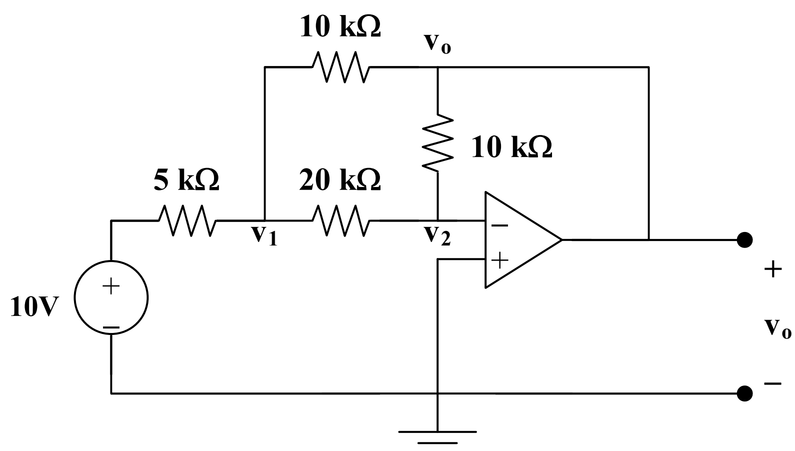
Chapter 5, Solution 14.

Transform the current source as shown below. At node 1,

$$\frac{10 - v_1}{5} = \frac{v_1 - v_2}{20} + \frac{v_1 - v_o}{10}$$



But $v_2 = 0$. Hence $40 - 4v_1 = v_1 + 2v_1 - 2v_o \longrightarrow 40 = 7v_1 - 2v_o$ (1)

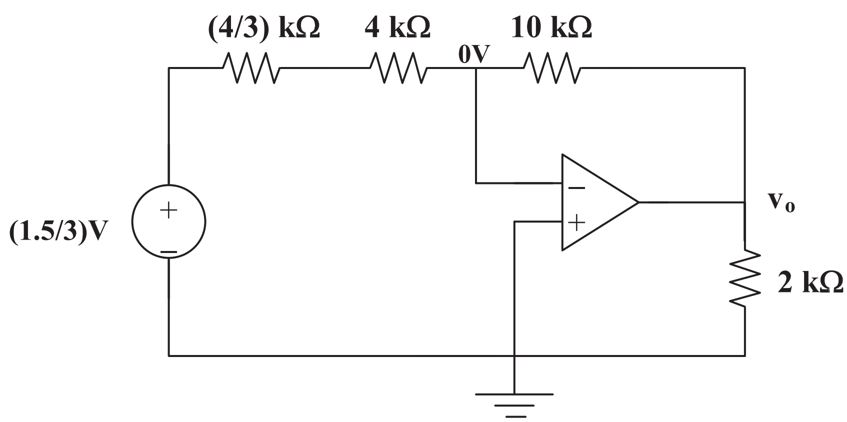
At node 2, $\frac{v_1 - v_2}{20} = \frac{v_2 - v_o}{10}, \quad v_2 = 0$ or $v_1 = -2v_o$ (2)

From (1) and (2), $40 = -14v_o - 2v_o \longrightarrow v_o = \mathbf{-2.5V}$

Chapter 5, Solution 19.

We convert the current source and back to a voltage source.

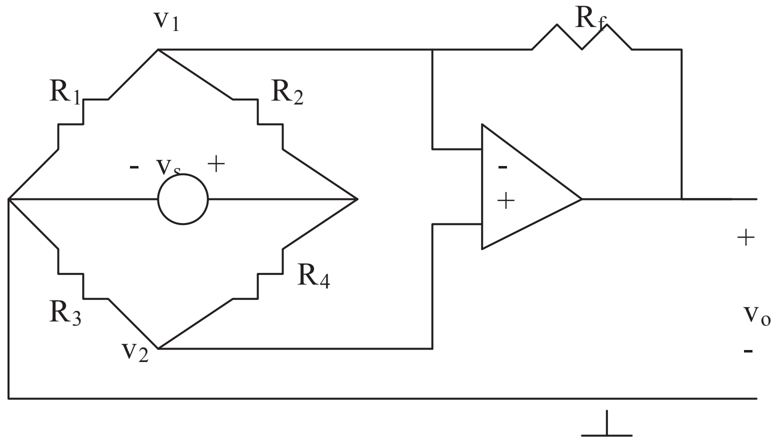
$$2\|4 = \frac{4}{3}$$



$$v_o = -\frac{10k}{\left(4+\frac{4}{3}\right)k}\left(\frac{1.5}{3}\right) = -937.5 \text{ mV}.$$

