5.1 Use linearity and the assumption that $V_o = 1$ V to find the actual value of V_o in Fig. P5.1.

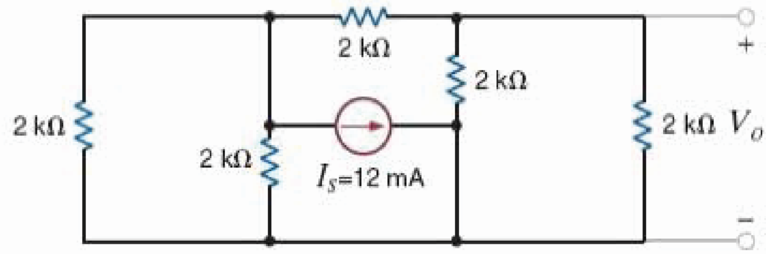
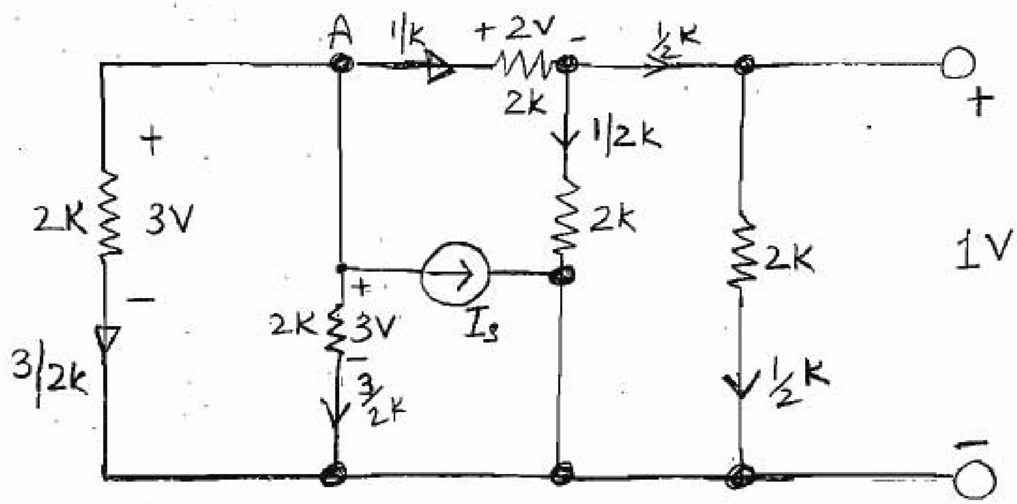


Figure P5.1

SOLUTION:



KCL at node

$$\frac{3}{2k} + \frac{3}{2k} + I_s + \frac{1}{k} = 0$$

$$I_s = -\frac{4}{k}\,A$$

$$\frac{V_o}{I_s} = \frac{1}{-\frac{4}{k}A} = \frac{V_o}{\frac{12}{k}A} \Rightarrow V_o = -3V$$

5.13 Find V_o in the circuit in Fig. P5.13 using superposition.

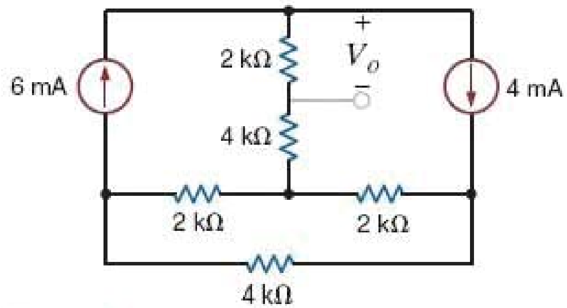
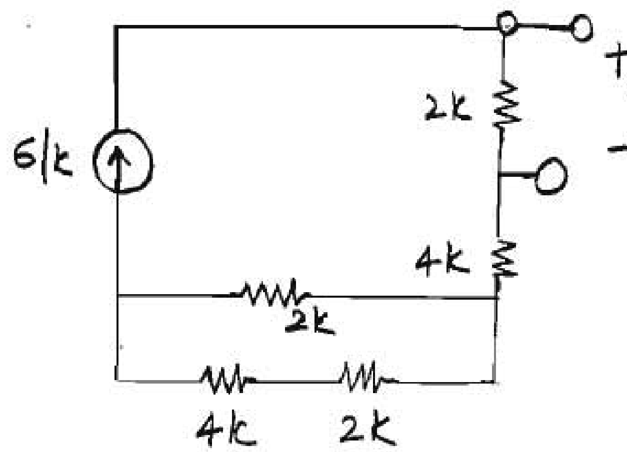
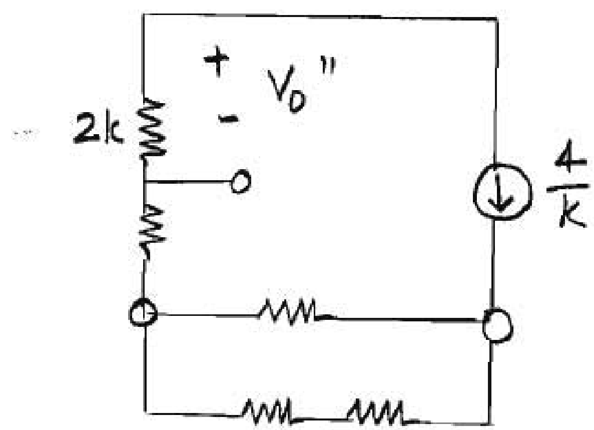


Figure P5.13

SOLUTION:



$V_o' = 12V$



$V_o'' = -8V$

$$V_o = V_o' + V_o'' = 12 - 8 = 4V$$

5.21 Use superposition to find I_o in the circuit in Fig. P5.21.

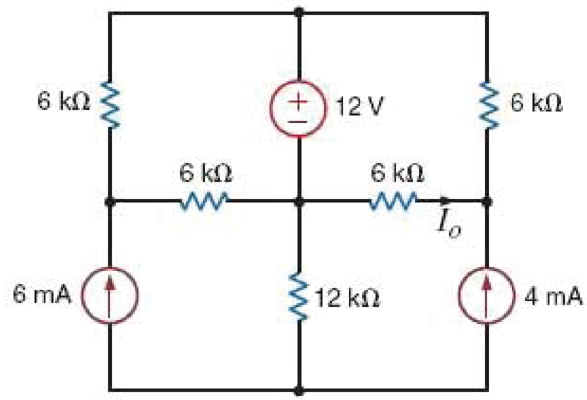
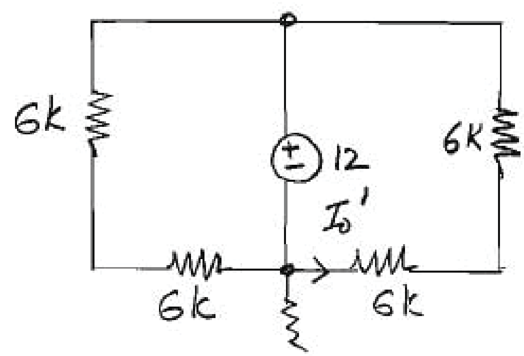
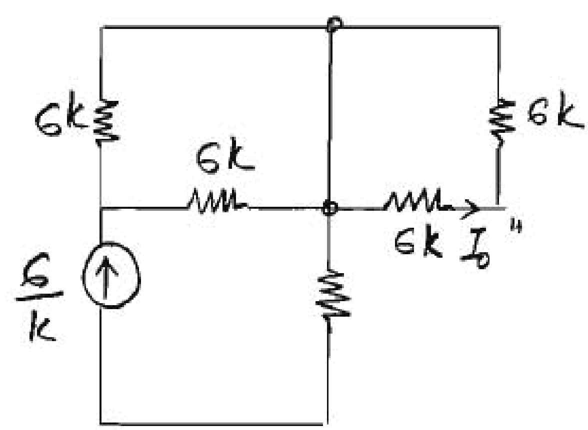


Figure P5.21

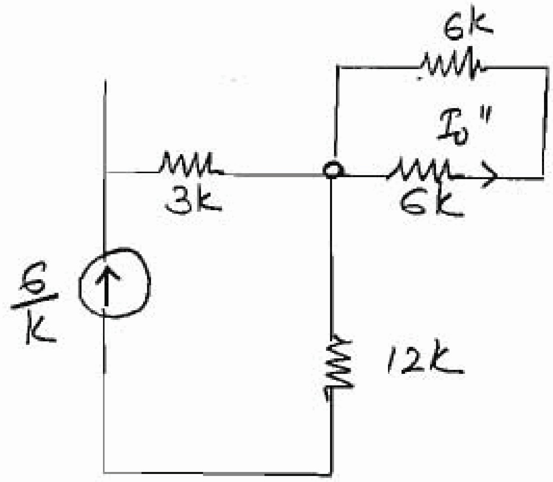
SOLUTION:



