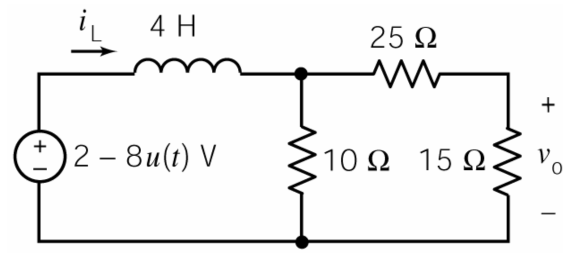
First–Order Circuits

Example 1:
Determine the voltage $v_o(t)$.



Solution:
This is a first order circuit containing an inductor.
First, determine $i_L(t)$.

Consider the circuit for time *t* < 0.

Step 1: Determine the initial inductor current.

Consider the circuit for time *t* > 0.

Step 2. The circuit will not be at steady state immediately after the source voltage changes abruptly at time $t = 0$. Determine the Norton equivalent circuit for the part of the circuit connected to the inductor.

Step 3. The time constant of a first order circuit containing an inductor is given by $\tau = \frac{L}{R_t}$.

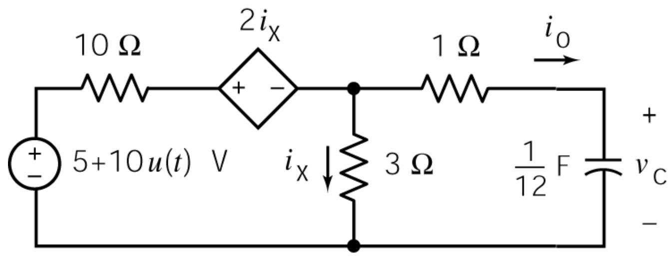
Then $a = \frac{1}{\tau}$.

Step 4. The inductor current is given by $i_L(t) = i_{sc} + \left(i(0) - i_{sc}\right)e^{-at}$ for $t \geq 0$

Step 5. Express the output voltage as a function of the source voltage and the inductor current.

Step 6. The output voltage is given by

Example 2:
Determine the current $i_o(t)$.



Solution:
This is a first order circuit containing a capacitor. First, determine $v_C(t)$.

Consider the circuit for time *t* < 0.

Step 1: Determine the initial capacitor voltage.

Consider the circuit for time *t* > 0.

Step 2. The circuit will not be at steady state immediately after the source voltage changes abruptly at time $t = 0$. Determine the Thevenin equivalent circuit for the part of the circuit connected to the capacitor. First, determine the open circuit voltage, v_{oc}:

Step 3. The time constant of a first order circuit containing an capacitor is given by $\tau = R_t C$.

Then $a = \frac{1}{\tau}$.

Step 4. The capacitor voltage is given by $v_C(t) = v_{oc} + (v_C(0) - v_{oc})e^{-at}$ for $t \ge 0$

Step 5. Express the output current as a function of the source voltage and the capacitor voltage.

Step 6. The output current is given by