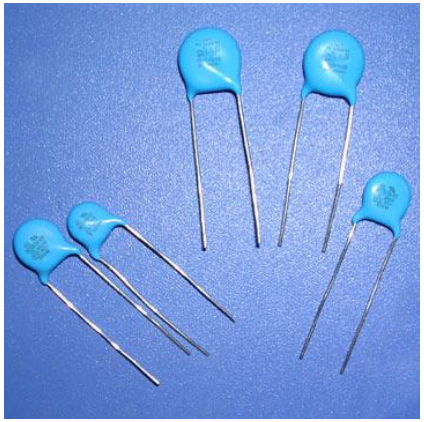
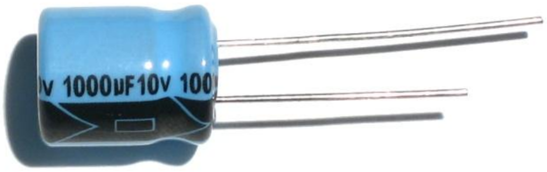
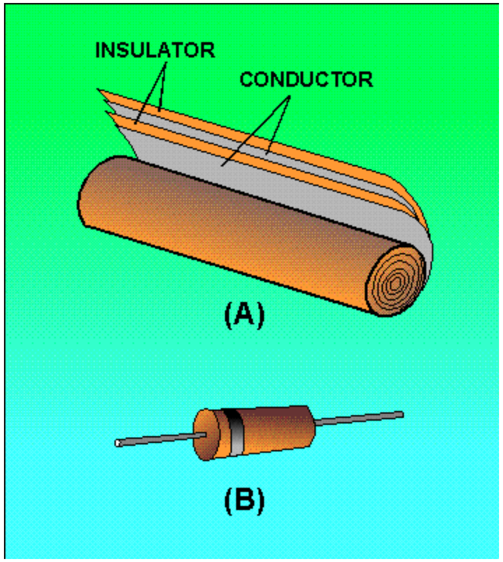
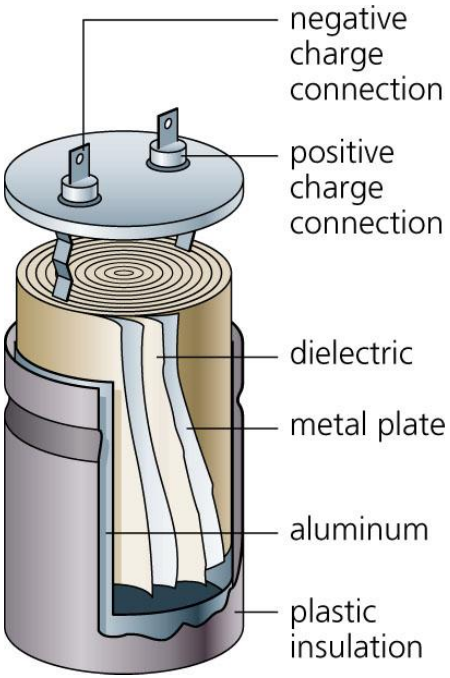
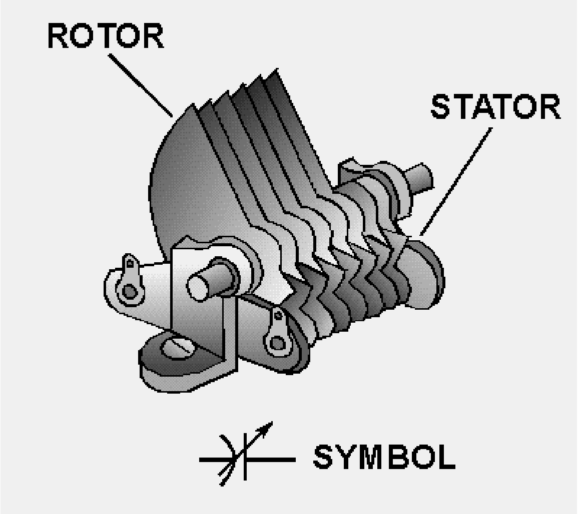