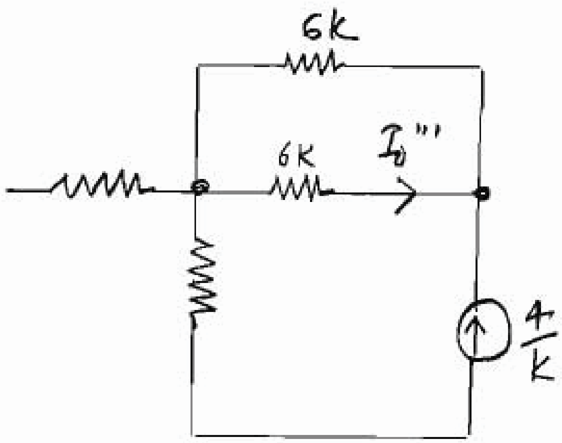
$I_o' = -1mA$



$I_o'' \Rightarrow$



$I_o'' = 0$



$I_o''' = -2mA$

$$I_o = I_o' + I_o'' + I_o'''$$
$$= -1 + 0 - 2$$
$$= -3mA$$

5.4 Find I_o in the circuit in Fig. P5.4 using linearity and the assumption that $I_o = 1$ mA.

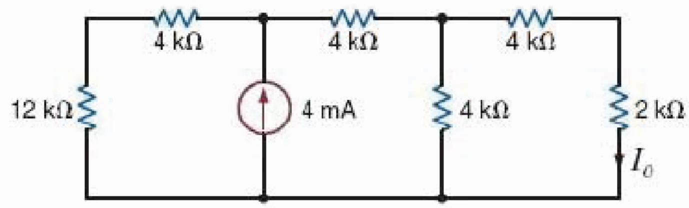
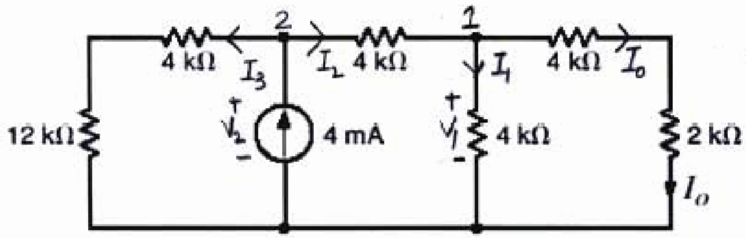


Figure P5.4

SOLUTION:



Assume $I_0 = 1\text{mA}$

$$V_1 = I_0\,(2k + 4k) = 1m\,(6k) = 6\,V$$

KCL at 1: $I_2 = I_1 + I_0$

$$I_2 = \frac{V_1}{4k} + I_0 = \frac{6}{4k} + 1m = 2.5mA$$

KVL around middle loop:

$$V_2 = I_2\,(4k) + V_1 = 2.5m(4k) + 6 = 16V$$

KCL at 2: $I_S = I_3 + I_2$

$$I_S = \frac{V_2}{16k} + 2.5m = \frac{16}{16k} + 2.5m = 3.5mA$$

Actually, $I_S = 4mA$

$$I_0 = 1m\left(\frac{4m}{3.5m}\right) = 1.14mA$$

5.40 Find I_o in the circuit in Fig. P5.40 using Thévenin's theorem.

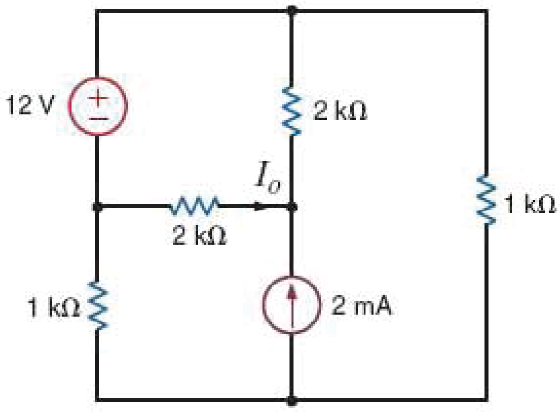
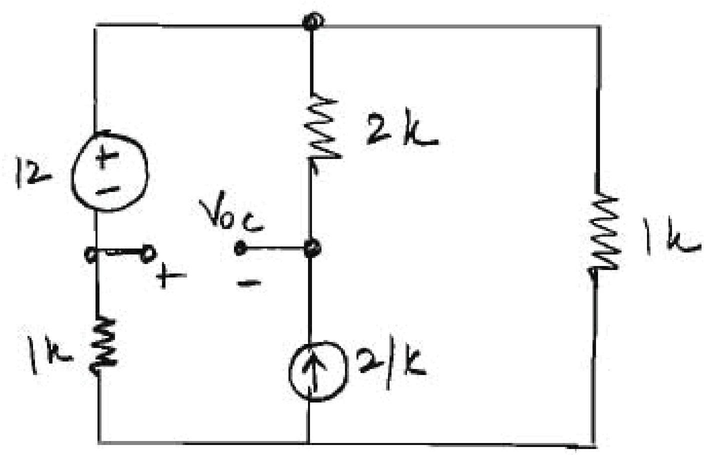


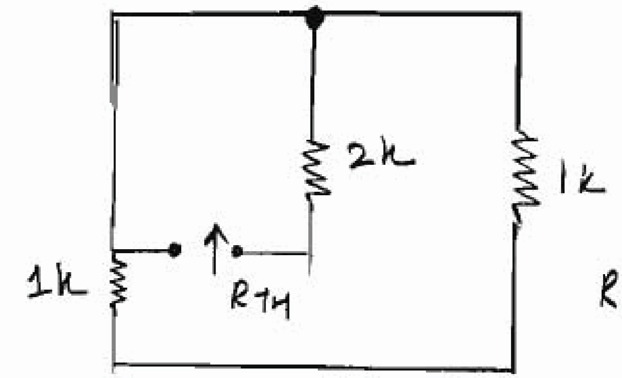
Figure P5.40

SOLUTION:

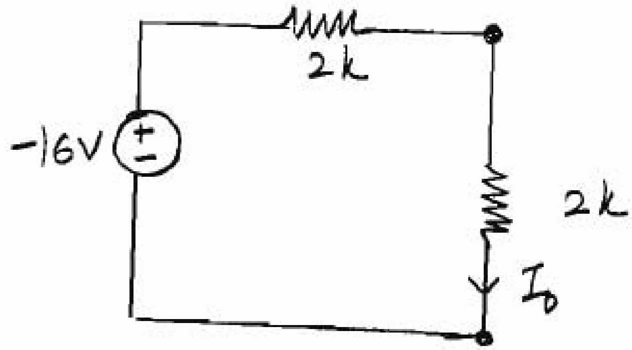


$$-V_{oc} - 12 - 2k\left(\frac{2}{k}\right) = 0$$

$$V_{oc} = -16V$$



$R_{TH} = 2k$



$$I_o = \frac{-16}{4k}$$
$$= -4mA$$

5.53 Find I_o in the network in Fig. P5.53 using Norton's theorem.

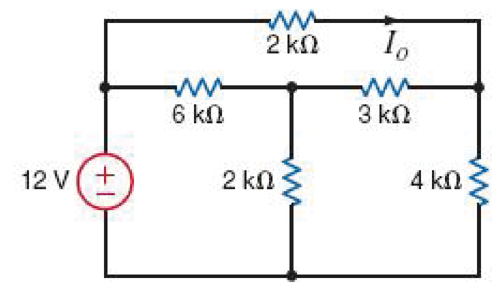
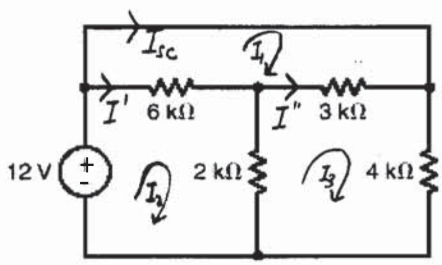


Figure P5.53

SOLUTION:



$I_1 = I_{sc}$

$I_2 = I' + I_{sc}$

$I' = I_2 - I_1$

$I'' + I_1 = I_3$

$I'' = I_3 - I_1$

$I = I_2 - I_3$

KVL left loop : $12 = 6kI' + 2kI$

$12 = 6k(I_2 - I_1) + 2k(I_2 - I_3)$

KVL right loop: $3kI'' + 4kI_3 - I(2k) = 0$

$3k(I_3 - I_1) + 4kI_3 - (I_2 - I_3)(2k) = 0$

$-3kI_1 - 2kI_2 + 9kI_3 = 0$

KVL outer loop : $12 = 4k\,I_3$

$I_3 = 3mA$

$-3k\,I_1 - 2k\,I_2 = -27$

$12 = -6k\,I_1 + 8k\,I_2 - 2k(3m)$

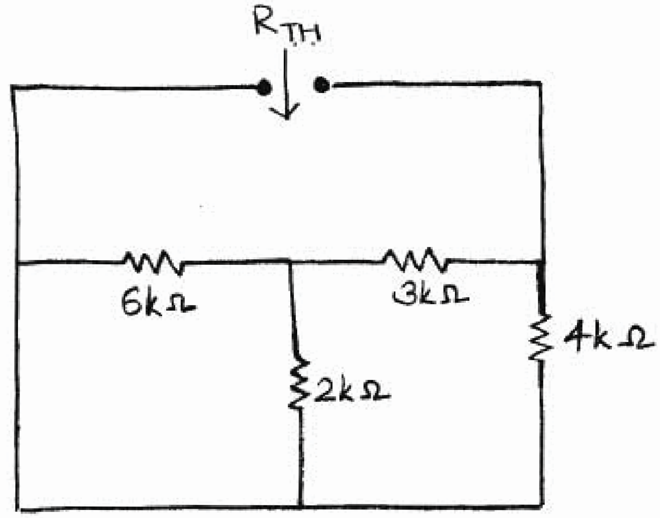
$-6k\,I_1 + 8k\,I_2 = 18$

$-3k\,I_1 - 2k\,I_2 = -27$

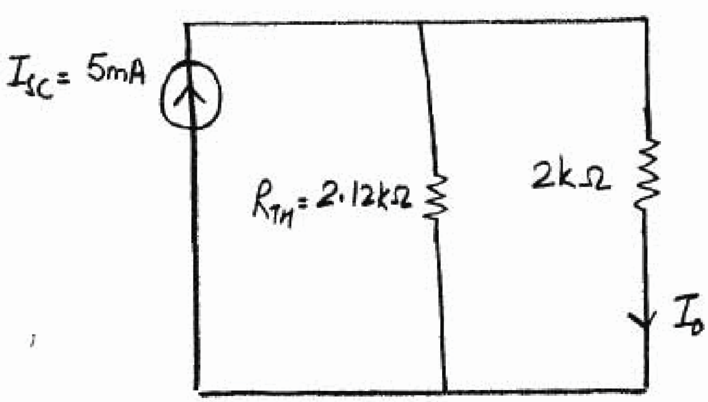
$I_1 = 5mA$

$I_2 = 6mA$

$I_{SC} = 5mA$



$R_{TH} = \left[(6k \,||\, 2k) + 3k\right] || 4k = 2.12k\Omega$



$$I_0 = \left(\frac{2.12k}{2.12k + 2k}\right)(5m) = 2.57mA$$

5.6 Find I_o in the network in Fig. P5.6 using superposition.

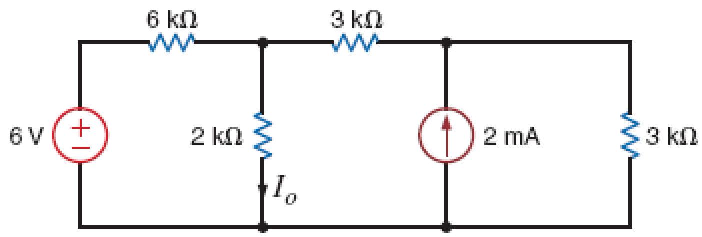
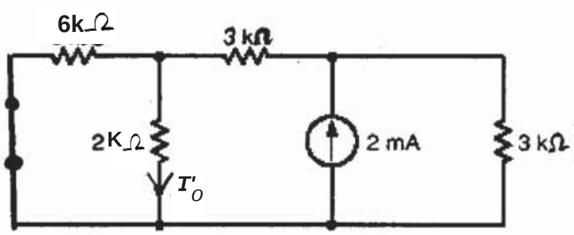
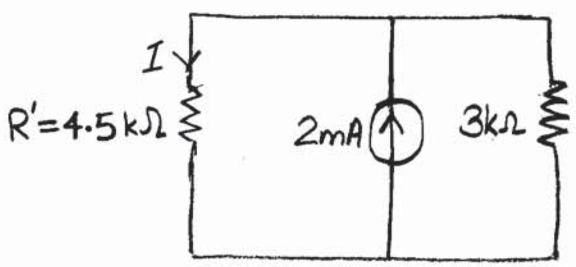


Figure P5.6

SOLUTION:

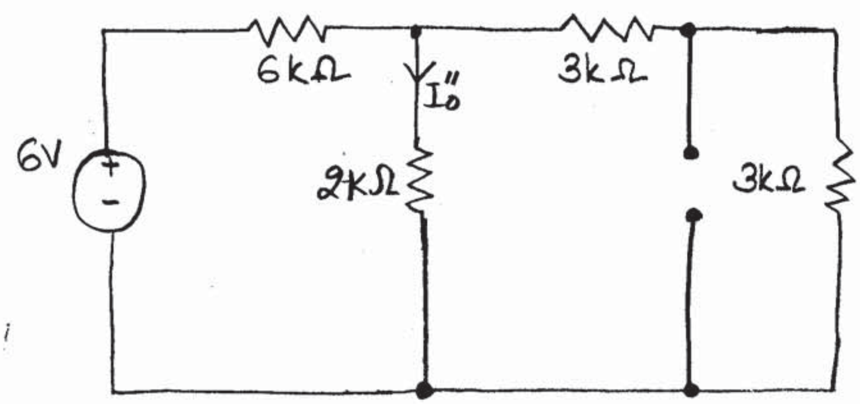


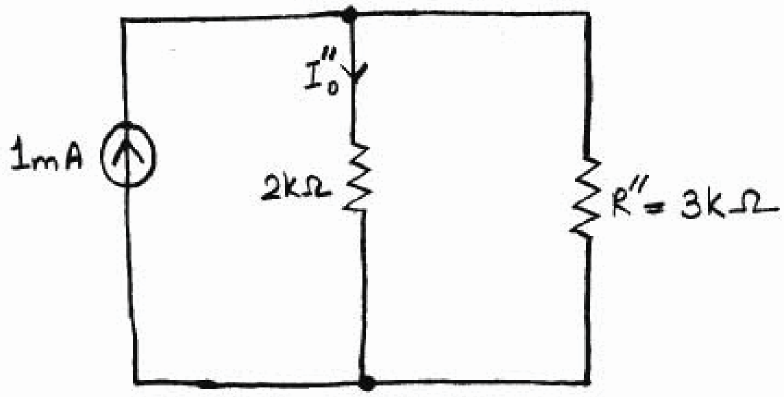
$$R' = (6k \| 2k) + 3k = 4.5k\,\Omega$$



$$I = \frac{3k}{3k+4.5k}(2m) = 0.8mA$$

$$I_o' = \frac{6k}{6k+2k}(0.8m) = 0.6mA$$





$$R'' = \left(6k \,||\, (3k + 3k)\right) = 3k\Omega$$

$$I_0'' = \left(\frac{3k}{2k + 3k}\right)(1m) = 0.6mA$$

$$I_0 = 0.6m + 0.6m = 1.2mA$$

5.66 Find V_o in the circuit in Fig. P5.66 using Thévenin's theorem.

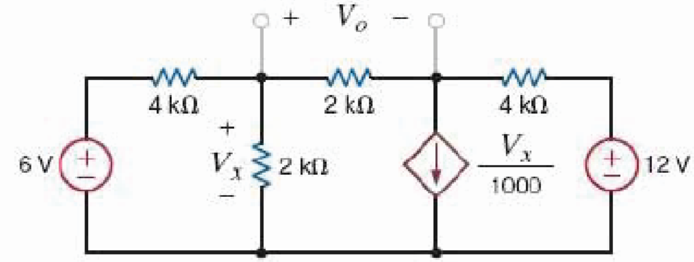
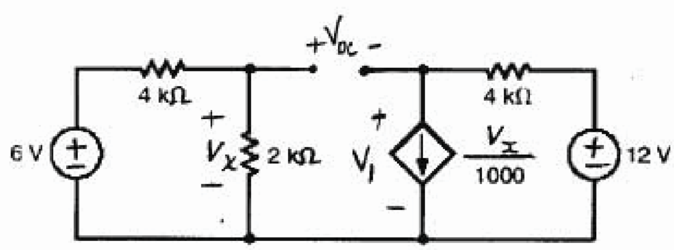


