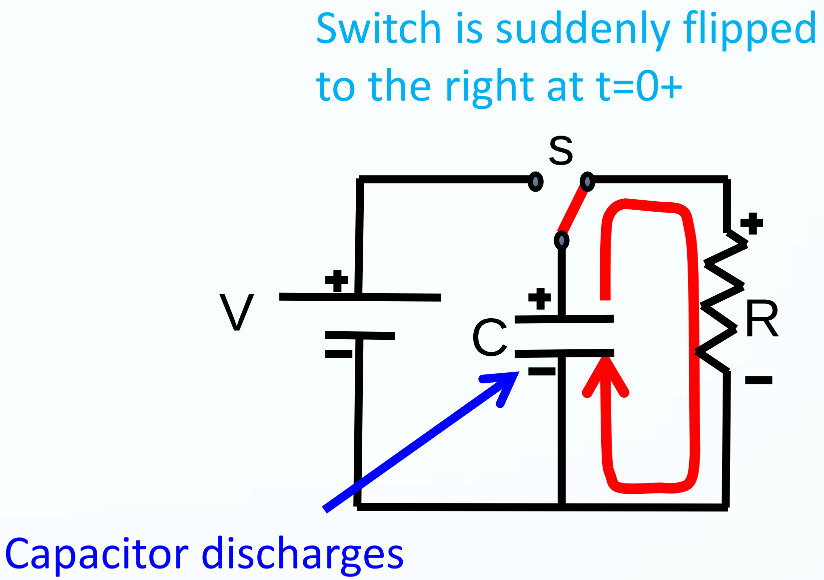


$$q = \varepsilon C\left(1 - e^{-t/RC}\right) = Q_f\left(1 - e^{-t/RC}\right)$$



Case 2: Discharging a capacitor

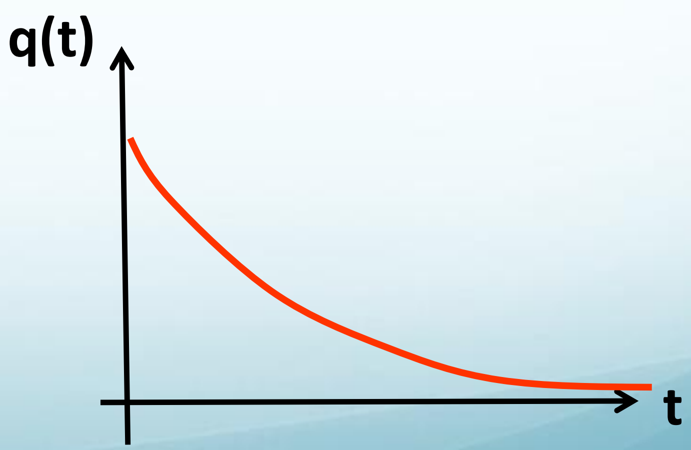




$$\boxed{q(t) = q_0 e^{-t/RC}}$$

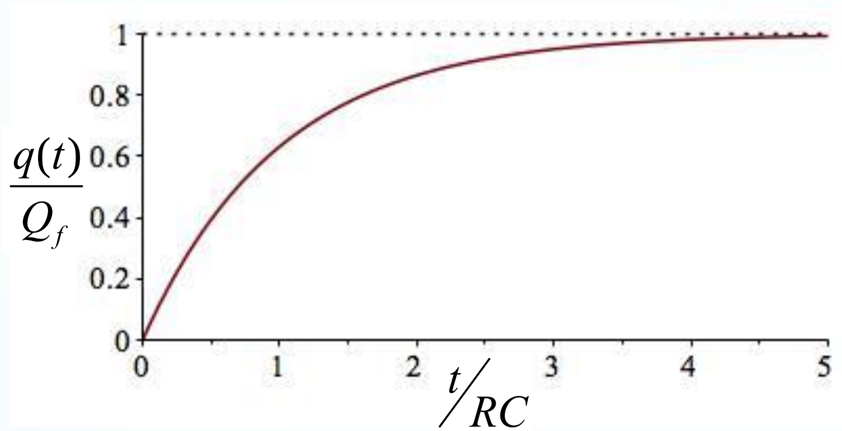
$$\boxed{i(t) = i_0 e^{-t/RC}}$$

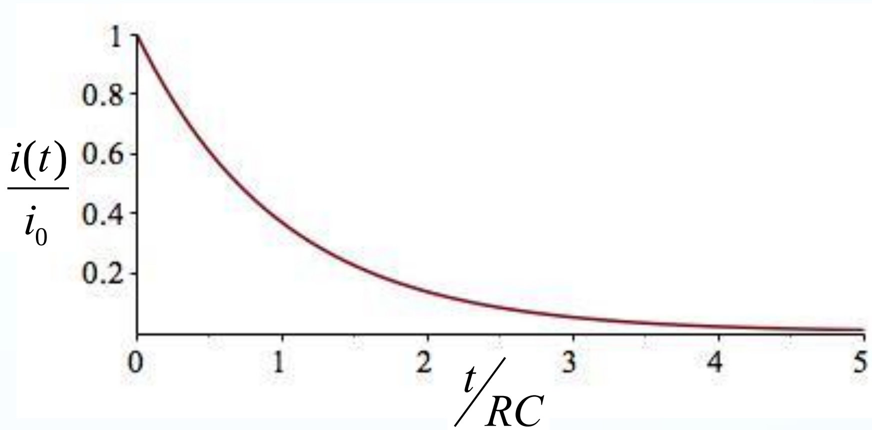
$$q_0 = CV$$



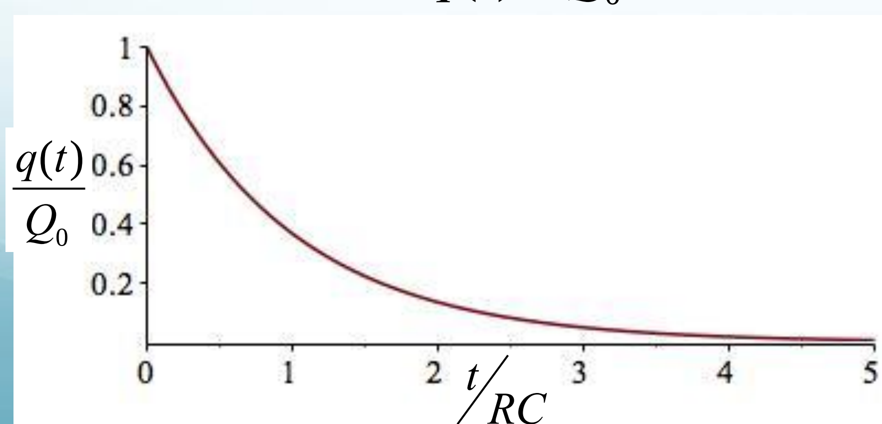
