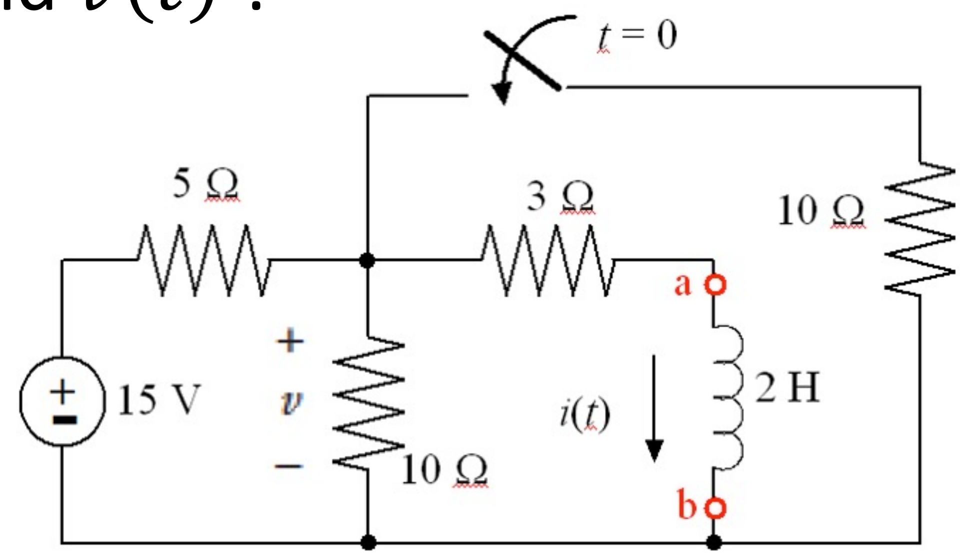
1^{st} Order Transients – 4

other circuit variables

Question – How do we find $v(t)$?



- Method 1:
  Propagate $i(t)$ from earlier class
  KVL:

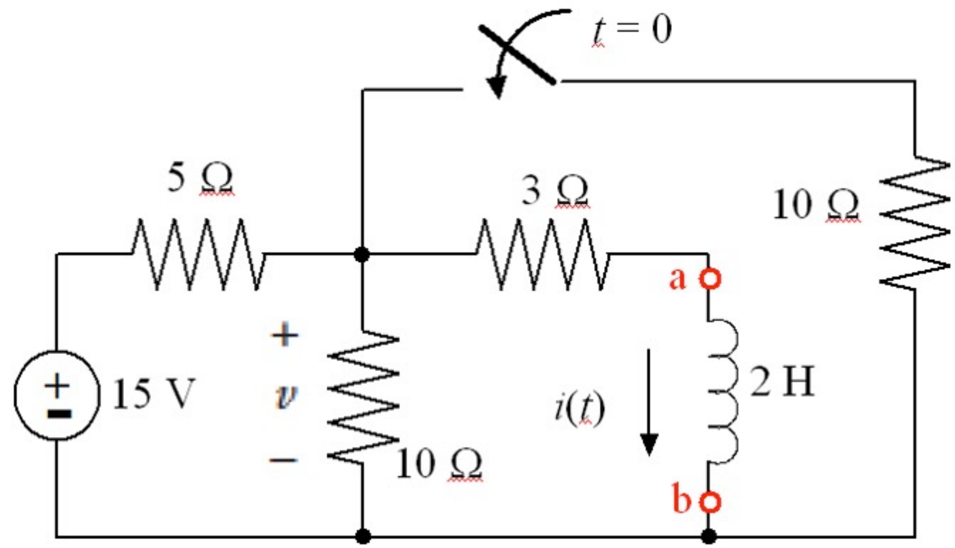
$$v(t) = 3\, i(t) + 2\,\frac{di(t)}{dt}$$

