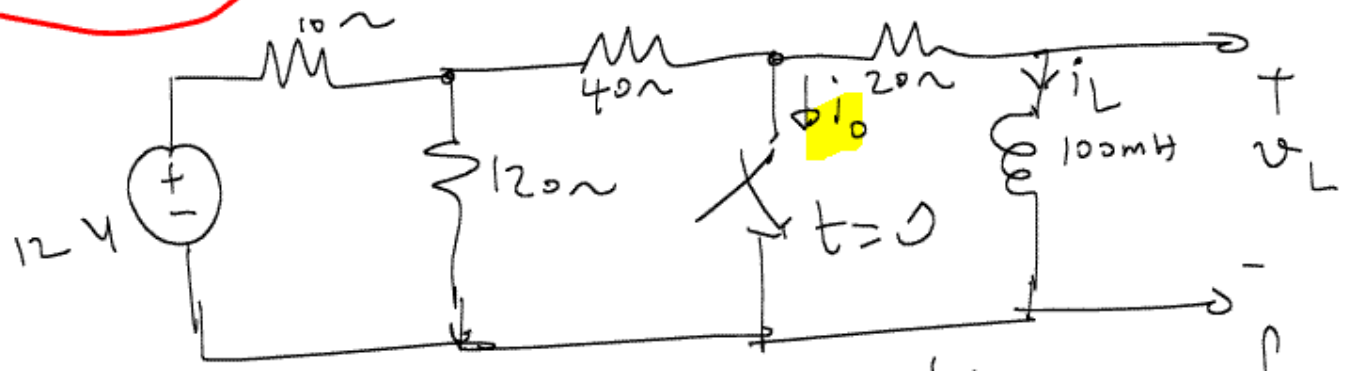
Lecture 12 - More chapter 7 examples

Administrivia:

- Lab next week: RC Circuits
- Midterm from 6:00-9:00 on Thursday??
- BY FRIDAY! (TOMORROW) ← check Google groups (under MIDTERM 2)

(7.3) [p. 306]



Q:) Switch is closed after being open for a long time

(a) Find $i_0(0^-)$ [instant before switch closes]

(b) Find: $i_L(0^-)$ (c) $i_0(0^+)$ (d) $i_L(0^+)$ (e) Find $i_0(t \to \infty)$

(f) Find $i_L(t \to \infty)$ (g) $i_L(t)$, $t \geq 0$ (h) $v_L(0^-)$, (i) $v_L(0^+)$

(j) $v_L(t \to \infty)$, (k) $v_L(t)$, $t \geq 0$ (l) $i_0(t)$, $t \geq 0$

Key: $f(t) = f_{final} + (f_{initial} - f_{final})\, e^{-t/\tau}$ $\left[\tau = \frac{L}{R}\right]$