Charging/Discharging Capacitors

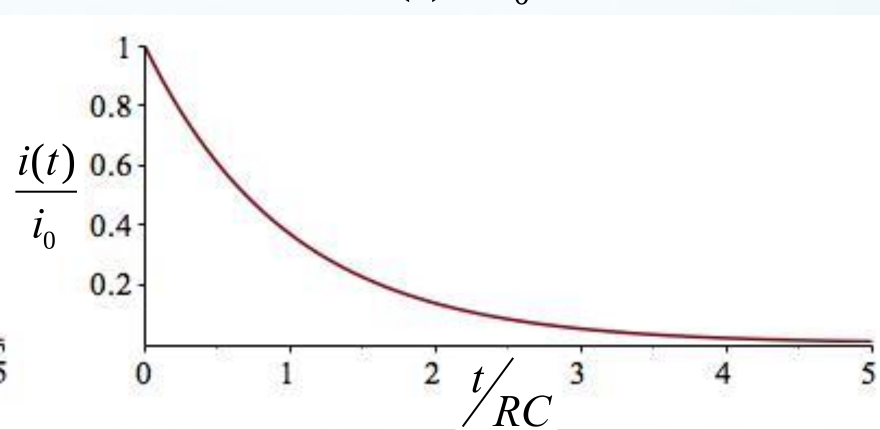
Charging: $q(t)=Q_f\left(1-e^{-\frac{t}{RC}}\right)$ $\qquad$ $i(t)=i_0 e^{-\frac{t}{RC}}$





Discharging: $q(t)=Q_0 e^{-\frac{t}{RC}}$ $\qquad$ $i(t)=i_0 e^{-\frac{t}{RC}}$





The RC time constant

The constant RC pops up in the exponential factor for both charging and discharging capacitors. What does it represent?

