Up until now, we have been concerned only with the steady state values of current, voltage, and power in different circuit elements. Certain circuit elements, like capacitors, actually exhibit behavior that change over time. This is called transient behavior.

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncharged</td>
<td>• Charge is free to accumulate with no resistance.</td>
</tr>
<tr>
<td></td>
<td>• Capacitor behaves like a conducting wire.</td>
</tr>
<tr>
<td>Charged</td>
<td>• No more charge can accumulate (capacitor is “full”)</td>
</tr>
<tr>
<td></td>
<td>• Capacitor behaves like an open circuit → No current flows through it.</td>
</tr>
</tbody>
</table>

So, as we charge up a capacitor, current through it will gradually drop to zero.

If a problem states that a circuit has achieved "steady state," this is synonymous with saying that a very long time has elapsed.
Simple Resistor-Capacitor (RC) Circuit

Initial state: Capacitor uncharged
Battery is disconnected

@t=0⁺ - Battery is connected
- All current flows through capacitor
  $\rightarrow$ No current thru resistor $I_R = 0$

$t$ from $0⁺$ to steady state:
- Capacitor charges up $\rightarrow$ $R_C$ increases
  $\rightarrow$ Current increases through resistor, decreases through capacitor

$t = \infty$ (steady state):
- Capacitor is fully charged
  $\rightarrow I_C = 0$
- $V_R = V_B$
- $I_R = \frac{V_B}{R}$

Example: Compound RC Circuit

Initial Condition: Capacitors Uncharged
Battery disconnected

@t=0⁺ - Battery Connected
All current goes through $C_3$ and $C_4$
$V_i = 12V$, $V_y = 0V$
$I_1 = \frac{12V}{12} = 1A$  $I_3 = 12A$
$I_2 = 0A$  $I_4 = 12A$

As time increases
$C_3$ and $C_4$ begin charging
$\rightarrow I_3$ and $I_4$ decrease
$\rightarrow I_2$ increases initially
As \( t \to \infty \), steady state is achieved

Capacitor 4 is completely charged
\[ I_4 = 0 \implies I_1 = 0 \]
\[ V_1 = I_1 R_1 = 0 \implies \text{No voltage across resistor 1} \]

\( V_3 = 0 \) because remaining charge on \( C_3 \) bleeds away through \( R_2 \) to other side of \( C_3 \)
\[ I_3 = 0 \]
\[ \text{Capacitor 3 is uncharged} \]

Total charge of capacitor 4 in steady state

\[ Q_4 = C_4 V_4 \]
\[ Q = (1 \mu F \times 12 \text{V}) = (1 \times 10^{-6} \text{F} \times 12 \text{V}) \]

\[ Q = 1.2 \times 10^{-5} \text{ coulombs} \]

Energy in capacitor 4 in steady state

\[ U = \frac{1}{2} CV^2 \]
\[ = \frac{1}{2} (1 \mu F \times 12 \text{V})^2 \]

\[ U = 72 \text{ J} \]