THE OHIO STATE UNIVERSITY

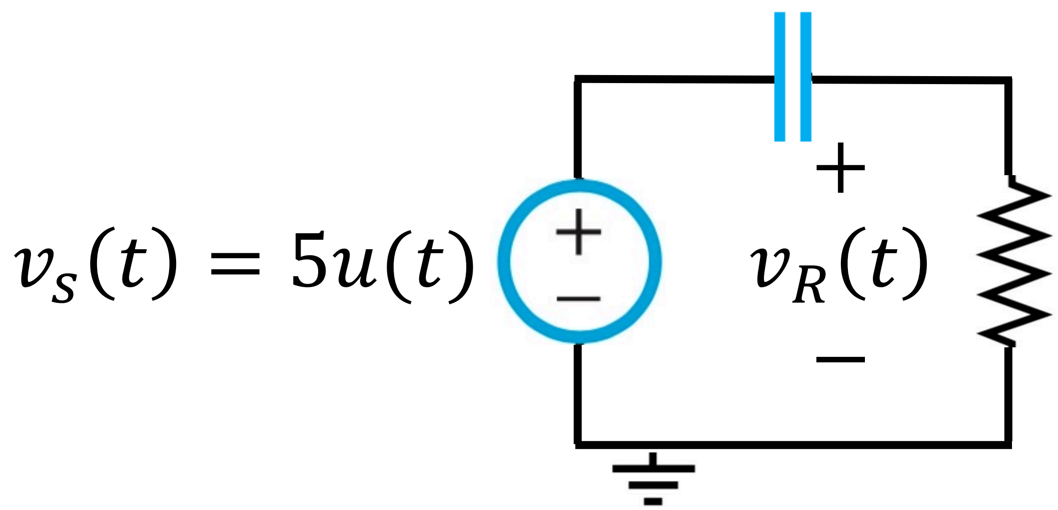
COLLEGE OF ENGINEERING

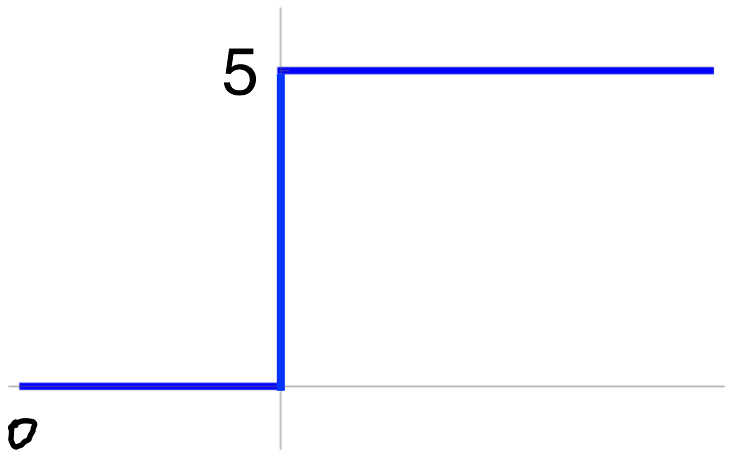
s-Domain Circuit Analysis

After This Lecture…

- Learning Objectives:
  - Use the Laplace transform for circuit analysis.

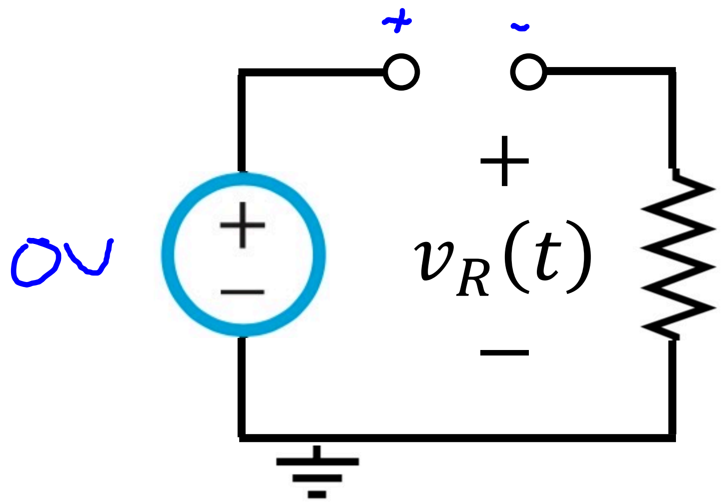
s-Domain Circuit Analysis





1. Calculate initial conditions.

s-Domain Circuit Analysis



1. Calculate initial conditions.

$V_C(0) = 0V$

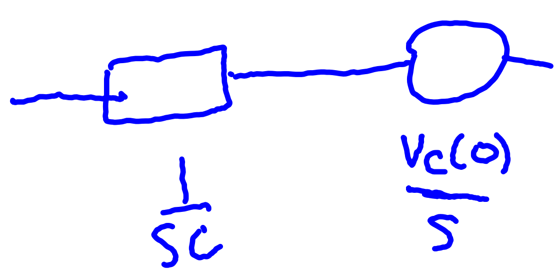
2. s-domain circuit.