Figure P5.66

SOLUTION:



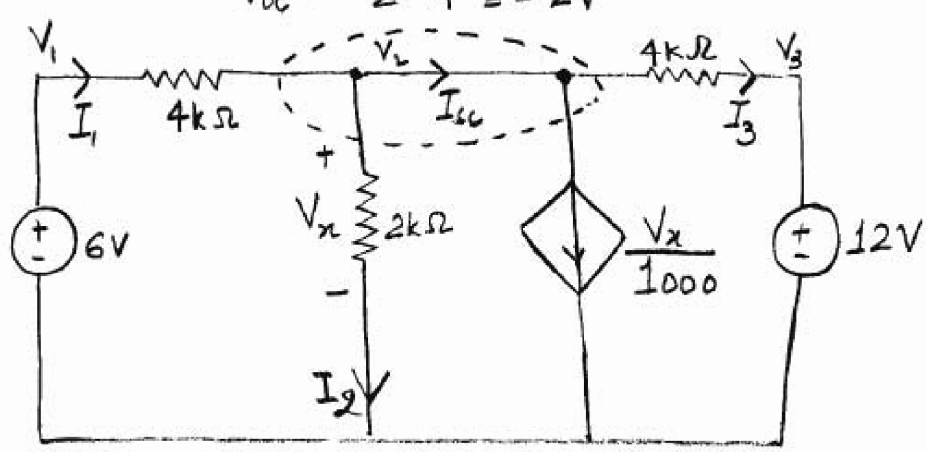
$$V_x = \left(\frac{2k}{2k+4k}\right)(6) = 2V$$

$$V_1 + \frac{V_x}{1000}(4k) = 12$$

$$V_1 = 4V$$

$$V_{OC} = V_x - V_1$$

$$V_{OC} = 2 - 4 = -2V$$

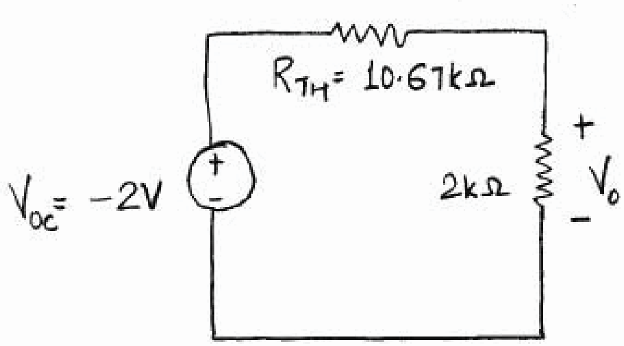


$$V_x = V_2$$
$$V_1 = 6V$$
$$V_3 = 12V$$
$$\frac{V_1 - V_2}{4k} = \frac{V_2}{2k} + \frac{V_x}{1000} + \frac{V_2 - V_3}{4k}$$
$$\frac{6 - V_2}{4k} = \frac{V_2}{2k} + \frac{V_2}{1000} + \frac{V_2 - 12}{4k}$$
$$V_2 = 2.25V$$

$$\frac{V_1 - V_2}{4k} = \frac{V_2}{2k} + I_{sc}$$

$$I_{sc} = \frac{6 - 2.25}{4k} - \frac{2.25}{2k}$$
$$= -0.1875 \text{ mA}$$

$$R_{TH} = \frac{-2}{-0.1875m}$$
$$= 10.67 k\Omega$$



$$V_o = \left(\frac{2k}{2k + 10.67k}\right)(-2) = -0.316V$$

5.85 Use source transformation to find V_o in the network in Fig. P5.85.

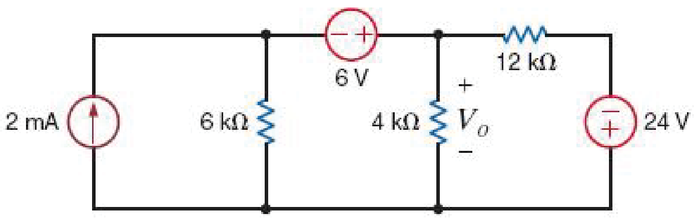
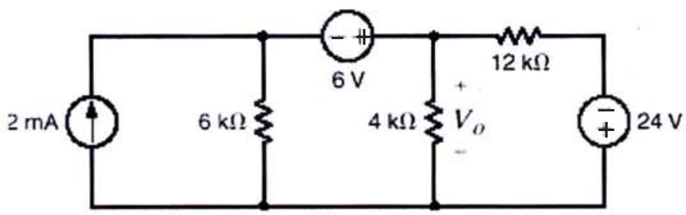
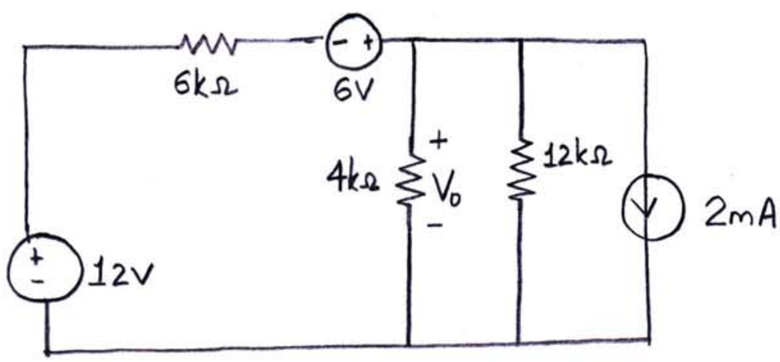
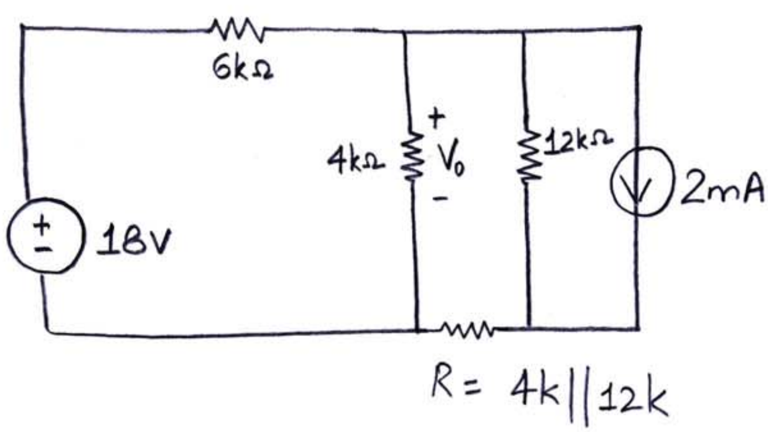


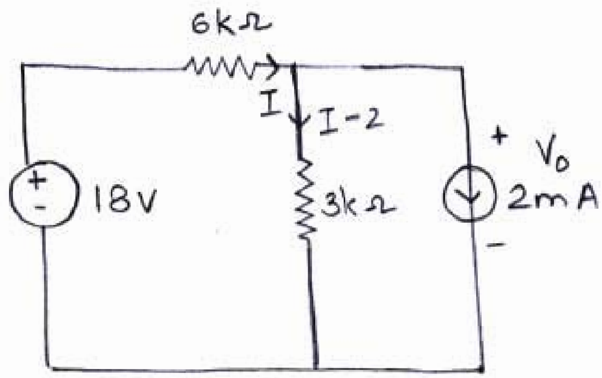
Figure P5.85

SOLUTION:









$$18 - 6kI - 3kI + 6 = 0$$

$$\frac{24}{9k} = I$$

$$2.66mA = I$$

$$\boxed{\therefore\ 3k(I-2) = 2V = V_o}$$

5.91 Find I_o in the circuit in Fig. P5.91 using source transformation.

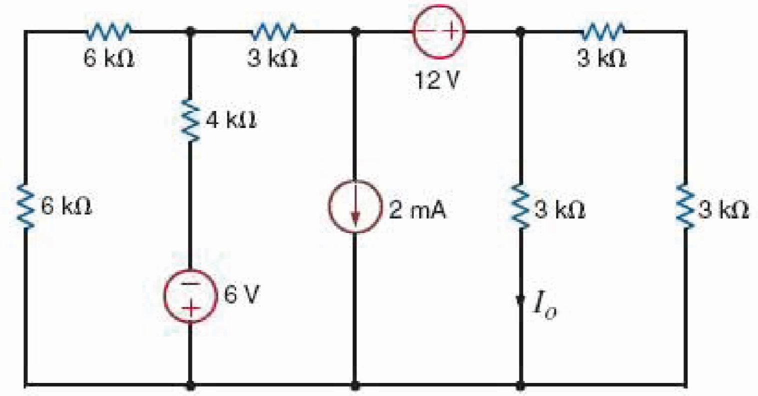
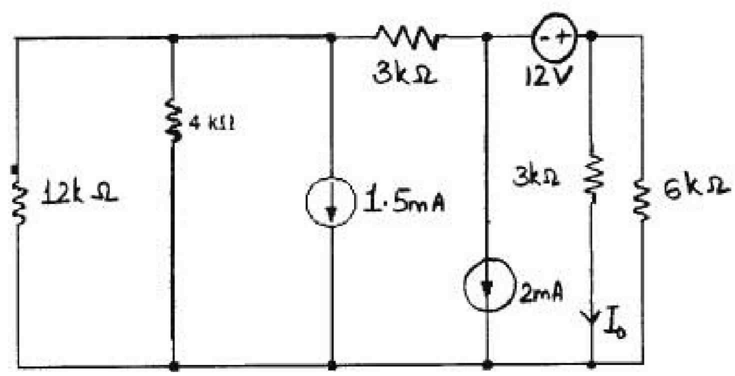
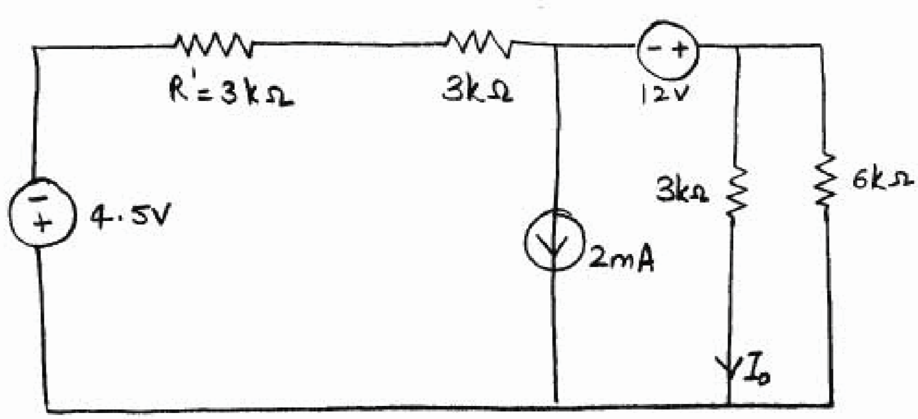


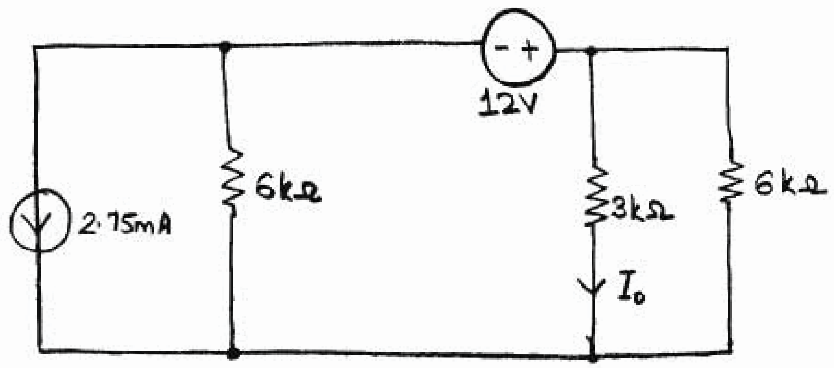
Figure P5.91

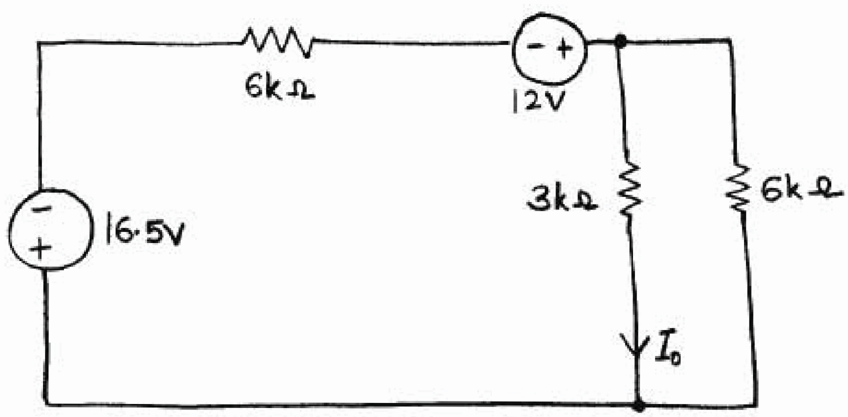
SOLUTION:

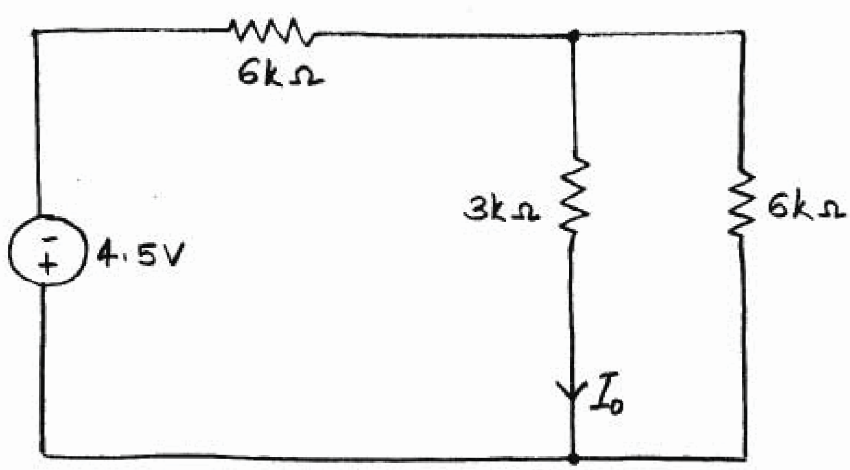


$$R' = 12k || 4k = 3k\Omega$$

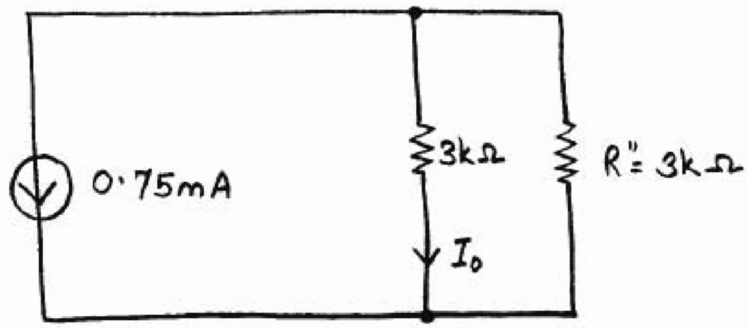








$$R'' = 6k \| 6k = 3k\Omega$$



$$I_0 = \left(\frac{3k}{3k+3k}\right)(-0.75m)$$

$$= -0.375\,mA$$

6.1 An uncharged 100-μF capacitor is charged by a constant current of 1 mA. Find the voltage across the capacitor after 4 s.

SOLUTION:

$$V(t) = \frac{1}{C}\int_0^T i(t)\,dt$$

$$V(t) = \frac{1}{100\mu}\int_0^4 1m\,dt$$

$$V(t) = \frac{1}{100\mu}\left[1m(4)-0\right]$$

$$V(t) = 40V$$

or

$$V = 40V$$

6.20 The waveform for the current in a 50-μF initially uncharged capacitor is shown in Fig. P6.20. Determine the waveform for the capacitor's voltage.