CAPACITANCE – Part 2

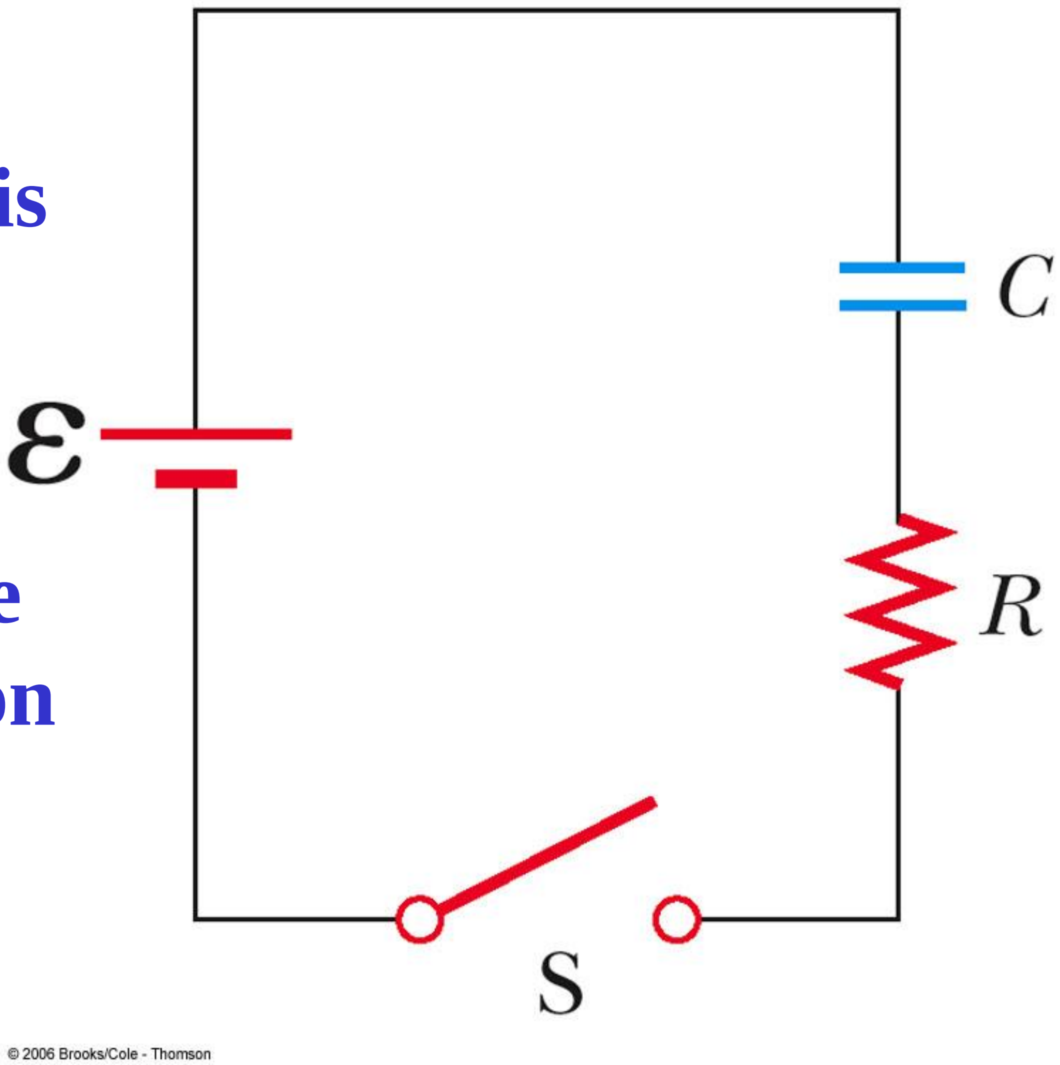






The RC Circuit

When the switch S is closed. the initial current $\mathcal{E}/R$ **decreases over time as charges collect on the plates.**