$t > 0$

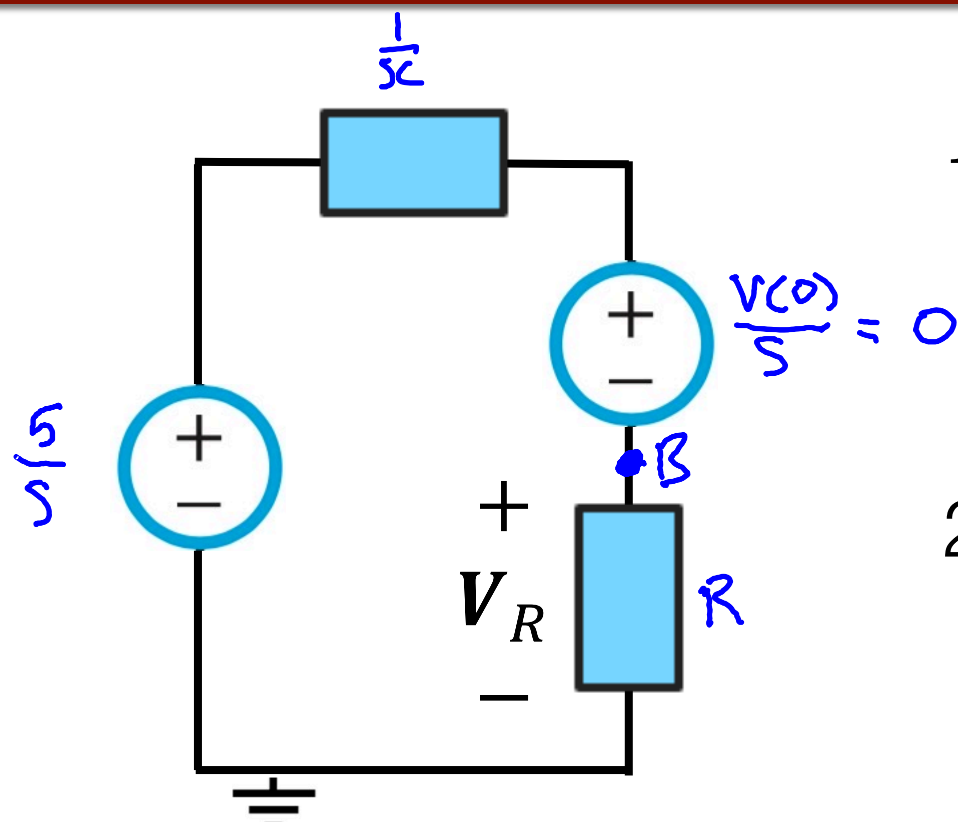
$V_S(t) = 5u(t) \rightarrow V_S(s) = \frac{5}{s}$

$Z_R = R$

Cap



s-Domain Circuit Analysis



1. Calculate initial conditions.

DC circuit

2. s-domain circuit.

Voltage Division

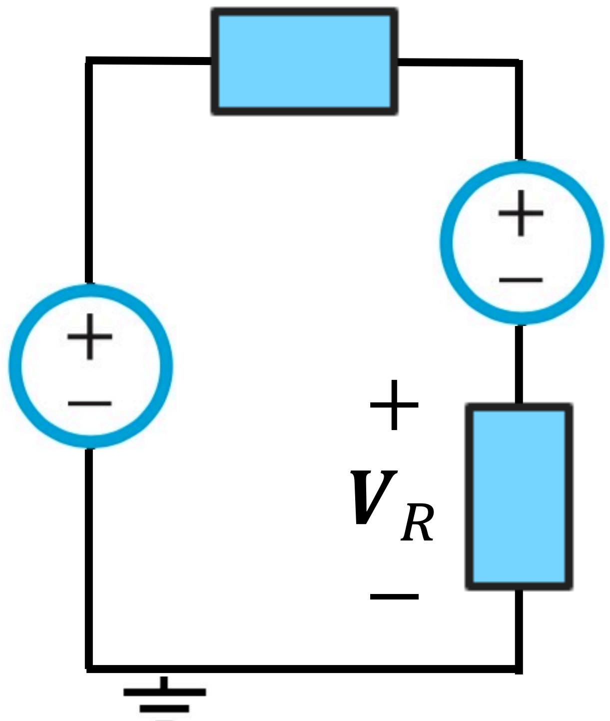
$$V_R = \frac{R}{R + \frac{1}{sC}} \cdot \frac{5}{s}$$