$$i_o = \frac{v_o}{2k} + \frac{v_o - 0}{10k} = \mathbf{-562.5\ \mu A}.$$

Chapter 5, Solution 24



We notice that $v_1 = v_2$. Applying KCL at node 1 gives

$$\frac{v_1}{R_1} + \frac{(v_1 - v_s)}{R_2} + \frac{v_1 - v_o}{R_f} = 0 \quad \longrightarrow \quad \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_f}\right)v_1 - \frac{v_s}{R_2} = \frac{v_o}{R_f} \qquad (1)$$

Applying KCL at node 2 gives

$$\frac{v_1}{R_3} + \frac{v_1 - v_s}{R_4} = 0 \quad \longrightarrow \quad v_1 = \frac{R_3}{R_3 + R_4} v_s \qquad (2)$$

Substituting (2) into (1) yields

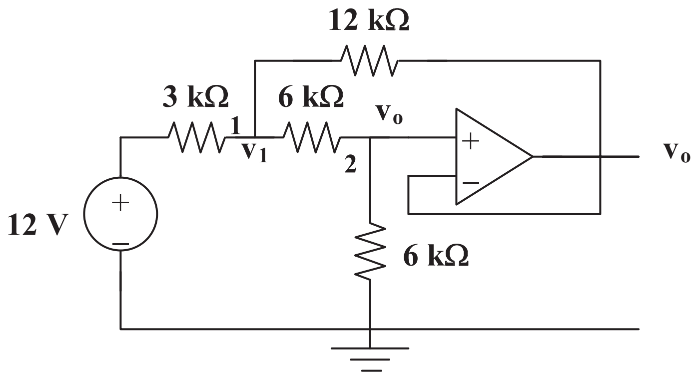
$$v_o = R_f \left[\left(\frac{R_3}{R_1} + \frac{R_3}{R_f} - \frac{R_4}{R_2}\right)\left(\frac{R_3}{R_3 + R_4}\right) - \frac{1}{R_2}\right] v_s$$

i.e.

$$\underline{\boldsymbol{k = R_f \left[\left(\frac{R_3}{R_1} + \frac{R_3}{R_f} - \frac{R_4}{R_2}\right)\left(\frac{R_3}{R_3 + R_4}\right) - \frac{1}{R_2}\right]}}$$

Chapter 5, Solution 31.

After converting the current source to a voltage source, the circuit is as shown below:



At node 1,

$$\frac{12 - v_1}{3} = \frac{v_1 - v_o}{6} + \frac{v_1 - v_o}{12} \longrightarrow 48 = 7v_1 - 3v_o \qquad (1)$$

At node 2,

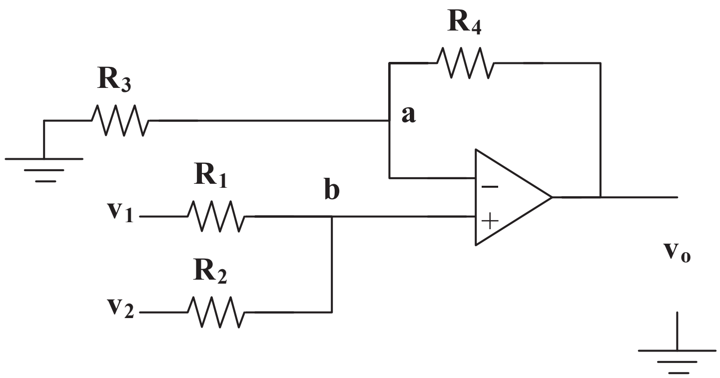
$$\frac{v_1 - v_o}{6} = \frac{v_o - 0}{6} = i_x \longrightarrow v_1 = 2v_o \qquad (2)$$

From (1) and (2),

$$v_o = \frac{48}{11}$$

$$i_x = \frac{v_o}{6k} = \mathbf{727.2\mu A}$$

Chapter 5, Solution 44.