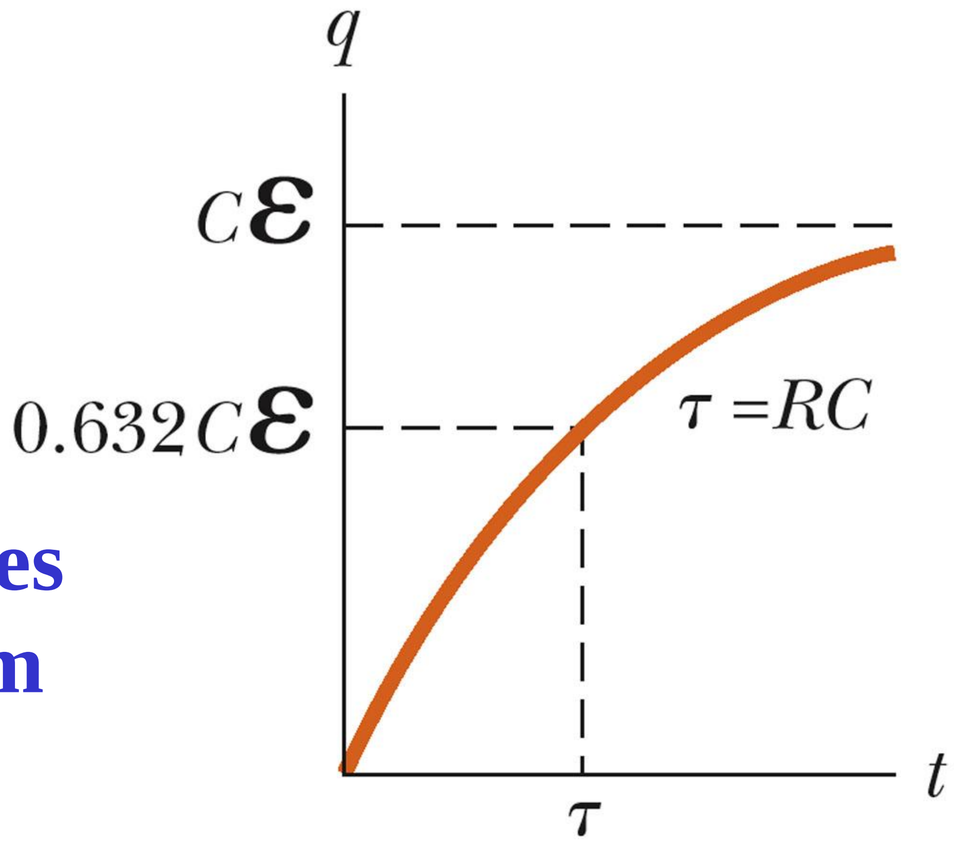


$$I_0 = \mathcal{E}/R$$

$$I = I_0 e^{-t/RC}$$

$$I_0 = \mathcal{E}/R$$

$$I = I_0 e^{-t/RC}$$

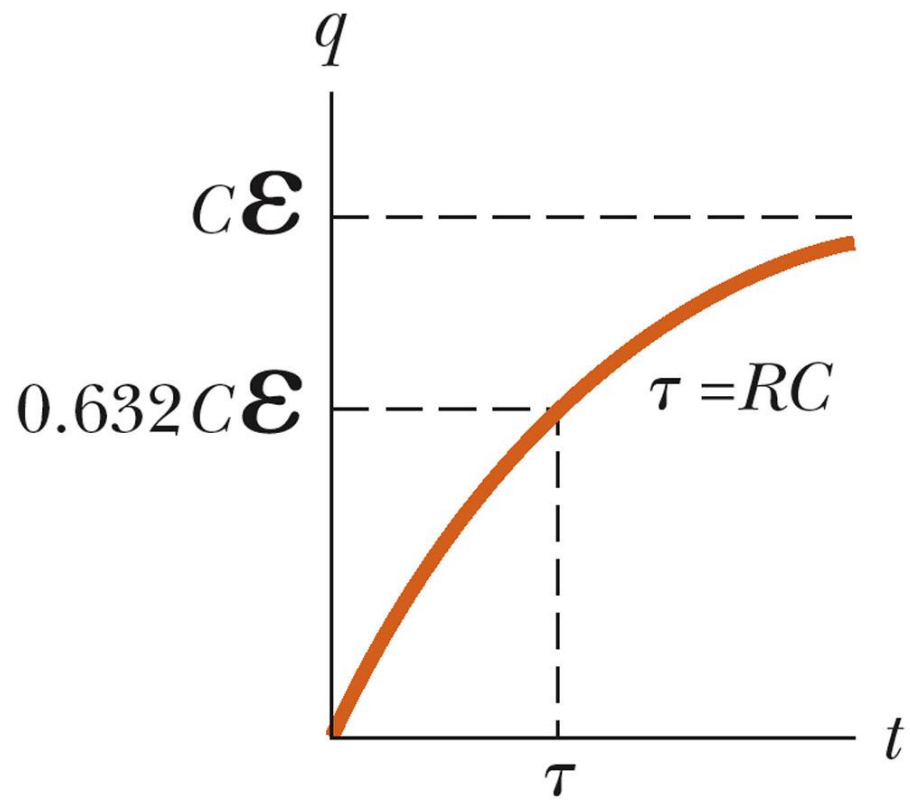


The charge on the plates approaches a maximum value,

$Q = C\mathcal{E}$,

and the voltage across the plates approaches $\mathcal{E}$.

The charging time depends on the *time constant*, $\tau = RC$. At time $t = \tau$ the capacitor has reached 63.2% of its maximum charge.



In a circuit with a large time constant, the capacitor charges very slowly.

The capacitor charges very quickly if there is a small time constant.