Highest exponent of S needs a coefficient of 1

$$= \frac{5R}{sR + \frac{1}{C}} \quad \frac{1/R}{1/R}$$

$$= \frac{5}{s + 1/CR}$$

s-Domain Circuit Analysis



1. Calculate initial conditions.

2. s-domain circuit.

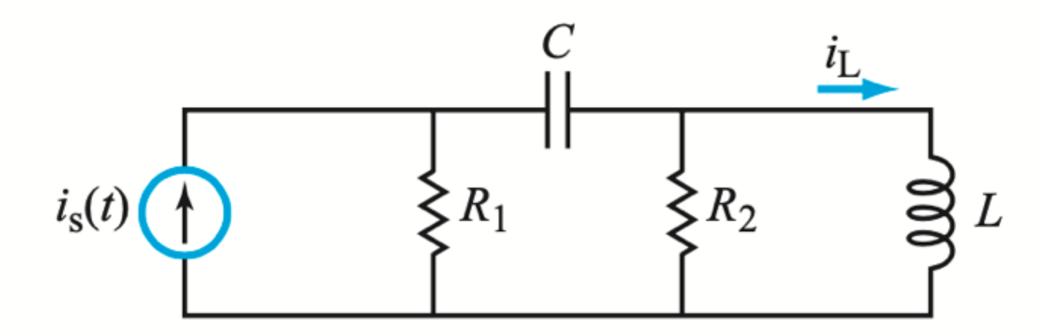
3. Go back to time domain.

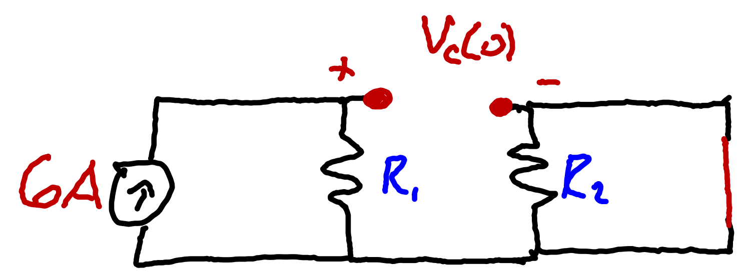
1. $\delta(t)$	$\longleftrightarrow$	1
2. $u(t)$	$\longleftrightarrow$	$\frac{1}{s}$
3. t	$\longleftrightarrow$	$\frac{1}{s^2}$
4. t^n	$\longleftrightarrow$	$\frac{n!}{s^{n+1}}$
5. e^{-at}	$\longleftrightarrow$	$\frac{1}{s+a}$
6. te^{-at}	$\longleftrightarrow$	$\frac{1}{(s+a)^2}$
7. $t^n e^{-at}$	$\longleftrightarrow$	$\frac{n!}{(s+a)^{n+1}}$

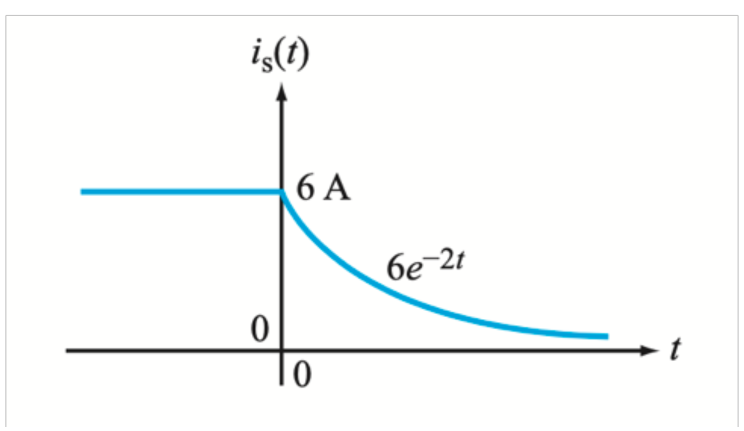
Example

Given the current-source waveform displayed below, determine $i_L(t)$ in the circuit, given that $R_1 = 10\Omega$, $R_2 = 5\Omega$, $L = 0.6196\text{H}$, and $LC = \left(\frac{1}{15}\right)\text{sec.}$