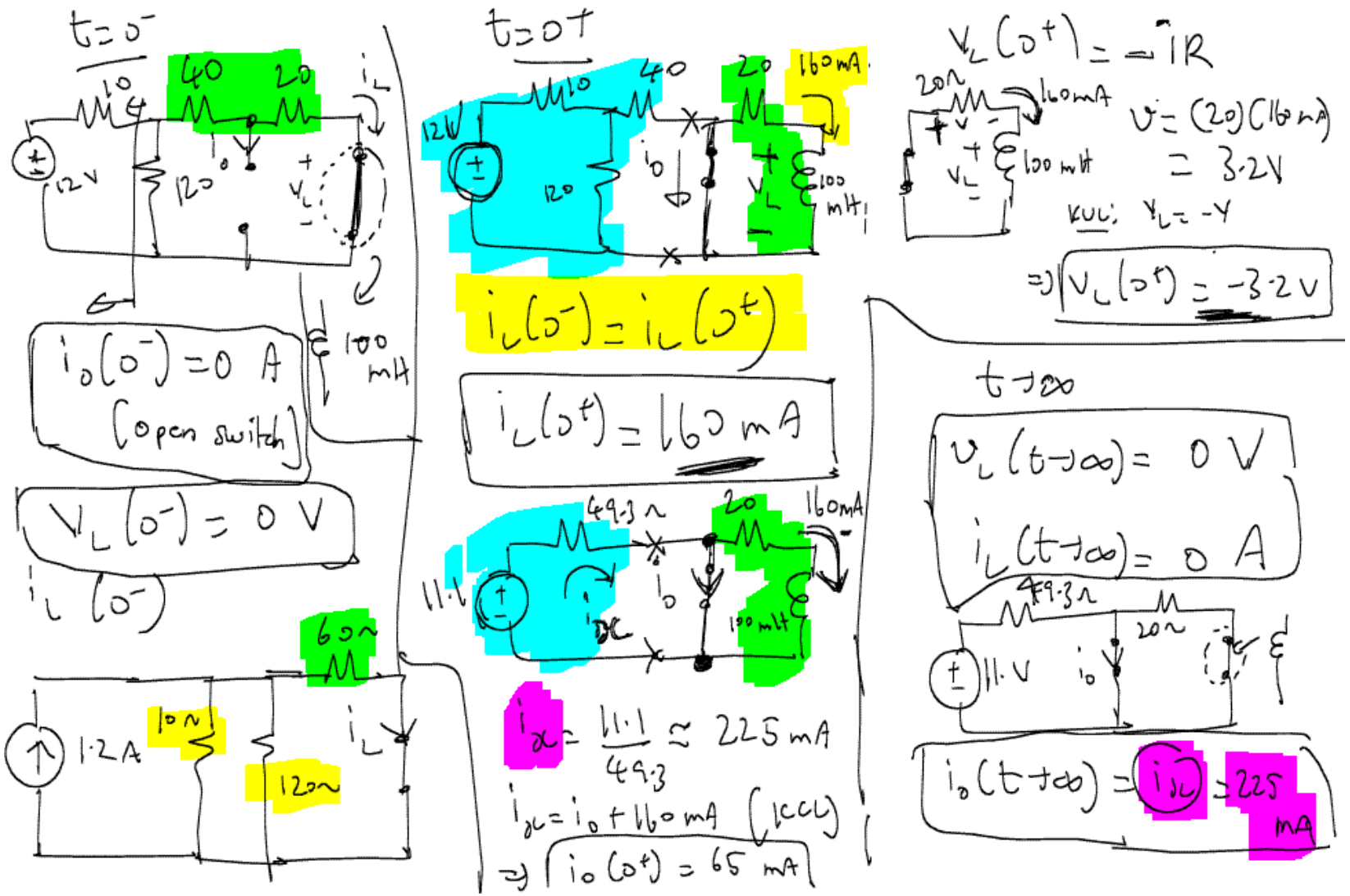
Step (1): Draw three circuits, at $t = 0^-$ [instant before switch closes]

$t = 0^+$ [instant after switch closed]

$t \to \infty$

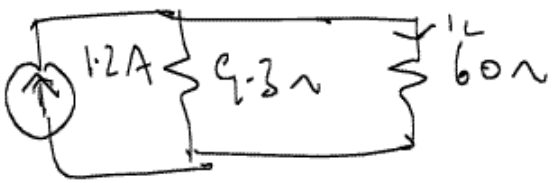
$V = L\frac{di}{dt}$ ⇒ i through an inductor cannot change instantly

as $t \to \infty$, i = constant ⇒ $V \to 0$


t = 0⁻
10
40
20
12V
120
100 mH
$i_o(0^-) = 0$ A
(open switch)
$V_L(0^-) = 0$ V
$i_L(0^-)$
60Ω
10Ω
120Ω
1.2A
t = 0⁺
160mA
$i_L(0^-) = i_L(0^+)$
$i_L(0^+) = 160$ mA
49.3Ω
11.1
$i_x = \frac{11.1}{49.3} \simeq 225$ mA
$i_x = i_o + 160$ mA (KCL)
$i_o(0^+) = 65$ mA
$V_L(0^+) = -iR$
$v = (20)(160\text{mA}) = 3.2$V
KVL: $V_L = -V$
$V_L(0^+) = -3.2$V
$t \to \infty$
$v_L(t \to \infty) = 0$ V
$i_L(t \to \infty) = 0$ A
11.1 V
$i_o(t \to \infty) = i_x = 225$ mA

$10 \| 120 = \frac{10 \cdot 120}{10+120}$

$= \frac{1200}{130} \approx 9.3\ \Omega$

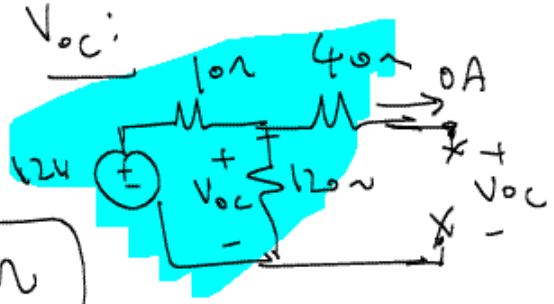


$i_L(0^-) = \frac{9.3}{(9.3+60)}(1.2)$

(current divider) $= 0.16\ A$

$\Rightarrow \boxed{i_L(0^-) = 160\ mA}$

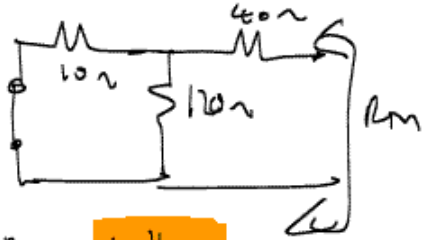
V_{oc}:



$V_{oc} = \left(\frac{120}{120+10}\right) 12$ (voltage divider)

$\Rightarrow V_{oc} = 11.1\ V$

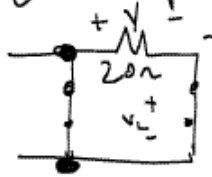
$R_{Th} = 49.3\ \Omega$



$R_{Th} = 10 \| 120 + 40$

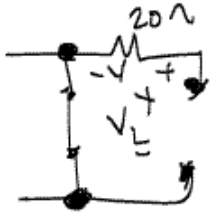
$= 49.3\ \Omega$

Note: What kind of inductor model as $t \to \infty$ (i.e., open or short)



$V = 0\ V$ (KVL, short circuit)

$i_L = 0$

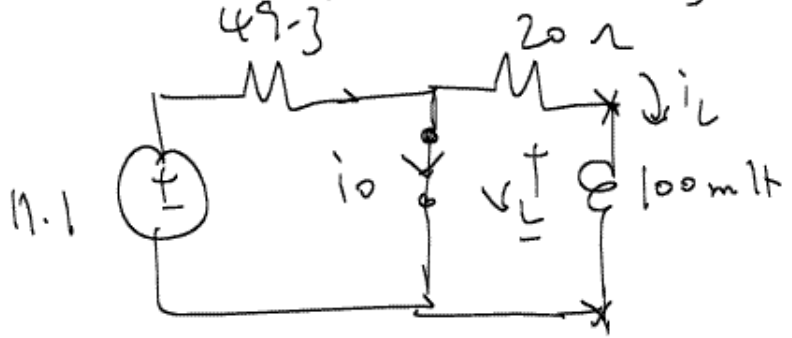


$i_L = 0\ A$

$V_L = 0\ V$

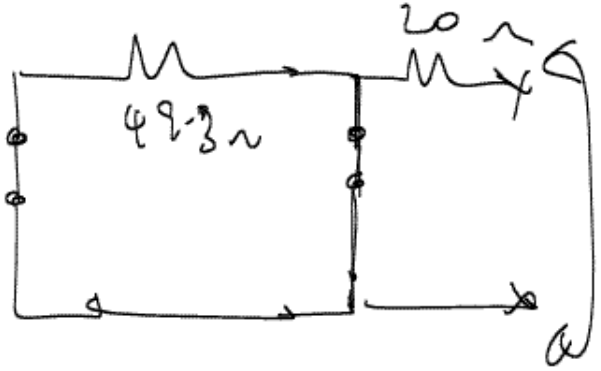
KVL: $V_L = V = i_L(20) = 0$

What's left? ⇒ τ, $i_o(t)$, $v_L(t)$, $i_L(t)$



$$\tau = \frac{L}{R_{Th}} = \frac{100\text{ mH}}{20\ \Omega} = 5\text{ ms}$$

$$i_o = i_{o_f} + \left(i_{o_i} - i_{o_f}\right)e^{-t/\tau}$$



$R_{Th} = 20\ \Omega \Rightarrow i_o = 225 + (65 - 225)e^{-t/5\text{ms}}$ mA

$$\Rightarrow \boxed{i_o = 225 - 160e^{-t/5\text{ms}}\ \text{mA}, \quad t \geq 0^+}$$

$$i_L(t) = i_{L_f} + \left(i_{L_i} - i_{L_f}\right)e^{-t/5\text{ms}}$$

$$\boxed{i_L(t) = 160\,e^{-t/5\text{ms}}\ \text{mA}, \quad t \geq 0^+}$$

$$v_L = v_{L_f} + \left(v_{L_i} - v_{L_f}\right)e^{-t/\tau}$$

$$\Rightarrow \boxed{v_L = -3.2e^{-t/5\text{ms}}\ \text{V}}$$

Note: $f(t) = f_{final} + (f_{initial} - f_{final}) e^{-t/\tau}$

$f(t=0) = \cancel{f_{final}} + f_{initial} - \cancel{f_{final}} = f_{initial}$

$f(t \to \infty) = f_{final}$ //

Next time: → Operational amplifiers intro.