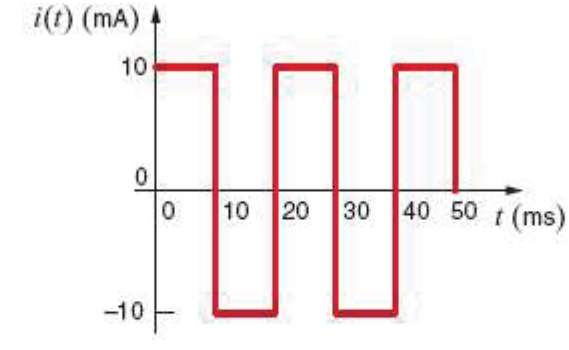


Figure P6.20

SOLUTION:

$$V_C(t) = \frac{1}{C}\int i_c(t)\,dt + V_0$$

for $i(t) = 10\text{mA}$

$$V_C(t) = \frac{1}{50\mu}\int 10\text{m}\,dt + V_0$$

$$V_C(t) = 200t + V_0$$

for $i(t) = -10\text{mA}$

$$V_C(t) = \frac{1}{50}\int -10\text{m}\,dt + V_0$$

$$V_C(t) = -200t + V_0$$

for $t < 0$

$$V_C(t) = 0$$

for $0 \leq t \leq 10\text{ms}$

$$V_C(t) = 200t\text{ V}$$

for $10ms \le t \le 20ms$

$$v_C(t) = -200t + 4 \quad V$$

for $20ms \le t \le 30ms$

$$v_C(t) = 200t - 4 \ V$$

for $30ms \le t \le 40ms$

$$v_C(t) = -200t + 8 \ V$$

for $40ms \le t \le 50ms$

$$v_C(t) = 200t - 8 \ V$$

for $t > 50ms$

$$v_C(t) = 0V$$

$$v_C(t) = \begin{cases} 0 & t < 0 \\ 200t \ V & 0 \le t \le 10ms \\ 4 - 200t \ V & 10ms \le t \le 20ms \\ -4 + 200t \ V & 20ms \le t \le 30ms \\ 8 - 200t \ V & 30ms \le t \le 40ms \\ -8 + 200t \ V & 40ms \le t \le 50ms \\ 0 & 50ms \le t \le 60ms \end{cases}$$

6.22 The current in an inductor changed from 0 to 200 mA in 4 ms and induces a voltage of 100 mV. What is the value of the inductor?

SOLUTION:

$$V(t) = L\frac{di(t)}{dt}$$

$$V = L\frac{\Delta I}{\Delta t}$$

$$\Delta I = 200\text{mA}$$

$$\Delta t = 4\text{ms}$$

$$L = V\left(\frac{\Delta t}{\Delta I}\right)$$

$$L = 100\text{m}\left(\frac{4\text{m}}{200\text{m}}\right)$$

$$L = 2\text{mH}$$

6.37 Draw the waveform for the voltage across a 24-mH inductor when the inductor current is given by the waveform shown in Fig. P6.37.

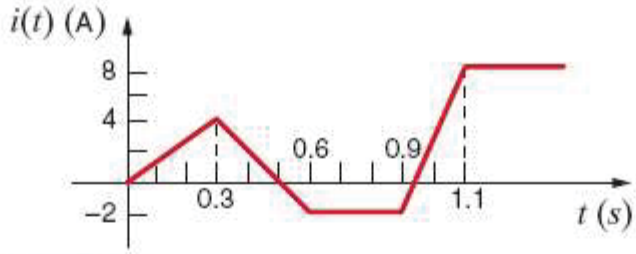


Figure P6.37

SOLUTION:

$$V(t) = L\frac{di(t)}{dt}$$

for $t \leq 0$, $V(t) = 0$

for $0 \leq t \leq 0.3s$

$$V(t) = 24m\left[\frac{40}{3}\right]$$

$$V(t) = 320mV$$

for $0.3s < t \leq 0.6s$

$$V(t) = 24m[-20]$$

$$V(t) = -480mV$$

for $0.6s < t \leq 0.9s$
$V(t) = 0$

for $0.9\,s < t \leq 1.1\,s$

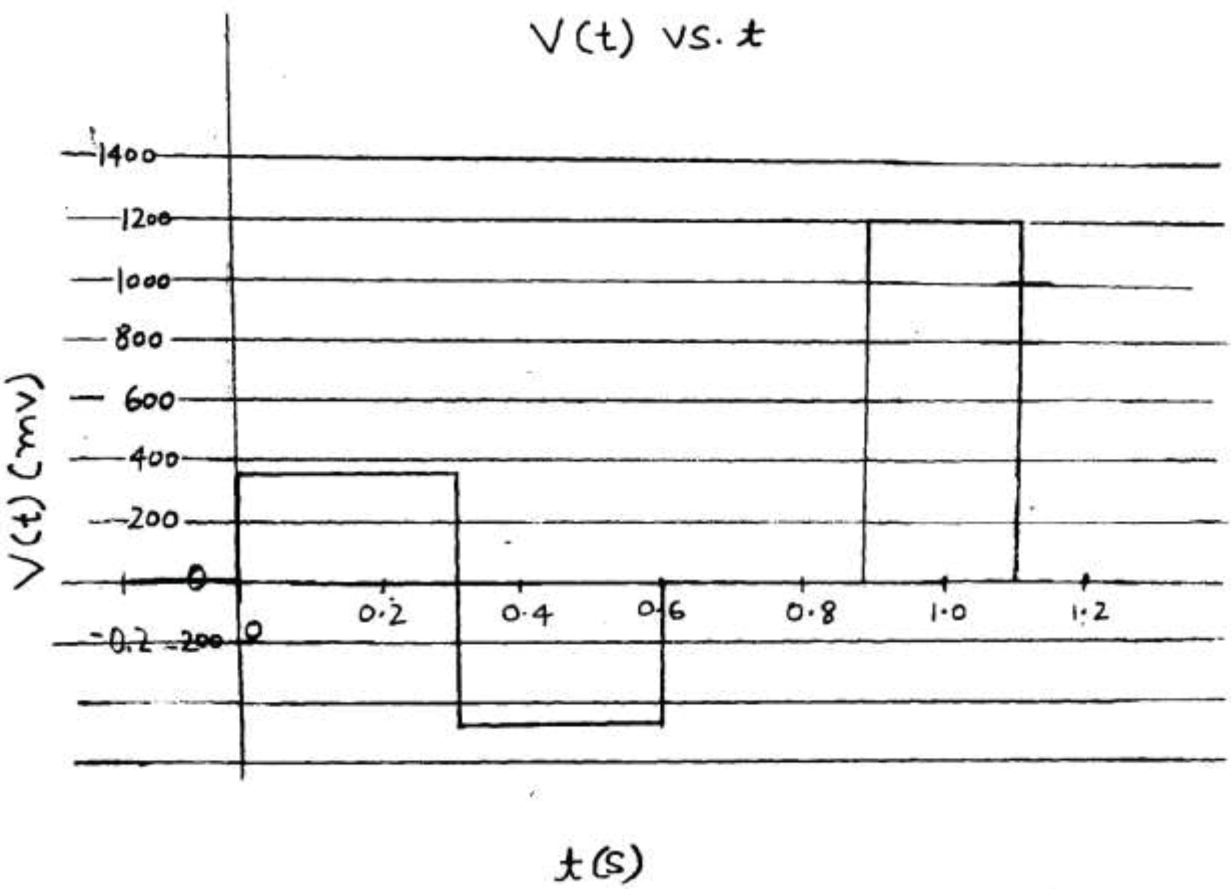
$$V(t) = 24m\,[50]$$

$$V(t) = 1200\,mV$$

for $t > 1.1\,s$

$$V(t) = 0$$

$$V(t) = \begin{cases} 0 & t \leq 0 \\ 320\,mV & 0 < t \leq 0.3\,s \\ -480\,mV & 0.3\,s < t \leq 0.6\,s \\ 0 & 0.6\,s < t \leq 0.9\,s \\ 1200\,mV & 0.9\,s < t \leq 1.1\,s \\ 0 & t > 1.1\,s \end{cases}$$