$$= 3(0.22\, e^{-2.75\,t} + 1.36) + 2(-2.75)(0.22\, e^{-2.75\,t})$$

$$= -0.55\, e^{-2.75\,t} + 4.09 \quad \text{volts}$$

- Method 2

  Direct solution



$$v(t) = (v_0 - v_\infty)\, e^{-t/\tau} + v_\infty$$

$$\tau = \frac{1}{2.75}\ \mathrm{sec}$$

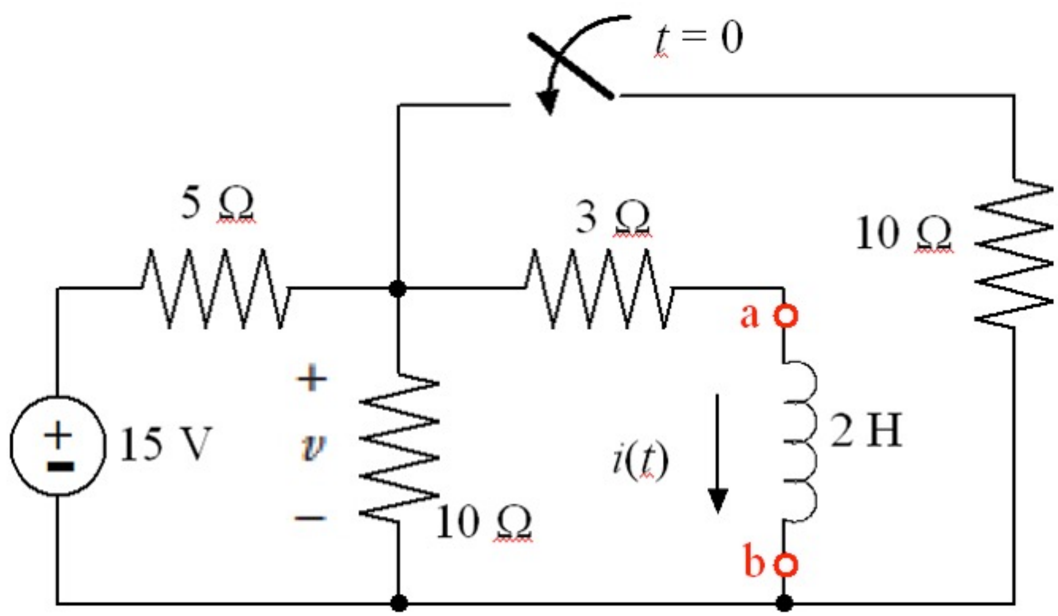
Same time constant !!

$$v_\infty = 15\,\frac{10||10||3}{10||10||3+5} = 4.09$$

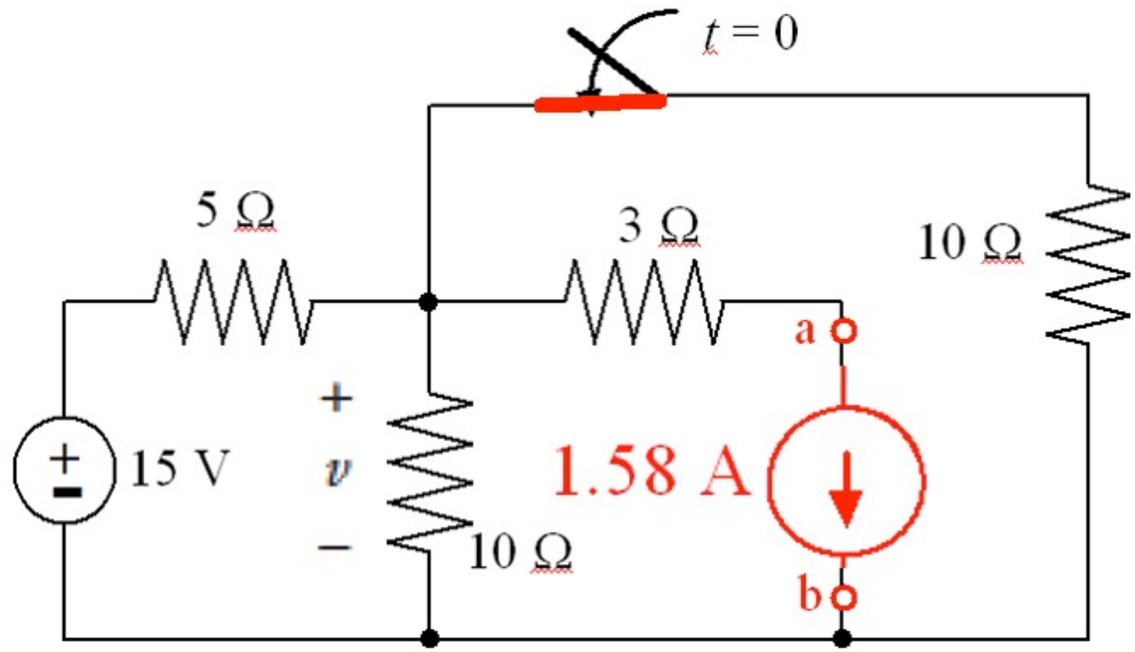
Voltage division (same idea)