At node b, $\frac{v_b - v_1}{R_1} + \frac{v_b - v_2}{R_2} = 0 \longrightarrow v_b = \frac{\frac{v_1}{R_1} + \frac{v_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}$ (1)

At node a, $\frac{0 - v_a}{R_3} = \frac{v_a - v_o}{R_4} \longrightarrow v_a = \frac{v_o}{1 + R_4/R_3}$ (2)

But $v_a = v_b$. We set (1) and (2) equal.

$$\frac{v_o}{1 + R_4/R_3} = \frac{R_2 v_1 + R_1 v_2}{R_1 + R_2}$$

or

$$v_o = \frac{(R_3 + R_4)}{R_3(R_1 + R_2)}(R_2 v_1 + R_1 v_2)$$

Chapter 5, Solution 65

The output of the first op amp (to the left) is 6 mV. The second op amp is an inverter so that its output is

$$v_o' = -\frac{30}{10}(6\text{mV}) = \text{-}18\,\text{mV}$$

The third op amp is a noninverter so that

$$\boldsymbol{v_o' = \frac{40}{40+8}v_o \quad \longrightarrow \quad v_o = \frac{48}{40}v_o' = \underline{-21.6\,\text{mV}}}$$

Chapter 5, Solution 73.

The first stage is a noninverting amplifier. The output is

$$v_{o1} = \frac{50}{10}(1.8) + 1.8 = 10.8V$$

The second stage is another noninverting amplifier whose output is

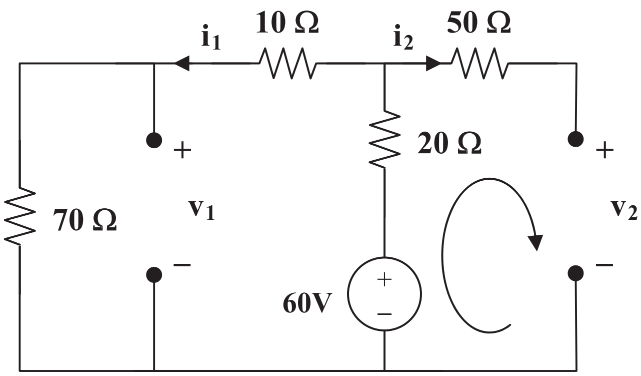
$$v_L = v_{01} = \mathbf{10.8V}$$

Chapter 5, Solution 89.

A **summer** with $\mathbf{v_o = -v_1 - (5/3)v_2}$ where v_2 = **6-V battery** and an **inverting amplifier** with $\mathbf{v_1 = -12v_s}$.

Chapter 6, Solution 13.

Under dc conditions, the circuit becomes that shown below:



$i_2 = 0$, $i_1 = 60/(70+10+20) = 0.6$ A

$v_1 = 70i_1 = 42$ V, $v_2 = 60–20i_1 = 48$ V

Thus, $v_1 =$ **42 V**, $v_2 =$ **48 V**.

Chapter 6, Solution 21.

4μF in series with 12μF = (4x12)/16 = 3μF
3μF in parallel with 3μF = 6μF
6μF in series with 6μF = 3μF
3μF in parallel with 2μF = 5μF
5μF in series with 5μF = 2.5μF

Hence C_{eq} = **2.5μF**

Chapter 6, Solution 25.