6.50 Find the total capacitance C_T of the network in Fig. P6.50.

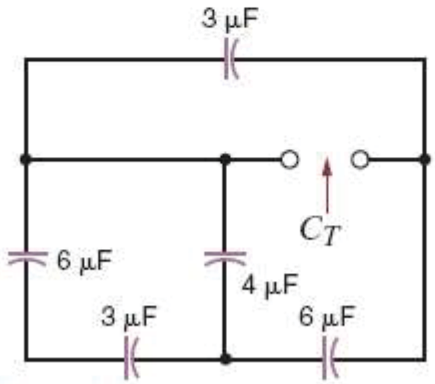
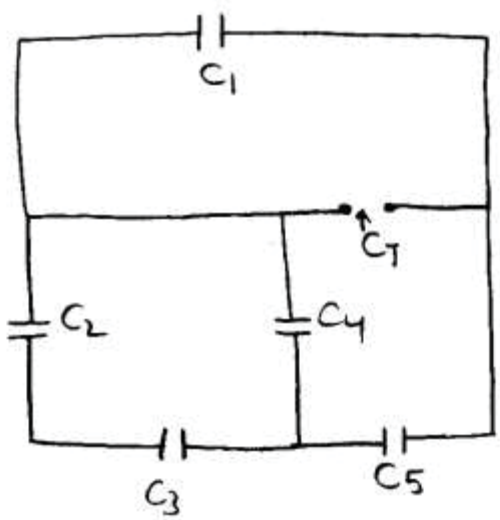


Figure P6.50

SOLUTION:

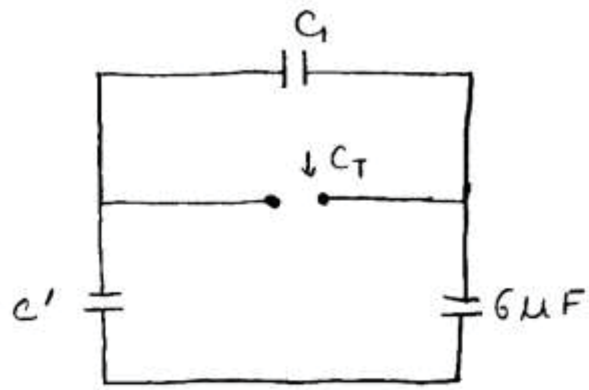


$C_1 = 3\mu F$, $C_2 = 6\mu F$, $C_3 = 3\mu F$,
$C_4 = 4\mu F$, $C_5 = 6\mu F$

$$C' = 4\mu + \frac{6\mu(C_3)}{6\mu + C_3}$$

$$C' = 4\mu + \frac{6\mu(3\mu)}{6\mu + 3\mu}$$

$$C' = 6\mu F$$



$$C_T = \frac{C'(6\mu)}{C' + 6\mu} + C_1$$

$$C_T = \frac{6\mu(6\mu)}{6\mu + 6\mu} + 3\mu$$

$$C_T = 6\mu F$$

6.56 Find C_T in the circuit in Fig. P6.56 if all capacitors are 6 μF.

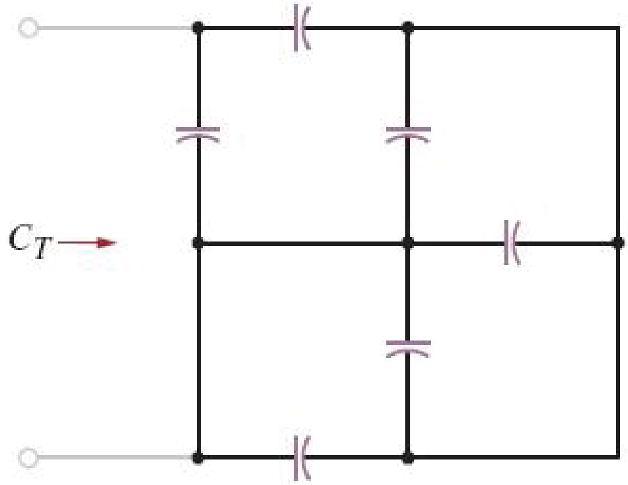
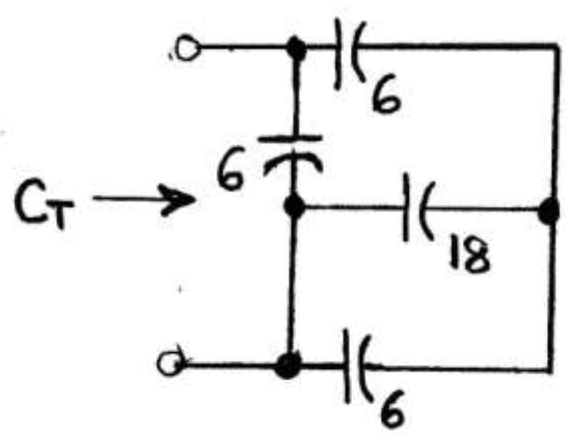
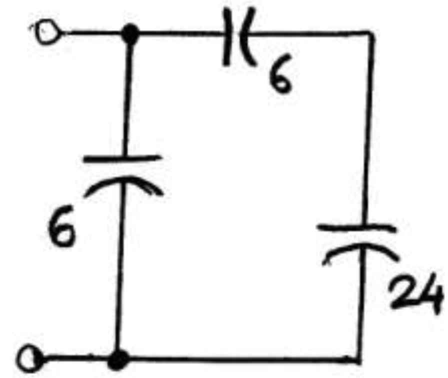
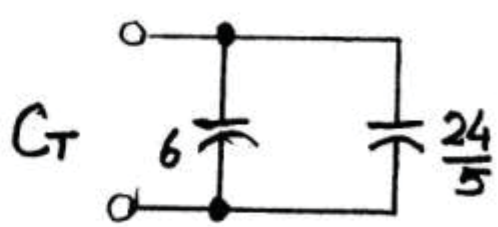


Figure P6.56

SOLUTION:







$$\frac{24}{5}+6=\frac{24}{5}+\frac{30}{5}=\frac{54}{5}\,\mu F=C_T$$

6.69 Determine the inductance at terminals *A*-*B* in the network in Fig. P6.69.

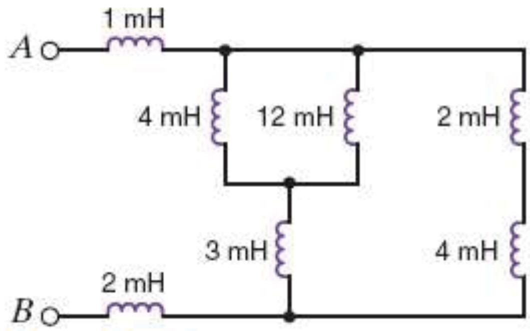
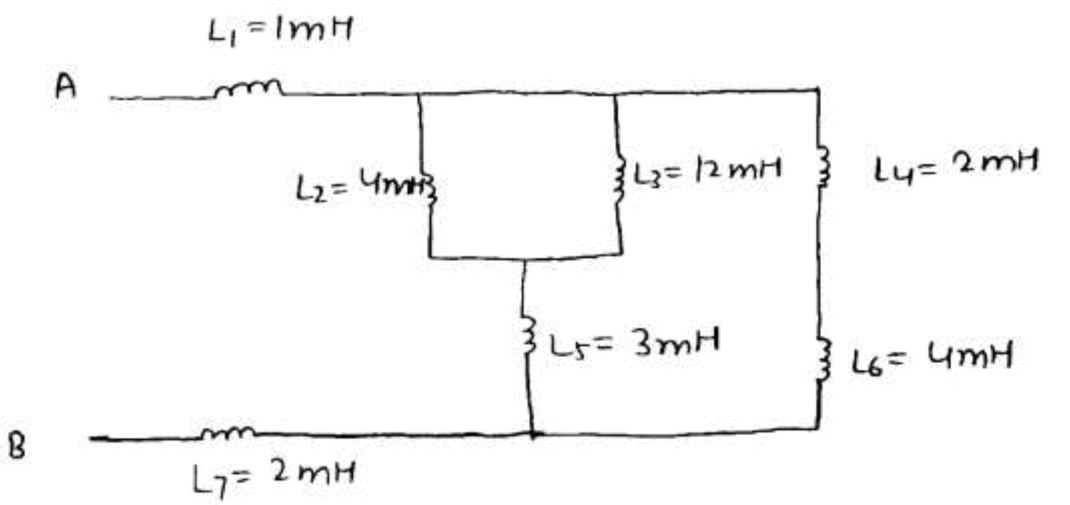