- How do we find v_0 ?
  - **Cannot** use voltage before the switch (IC) since it need not be continuous
  - **Can** exploit the fact that

$$i_L(0) = 1.58 \quad \text{amps}$$



At time $t = 0$:

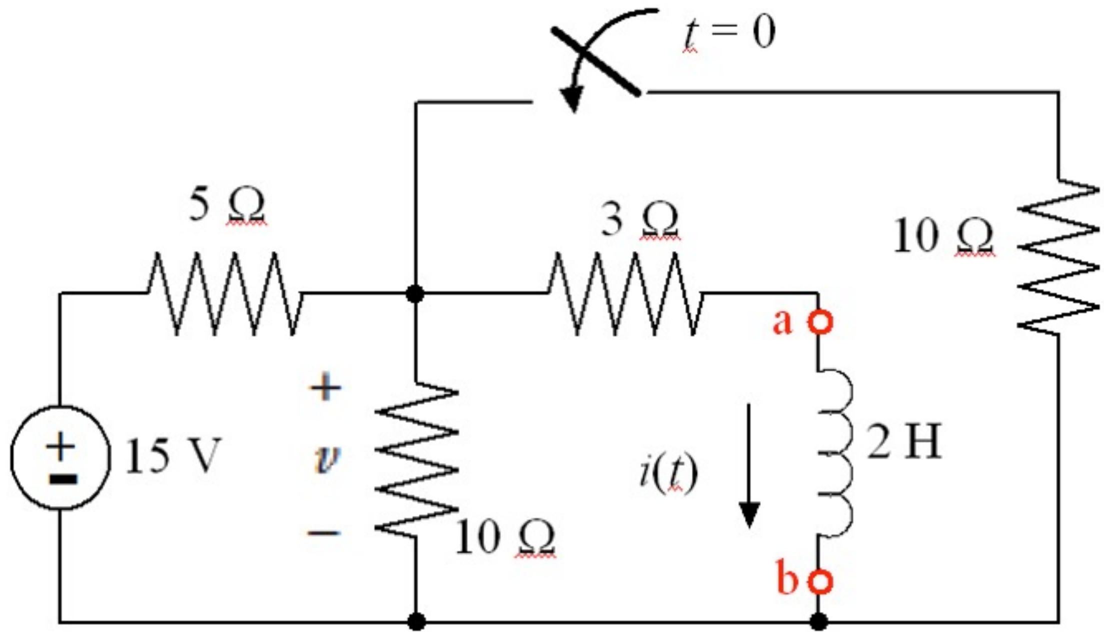


Node analysis:

$$\frac{v_0 - 15}{5} + \frac{v_0}{10} + \frac{v_0}{10} + 1.58 = 0$$

$$v_0 = 3.55 \quad \text{volts}$$

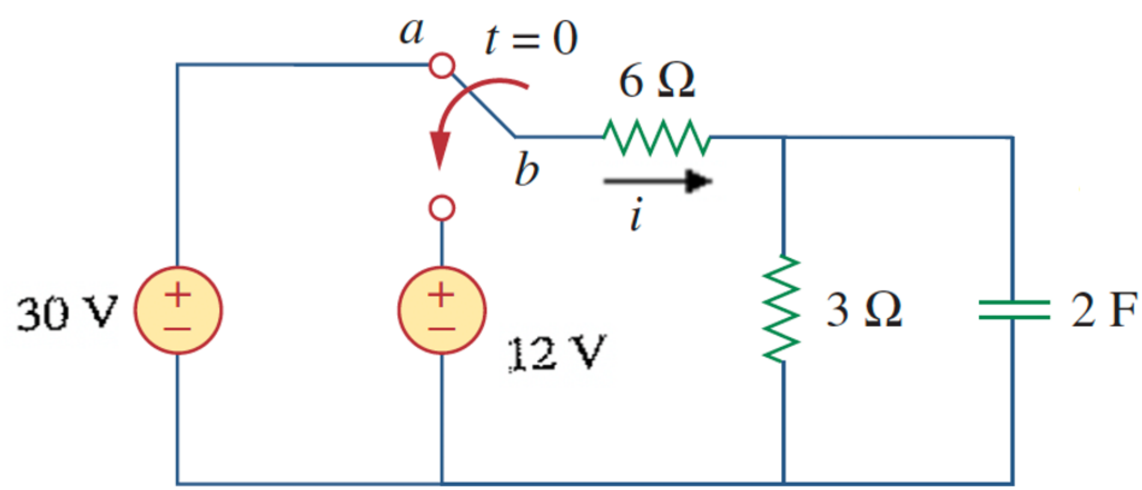
- So



$$
\begin{aligned}
v(t) &= (v_0 - v_\infty)\, e^{-\frac{R}{L}t} + v_\infty \\
&= (3.55 - 4.09)\, e^{-2.75\,t} + 4.09 \\
&= -0.55\, e^{-2.75\,t} + 4.09 \quad \text{volts}
\end{aligned}
$$

- Also, for $t < 0$, $v(t) = \frac{90}{13} = 4.74$ volts, so we see a "jump" at $t = 0$