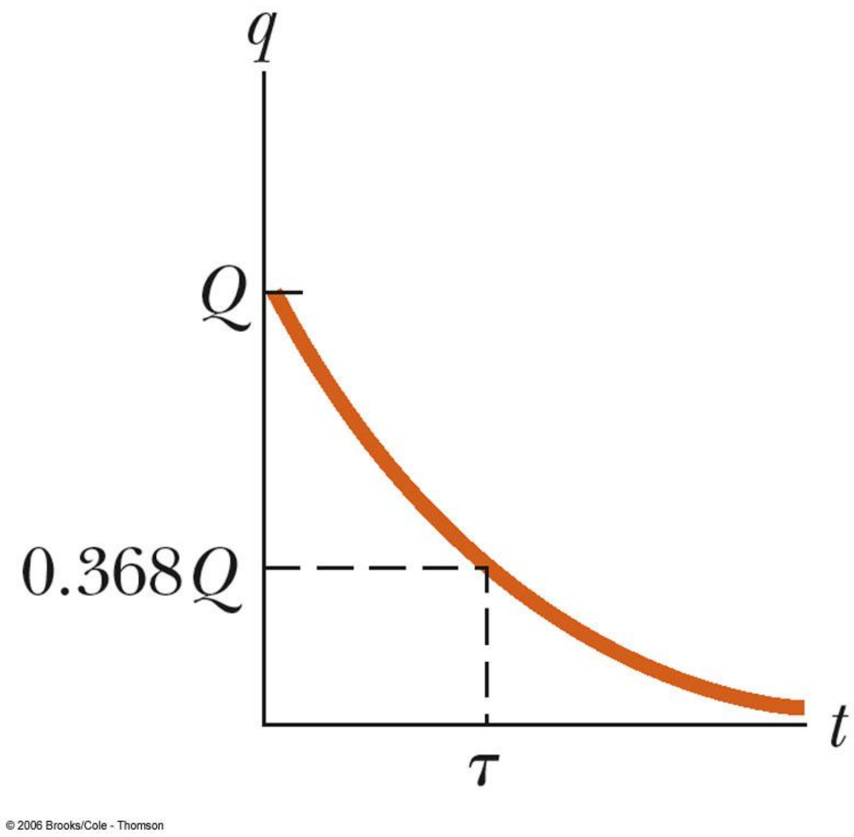
After $t = 10\tau$, the capacitor is over 99.99% charged

When a charged capacitor is placed in the circuit, it discharges exponentially.

$$q = Qe^{-t/RC}$$

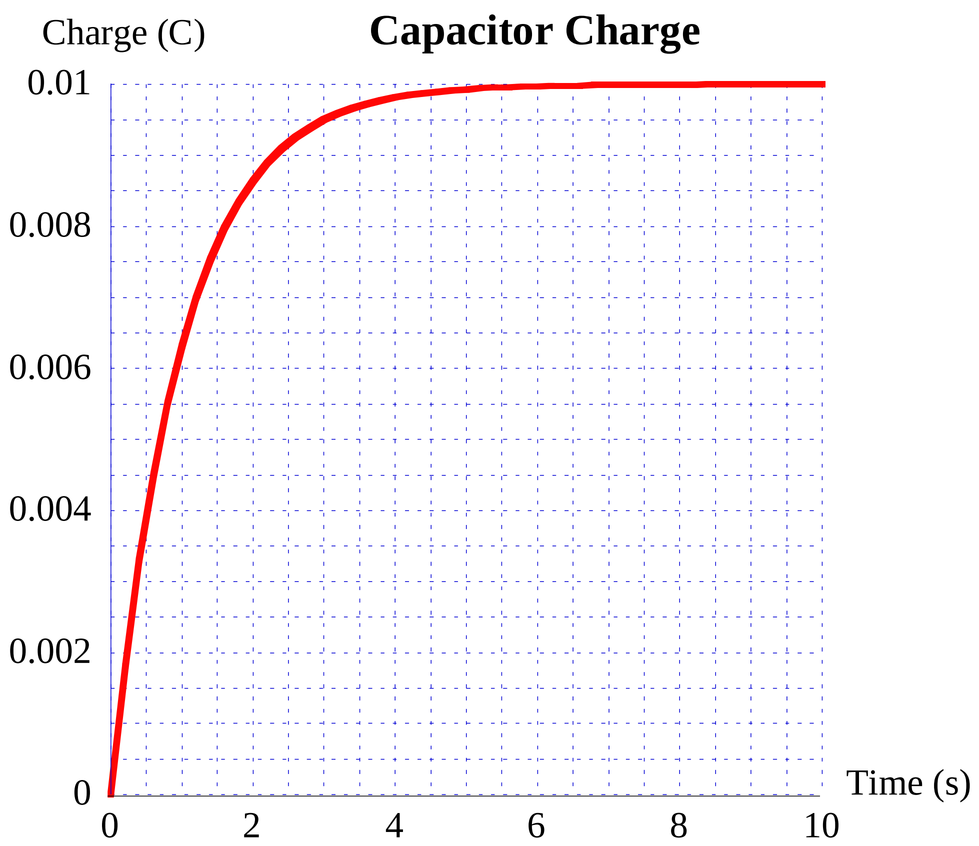
At $t = \tau = RC$, the charge decreases to $0.368\ Q_{max}$.

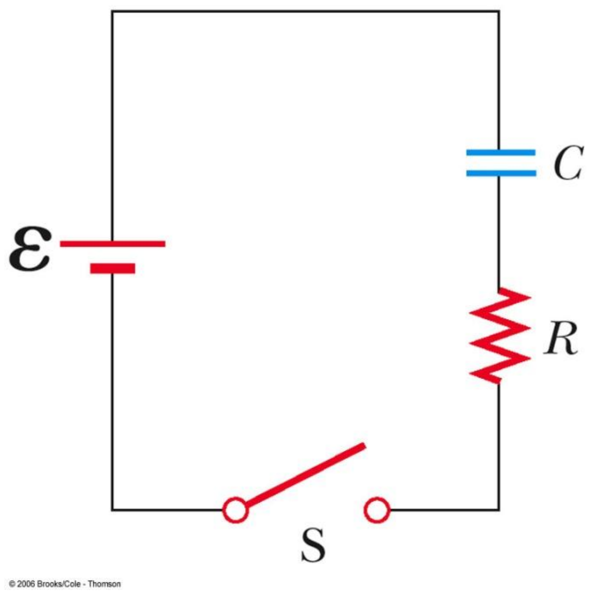
In other words, in one time constant, the capacitor loses 63.2% of its initial charge.