(a) For the capacitors in series,

$$Q_1 = Q_2 \longrightarrow C_1 v_1 = C_2 v_2 \longrightarrow \frac{v_1}{v_2} = \frac{C_2}{C_1}$$

$$v_s = v_1 + v_2 = \frac{C_2}{C_1} v_2 + v_2 = \frac{C_1 + C_2}{C_1} v_2 \longrightarrow \boldsymbol{v_2 = \frac{C_1}{C_1 + C_2} v_s}$$

Similarly, $\boldsymbol{v_1 = \frac{C_2}{C_1 + C_2} v_s}$

(b) For capacitors in parallel

$$v_1 = v_2 = \frac{Q_1}{C_1} = \frac{Q_2}{C_2}$$

$$Q_s = Q_1 + Q_2 = \frac{C_1}{C_2} Q_2 + Q_2 = \frac{C_1 + C_2}{C_2} Q_2$$

or

$$Q_2 = \frac{C_2}{C_1 + C_2}$$

$$Q_1 = \frac{C_1}{C_1 + C_2} Q_s$$

$$i = \frac{dQ}{dt} \longrightarrow \boldsymbol{i_1 = \frac{C_1}{C_1 + C_2} i_s}, \quad \boldsymbol{i_2 = \frac{C_2}{C_1 + C_2} i_s}$$

Chapter 6, Solution 40.

$$i = \begin{cases} 5t, & 0 < t < 2ms \\ 10, & 2 < t < 4ms \\ 30 - 5t, & 4 < t < 6ms \end{cases}$$

$$v = L\frac{di}{dt} = \frac{5x10^{-3}}{10^{-3}}\begin{cases} 5, & 0 < t < 2ms \\ 0, & 2 < t < 4ms \\ -5, & 4 < t < 6ms \end{cases} = \begin{cases} 25, & 0 < t < 2ms \\ 0, & 2 < t < 4ms \\ -25, & 4 < t < 6ms \end{cases}$$

At t = 1ms, v = **25 V**
At t = 3ms, v = **0 V**
At t = 5ms, v= **–25 V**

Chapter 6, Solution 53.

$$L_{eq} = 6 + 10 + 8 \| [5 \| (8+12) + 6 \| (8+4)]$$

$$= 16 + 8 \| (4+4) = 16 + 4$$

L_{eq} = **20 mH**

Chapter 6, Solution 53.

$$L_{eq} = 6 + 10 + 8 \| \left[5 \| (8 + 12) + 6 \| (8 + 4) \right]$$

$$= 16 + 8 \| (4 + 4) = 16 + 4$$

L_{eq} = **20 mH**

Chapter 6, Solution 65.

(a) $w_5 = \frac{1}{2}L_1 i_1^2 = \frac{1}{2}x5x(4)^2 = \mathbf{40\ J}$

$w_{20} = \frac{1}{2}(20)(-2)^2 = \mathbf{40\ J}$

(b) $w = w_5 + w_{20} = \mathbf{80\ J}$

(c) $i_1 = \frac{1}{L_1}\int_0^t -50e^{-200t}dt + i_1(0) = \frac{1}{5}\left(\frac{1}{200}\right)\left(50e^{-200t}x10^{-3}\right)\Big|_0^t + 4$

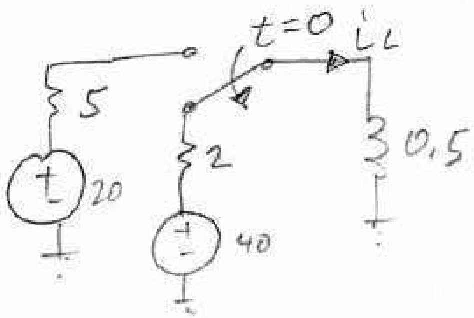
$= \mathbf{[5x10^{-5}(e^{-200t} - 1) + 4]\ A}$

$i_2 = \frac{1}{L_2}\int_0^t -50e^{-200t}dt + i_2(0) = \frac{1}{20}\left(\frac{1}{200}\right)\left(50e^{-200t}x10^{-3}\right)\Big|_0^t - 2$

$= \mathbf{[1.25x10^{-5}\ (e^{-200t} - 1) - 2]\ A}$

(d) $i = i_1 + i_2 = \mathbf{[6.25x10^{-5}\ (e^{-200t} - 1) + 2]\ A}$

Supplemental 1



Initial conditions:

$t=0^-$	$t=0^+$	$t=\infty$
$I_L(t) = 4A$	$I_L = 4A$	$I_L = 20A$
$V_L(t) = 0V$	$V_L = 32V$	$V_L = 0$