Example: find $i(t)$

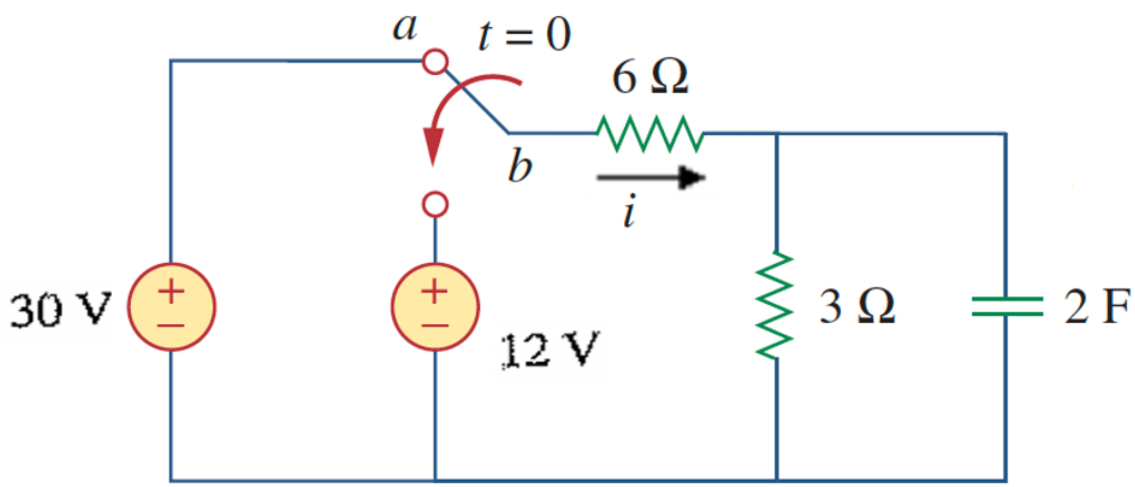


Form: $i(t) =$

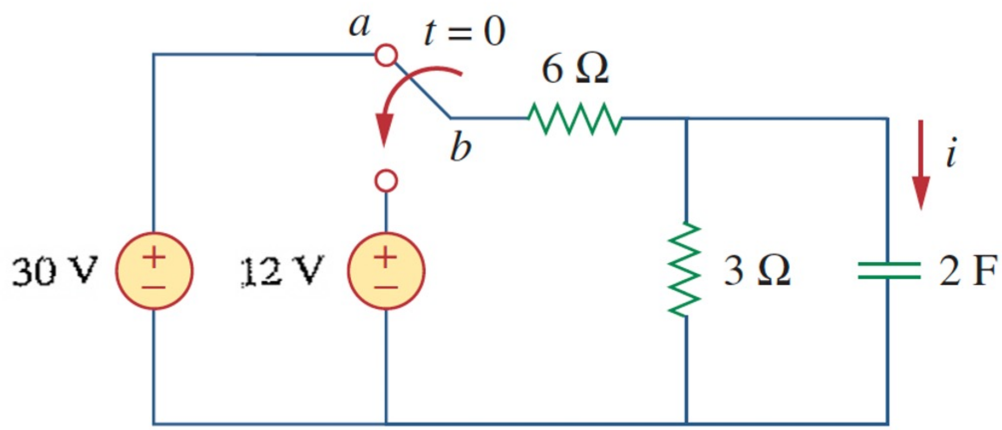
Time constant: $\tau = RC =$

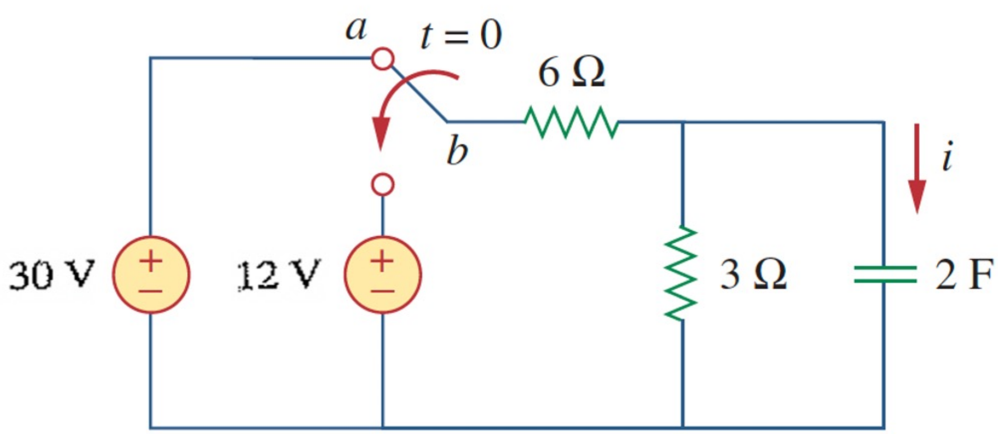
Final value: $i_{\infty} =$

Initial value: use $v_c(0)$



Example: same circuit, different variable

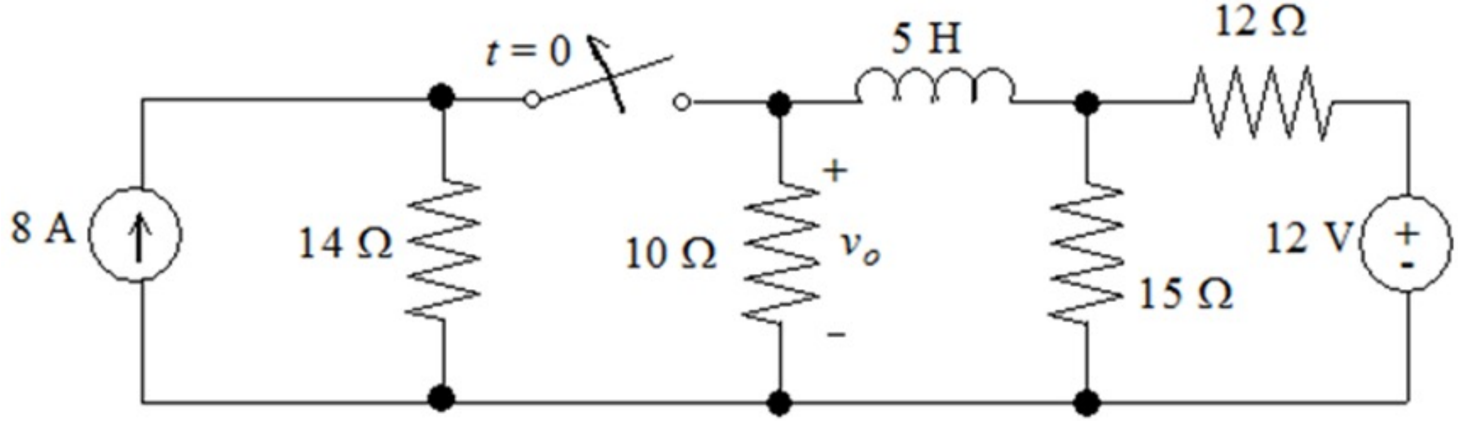




$$R = 2\ \Omega$$
$$i(\infty) = 0\ A$$
$$v_C(0) = 10\ V$$
$$i(0) = -3\ A$$