Example:

$\mathcal{E}$ = 10 V, C = 1000 μF, R = 1 MΩ.

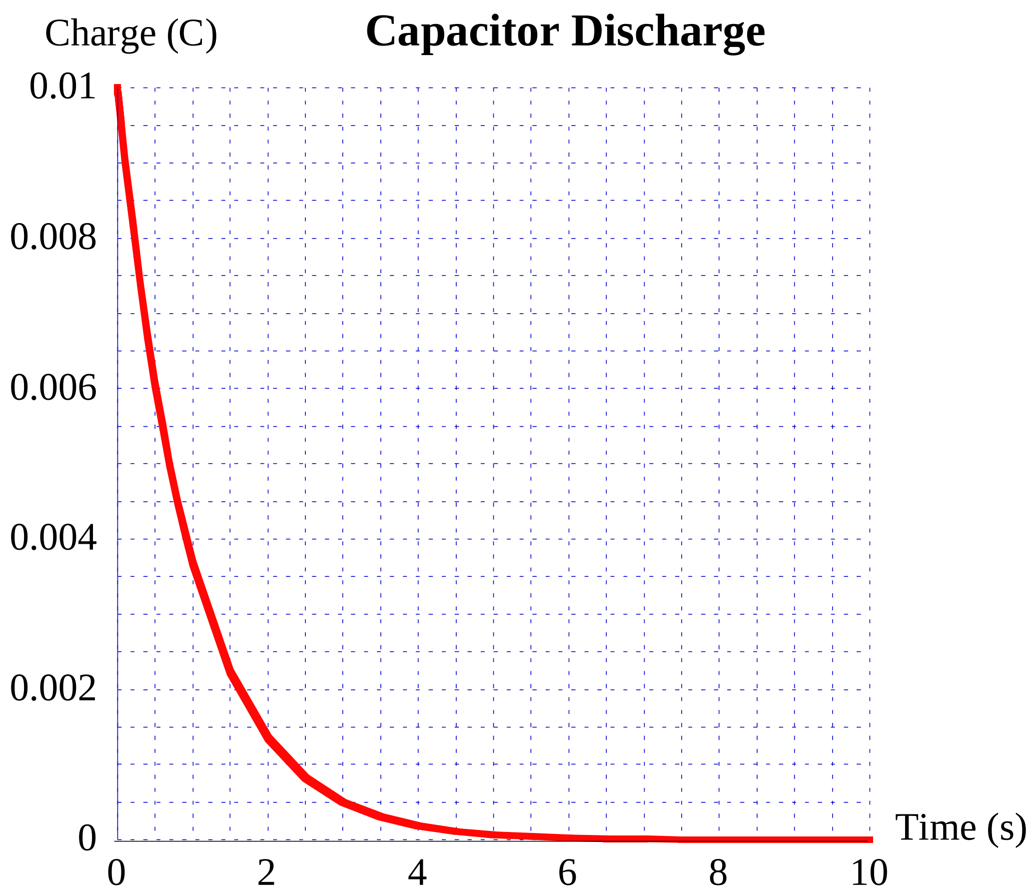


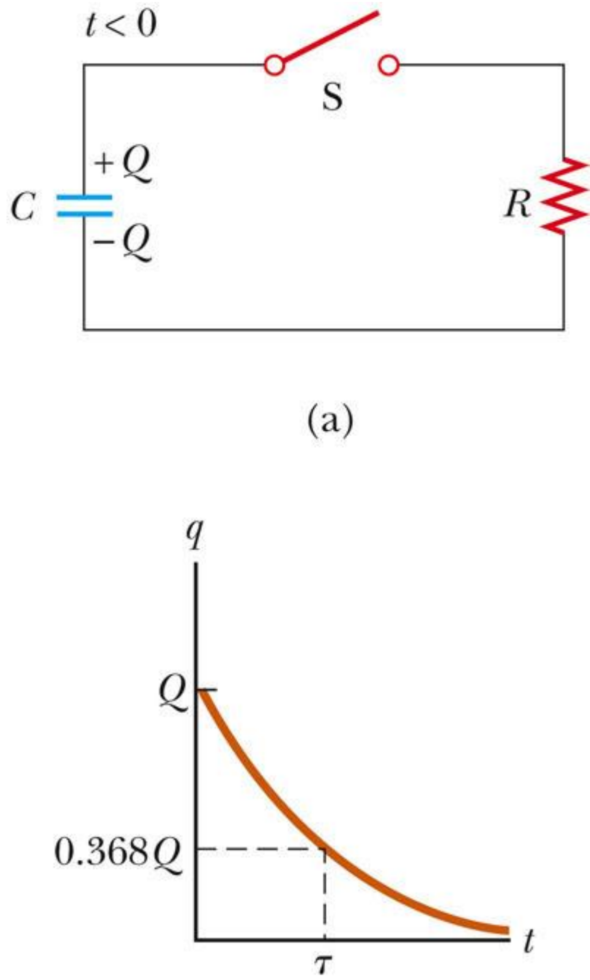


Capacitor charge: $q = Q_0\left(1 - e^{-t/RC}\right)$, $Q_0 = C\mathcal{E}$

Example:

$\mathcal{E}$ = 10 V, C = 1000 μF, R = 1 MΩ.





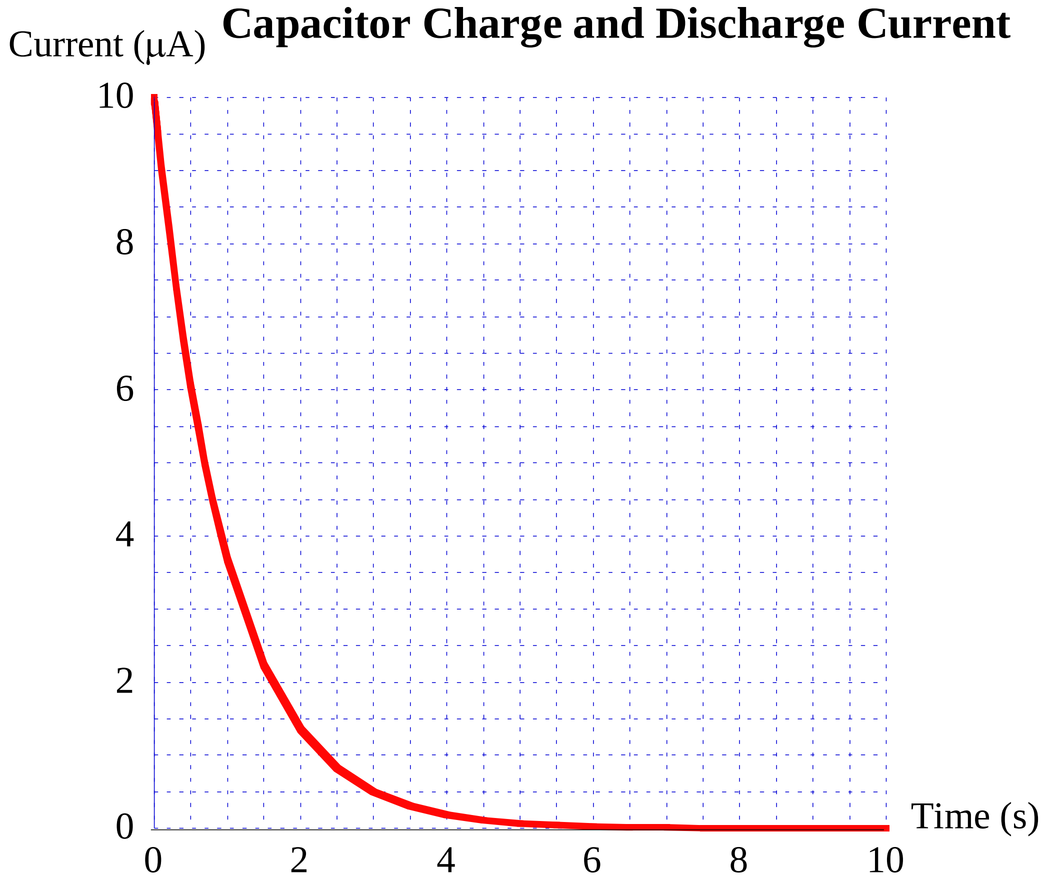
(a)

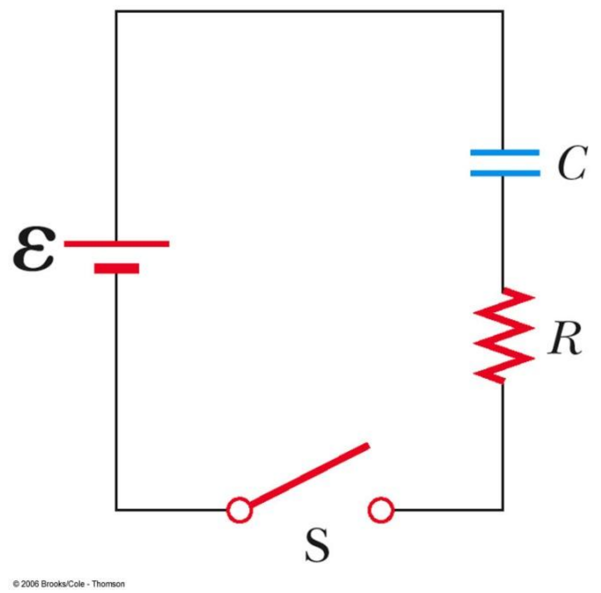
(b)