The units of RC is seconds: $\left[RC\right] = \frac{V}{A}\frac{C}{V} = \frac{C}{C/s} = s$

We call RC the "**RC time constant**" and it tells us how quickly a capacitor can charge or discharge.

$$\boxed{RC \,^{\circ}\; t}$$

After a time τ, the charge on a discharging capacitor is reduced by a factor of 1/e. After a time $N\tau$, it is reduced by a factor of $1/e^{N}$

$$\boxed{q(t) = Q_0 e^{-\frac{t}{t}}}$$

Top Hat Question

An RC circuit is shown below. Initially the switch is open and the capacitor is fully charged. At time t = 0, the switch is closed.

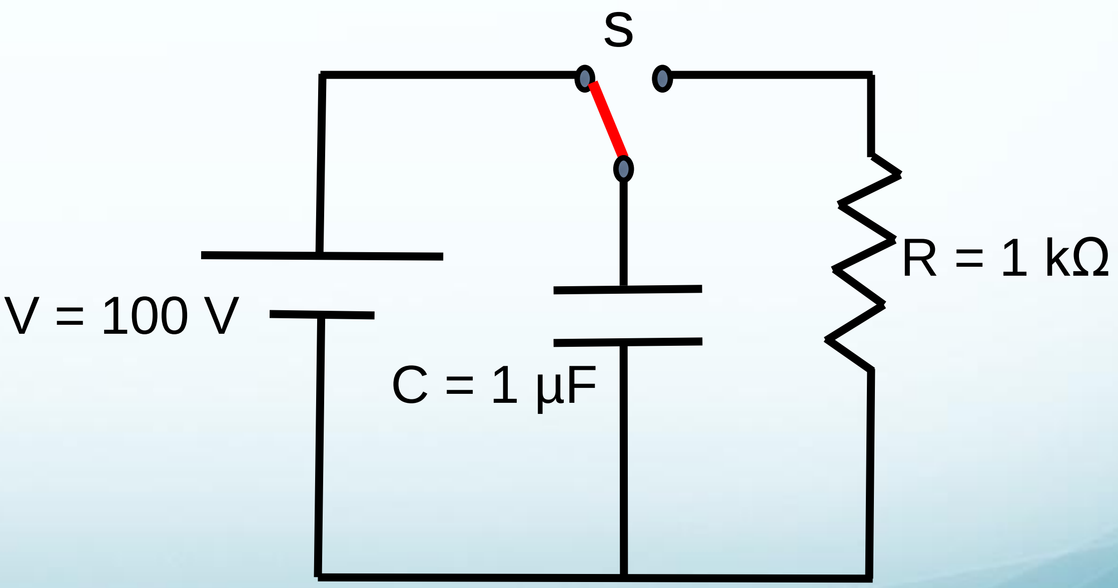
How much charge is left on the capacitor plates after t = 10 ms?