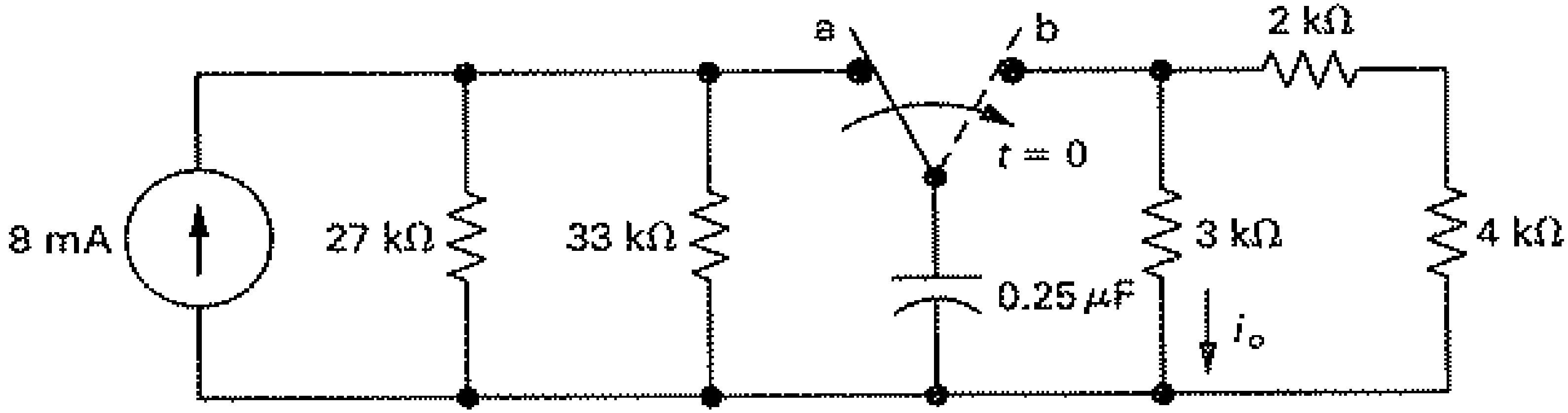
$R = 16.7\ \Omega$
$v(\infty) = 4\ V$
$i_L(0) = 3.2A$
$v(0) = -32\ V$

Practice problem: find $v_o(t)$



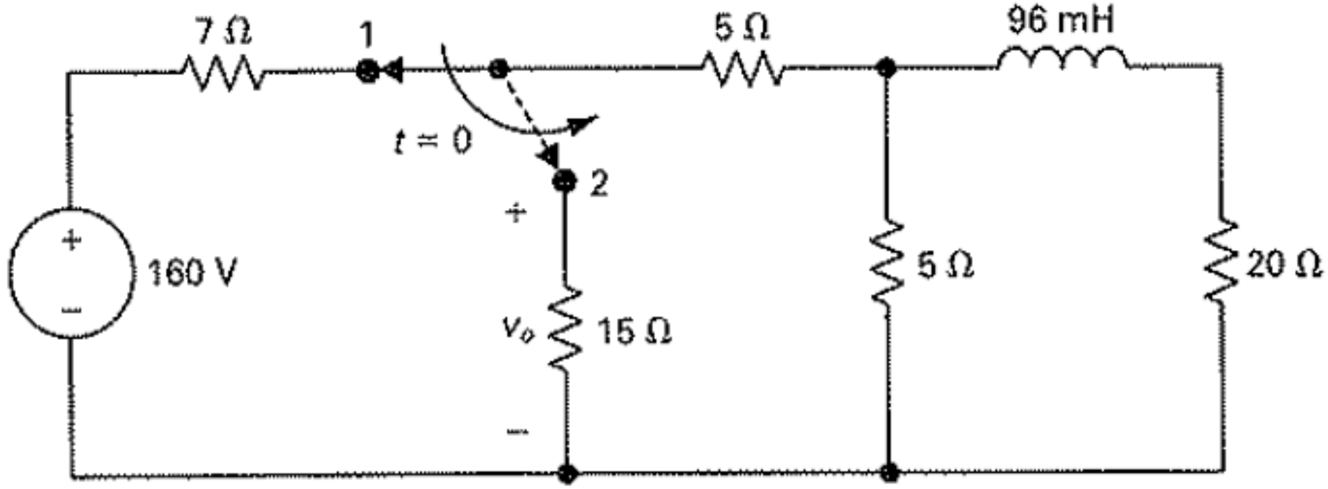
$R = 2\ k\Omega$
$i(\infty) = 0\ V$
$v_C(0) = 118.8\ V$
$i(0) = 39.6\ mA$

Practice problem: find $i_o(t)$



$R = 24\,\Omega$
$v(\infty) = 0\,V$
$i_L(0) = 2A$
$v(0) = -6\,V$

Practice problem: find $v_o(t)$



$-60e^{-80{,}000t}\ V$

Practice problem: find $v_o(t)$