Capacitor discharge: $q = Q_0 e^{-t/RC}$

Example:

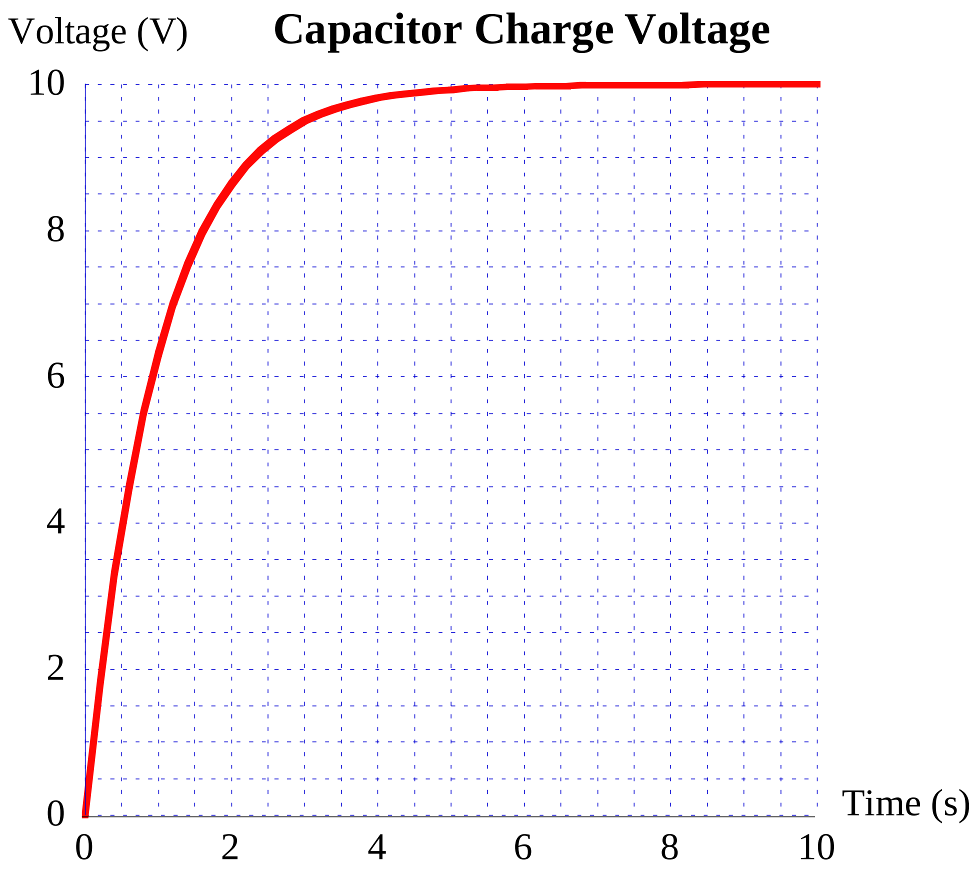
$\mathcal{E}$ = 10 V, C = 1000 μF, R = 1 MΩ.

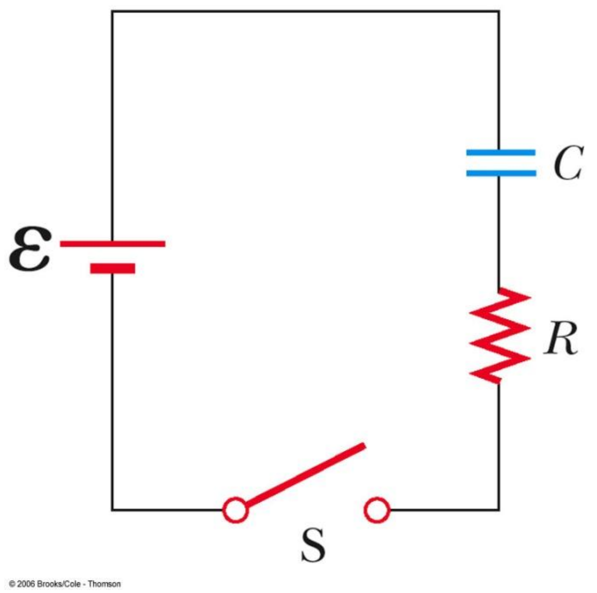




Charge and discharge current: $I = I_0 e^{-t/RC}$, $I_0 = \mathcal{E}/R$

Example:
$\mathcal{E}$ = 10 V, C = 1000 μF, R = 1 MΩ.