KVL: $-40 + I_L 2 + \frac{1}{2}\frac{dI_L}{dt} = 0$

$\Rightarrow \frac{1}{4} I_L' + I_L = 20$

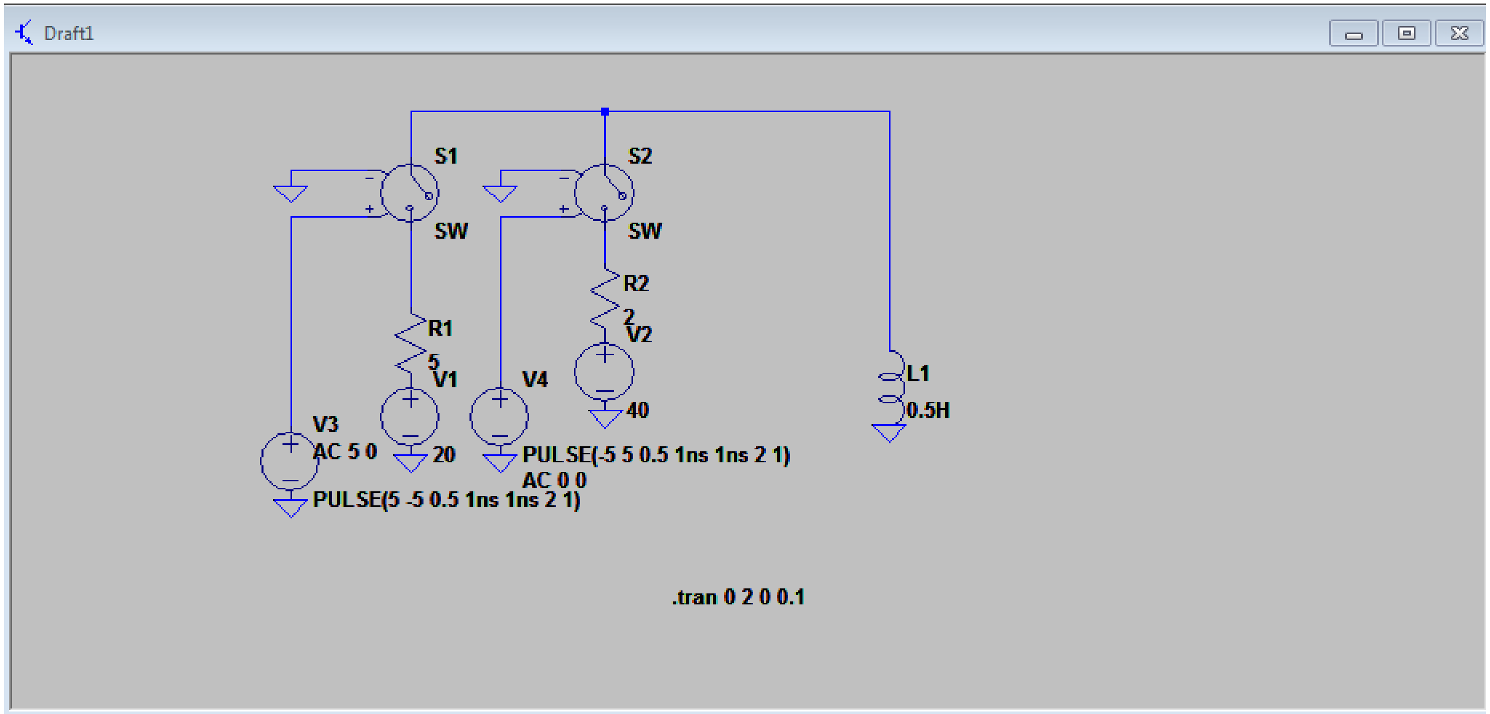
$\Rightarrow \tau = \frac{1}{4} \Rightarrow i_H(t) = C e^{-t/\tau}$