Figure P6.69

SOLUTION:



$$L_{AB} = \left[(L_4 + L_6) \right] \,||\, \left[(L_2 \,||\, L_3) + L_5 \right] + L_1 + L_7$$

$$L_{AB} = [6m] \,||\, \left[\frac{4m(12m)}{4m + 12m} + 3m \right] + 1m + 2m$$

$$L_{AB} = [6m] \,||\, [3m + 3m] + 3m$$

$$L_{AB} = 3m + 3m$$

$$L_{AB} = 6mH$$

6.72 Find L_T in the circuit in Fig. P6.72.

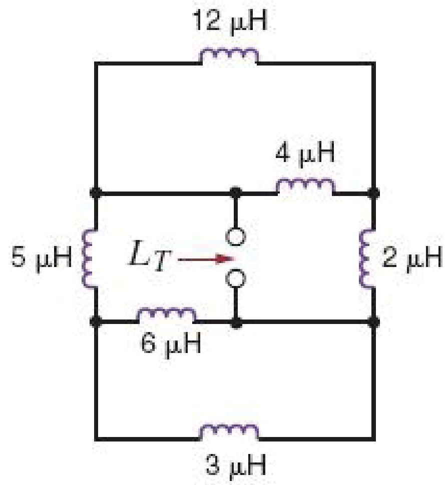
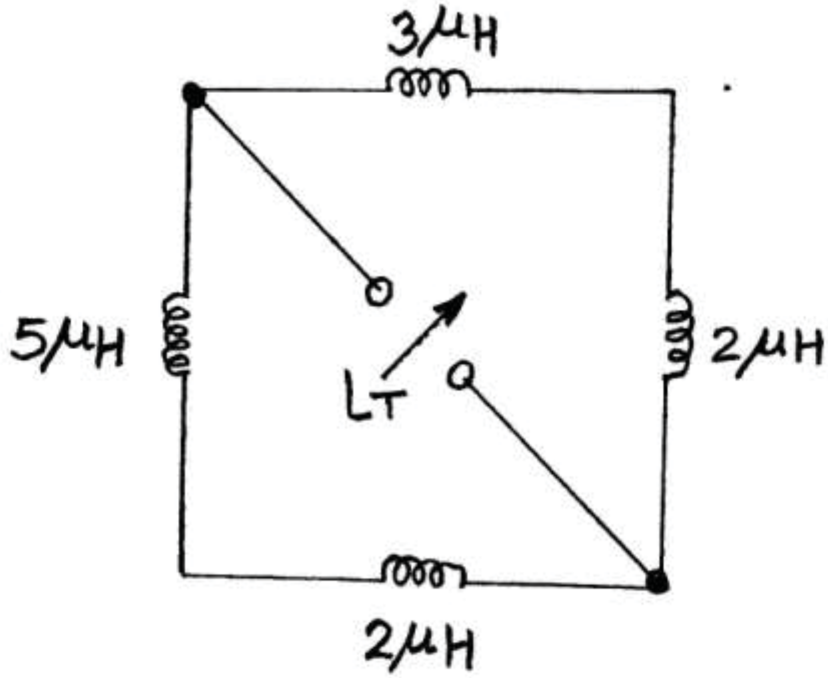


Figure P6.72

SOLUTION:



$$L_T = 7\mu H // 5\mu H$$

$$= \frac{35}{12}\mu H$$

6.9 The voltage across a 20-μF capacitor is shown in Fig. P6.9. Determine the waveform for the current in the capacitor.

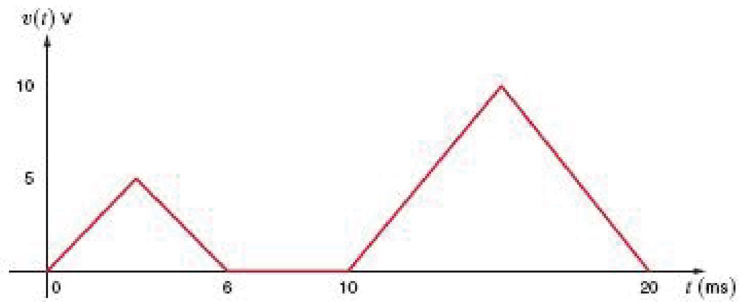


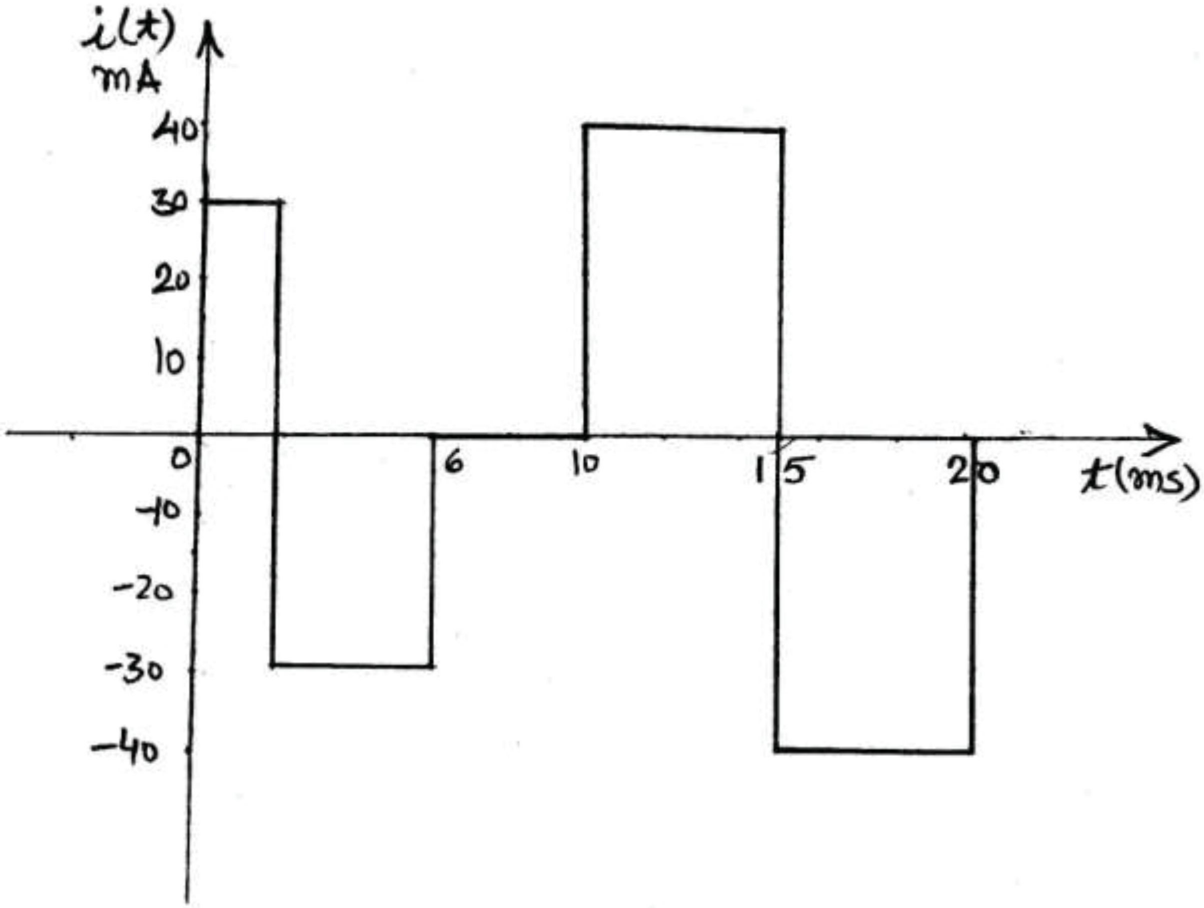
Figure P6.9

SOLUTION:

$$i(t) = \frac{C\,dv}{dt} = 20\times10^{-6}\,\frac{dv}{dt}$$

$v(t) = \frac{5}{3\times10^{-3}}t$	$0 \le t \le 3\text{ms}$
$= \frac{-5}{3\times10^{-3}}t + 6$	$3\text{ms} \le t \le 6\text{ms}$
$= 0$	$6\text{ ms} \le t \le 10\text{ms}$
$= \frac{10}{5\times10^{-3}}t - a$	$10\text{ ms} \le t \le 15\text{ms}$
$= \frac{-10}{5\times10^{-3}}t + c$	$15\text{ ms} \le t \le 20\text{ ms}$

$i(t) = 20\times10^{-6}\left(\frac{5}{3}\times10^{3}\right) = \frac{1}{3}\times10^{-1} = 33.3\text{ mA}$	0-3 ms
$= -33.3\text{ mA}$	3-6 ms
$= 0$	6-10 ms
$= (20\times10^{-6})(2\times10^{+3}) = 40\text{ mA}$	10-15 ms
$= -40\text{ mA}$	15-20 ms


i(t) mA
40
30
20
10
0
-10
-20
-30
-40
6
10
15
20
t(ms)