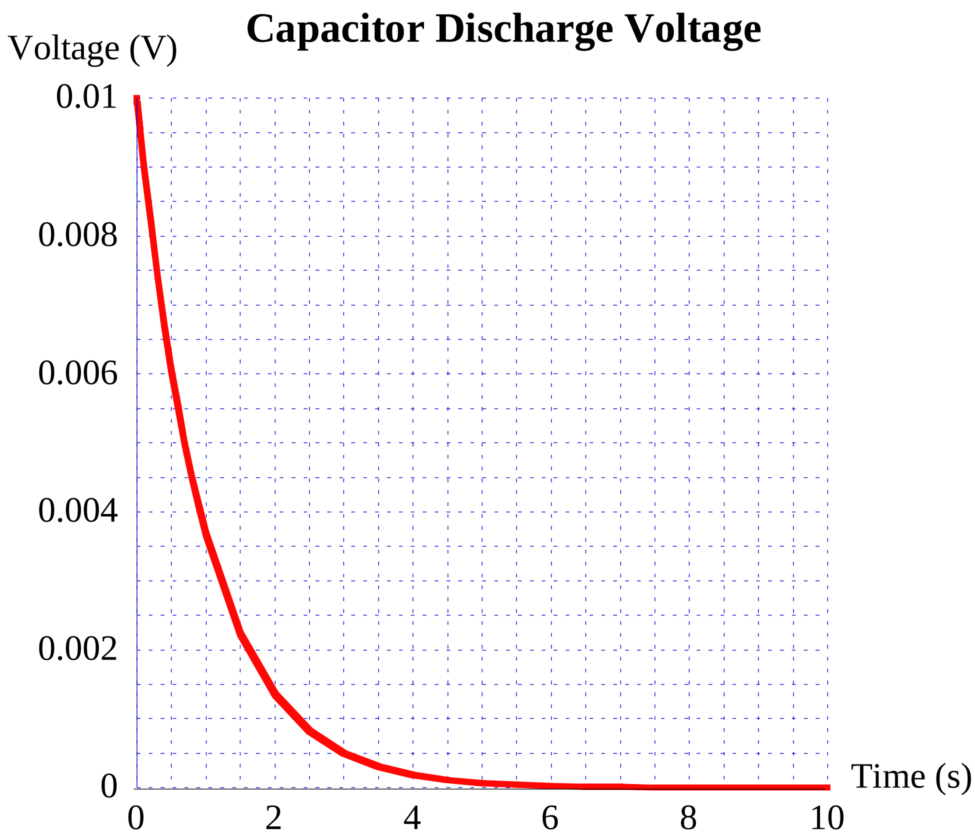


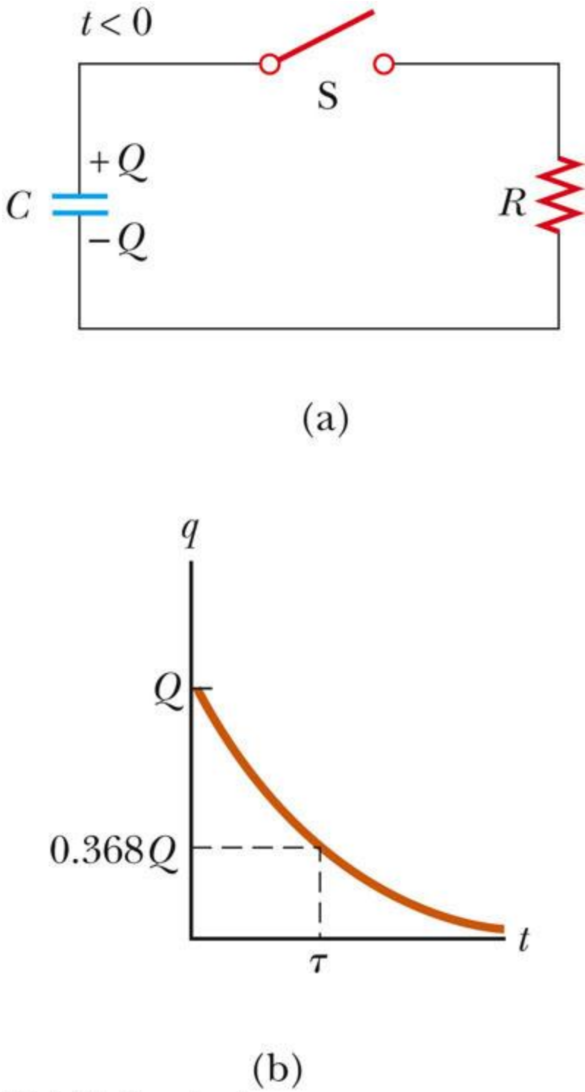
Potential difference across capacitor

Charge: $V = \mathcal{E}\left(1 - e^{-t/RC}\right)$

Example:

$\mathcal{E}$ = 10 V, *C* = 1000 μF, *R* = 1 MΩ.





Potential difference across capacitor

Discharge: $V = \mathcal{E} e^{-t/RC}$