• initial condition $t<0$







$V_c(0) = V_{R_1}$

$= i_{R_1}(R_1) = 6(10)$

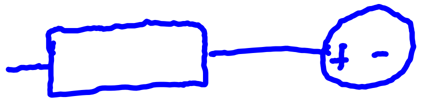
$= 60\text{V}$

$i_L(0) = 0\text{A}$

- Move circuit to S-Domain

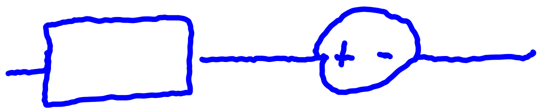
$$i_s(t) = 6e^{-2t} \Rightarrow I_s(s) = \frac{6}{s+2}$$

Capacitor

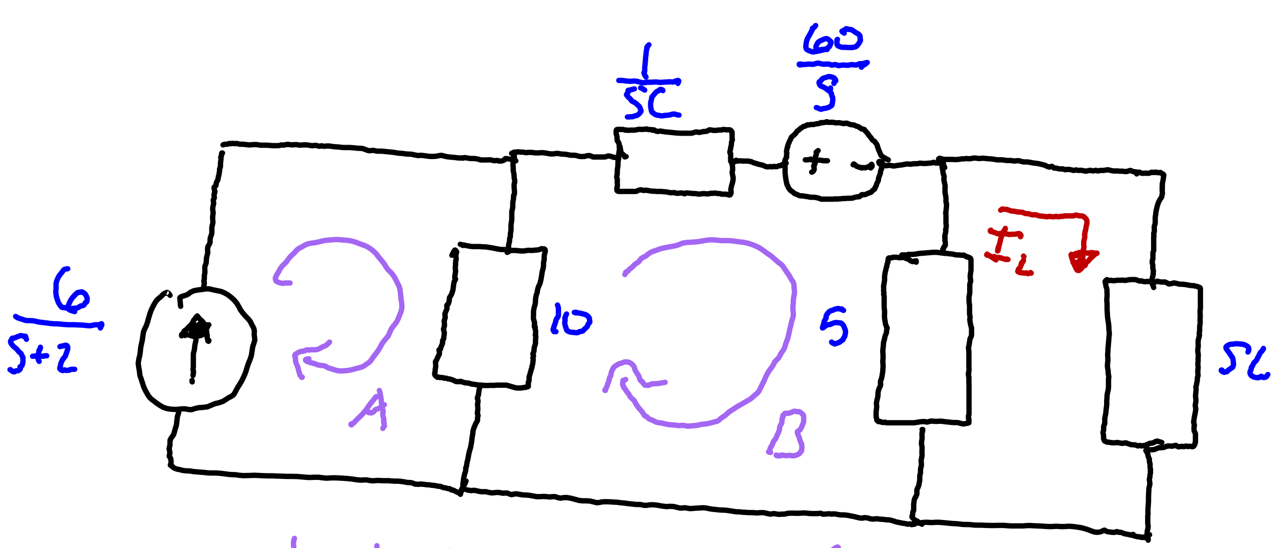


$$\frac{1}{sC} \qquad \frac{V_c(0)}{s} = \frac{60}{s}$$

inductor



$$sL \qquad i_L(0)L = 0$$



Mesh Current Analysis: $i_A = \frac{6}{s+2}$

KVL @ B:

$$V_{10} = V_{ZC} + \frac{60}{s} + V_5$$

$$10 i_{10} = \frac{1}{sC} i_{ZC} + \frac{60}{s} + 5 i_5$$

$$10\left(\frac{6}{s+2} - I_B\right) = \frac{1}{sC} I_B + \frac{60}{s} + 5(I_B - I_L)$$

$$\frac{60}{s+2} - \frac{60}{s} = I_B\left[\frac{1}{sC} + 5 + 10\right] - 5I_L$$

$$\frac{60s - 60s - 120}{(s+2)s} = I_B\left[\frac{1}{sC} + 15\right] - 5I_L \quad (1)$$

KVL @ L:

$$V_5 = V_{ZL}$$

$$5 i_5 = sL\, i_L$$

$$5(I_B - I_L) = sL I_L$$

$$5 I_B = I_L(sL + 5)$$

$$I_B = \frac{I_L(sL+5)}{5} \quad (2)$$

② in ①

I'm not writing all that, just download the slides bro

$$= I_L\left[s^2 + 6s + 5\right]$$

$$= I_L (s+1)(s+5)$$

$$I_L = \frac{-64.554}{(s+1)(s+2)(s+5)}$$