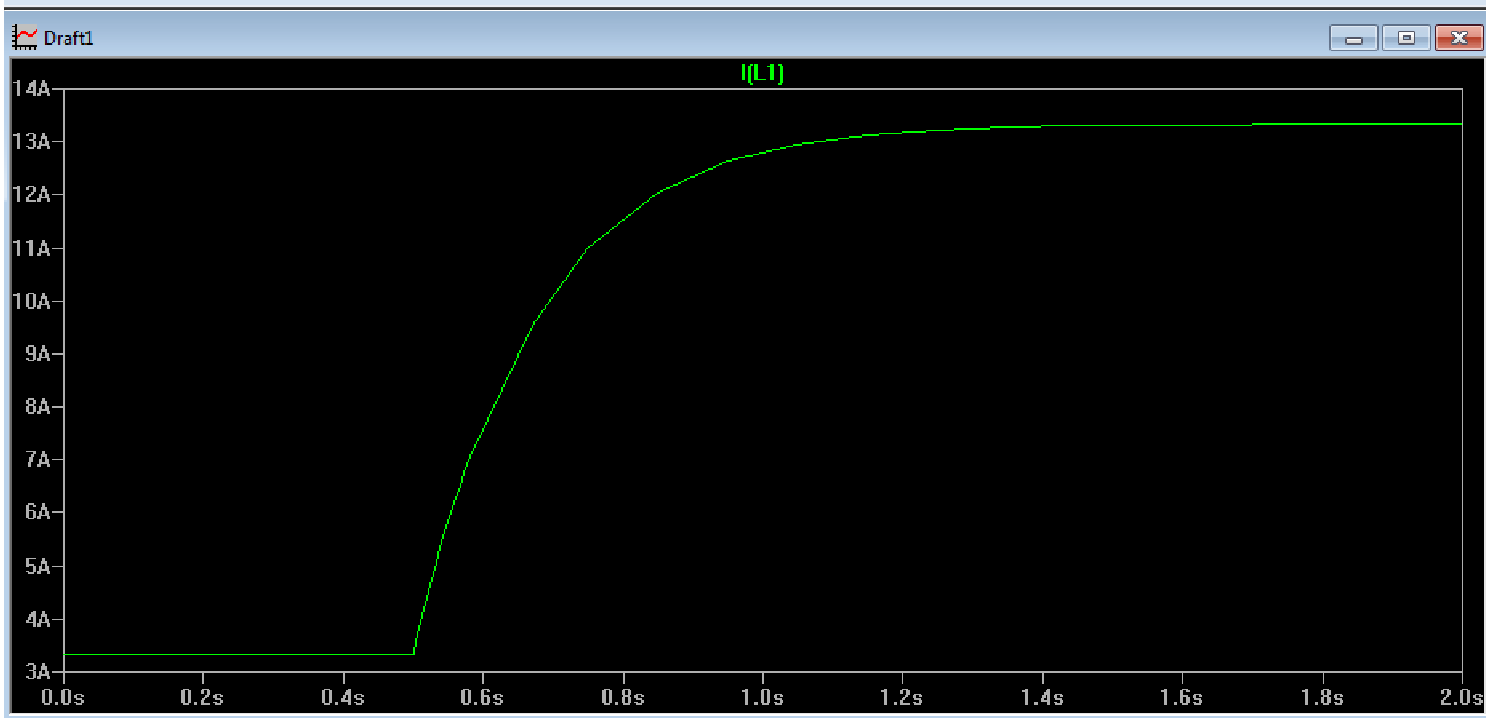
General solution: $i(t) = C e^{-t/\tau} + i_p \Rightarrow i_p = 20A \ @ \ t = \infty$

$i(t) = C e^{-t/\tau} + 20$

$\Rightarrow i(0^+) = 4 = C e^{-t/\tau} + 20 \Rightarrow -16 = C$

$\Rightarrow \boxed{i(t) = 20 - 16 e^{-4t}}$


Draft1
S1
SW
S2
SW
R1
5
V1
20
R2
2
V2
40
V3
AC 5 0
PULSE(5 -5 0.5 1ns 1ns 2 1)
V4
PULSE(-5 5 0.5 1ns 1ns 2 1)
AC 0 0
L1
0.5H
.tran 0 2 0 0.1


Draft1
I(L1)
14A
13A
12A
11A
10A
9A
8A
7A
6A
5A
4A
3A
0.0s
0.2s
0.4s
0.6s
0.8s
1.0s
1.2s
1.4s
1.6s
1.8s
2.0s