A. 0.67 nC

B. 14 μC

C. 37 μC

D. 4.5 nC



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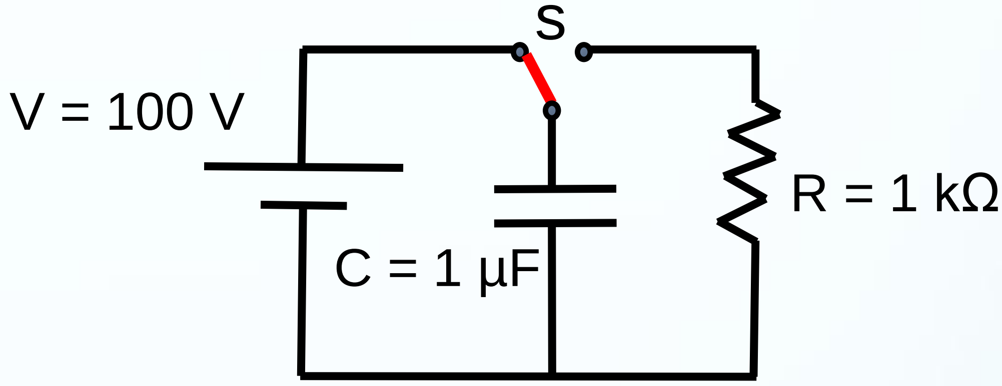
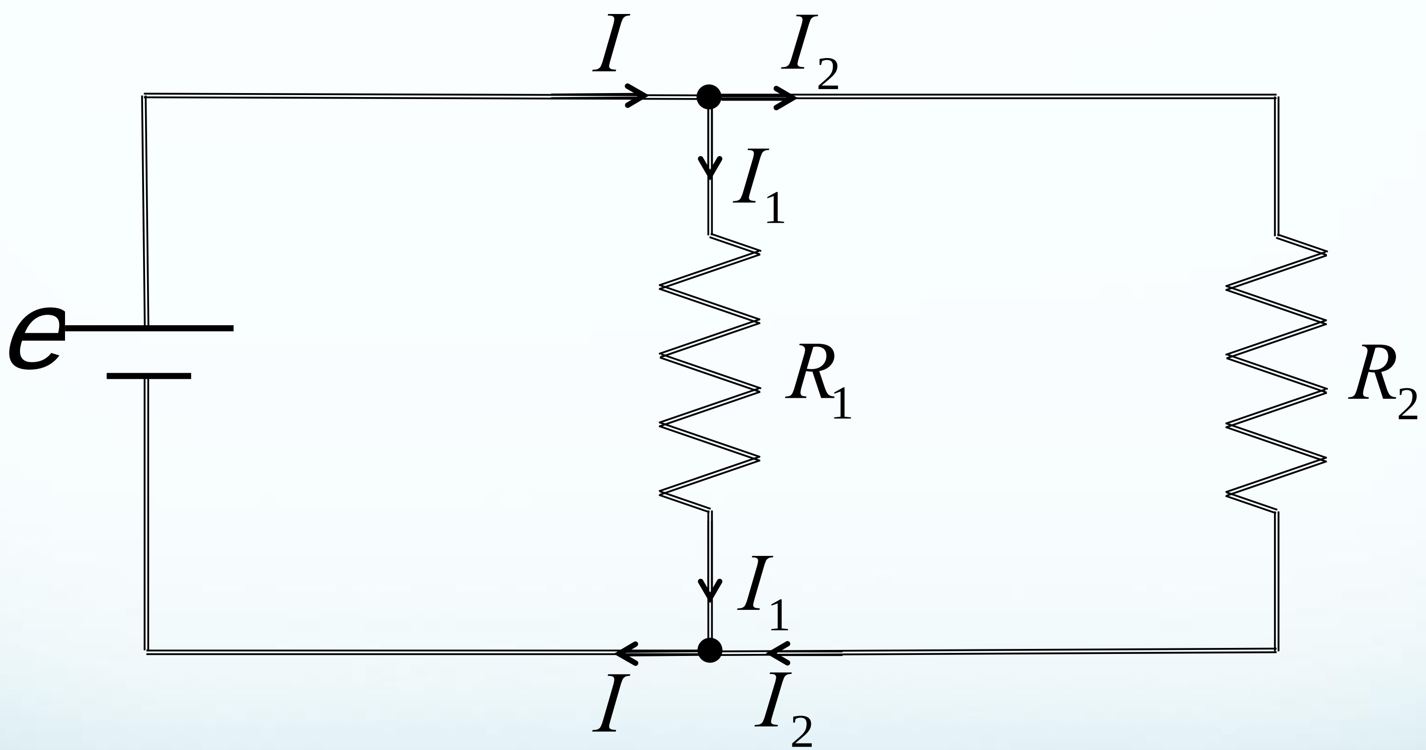


Kirchhoff's junction rule

A slightly more complicated circuit has multiple branches with resistors in parallel



Current is the flow of charges. Charge has to be conserved.

Current into junction = current out of junction

$$\boxed{I = I_1 + I_2}$$

This section we talked about:

Chapter 27

See you on Monday