3.23 Use nodal analysis to find V_o in the circuit of Fig. 3.72.

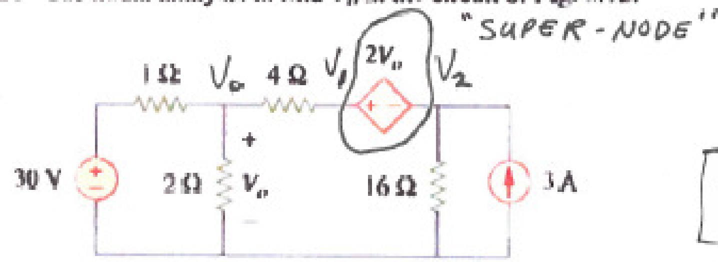


Figure 3.72
For Prob. 3.23.

RELATIONSHIP

$$V_2 + 2V_o = V_1$$

$$\boxed{2V_o - V_1 + V_2 = 0}$$

NODE V_o:

$$\frac{V_o - 30}{1} + \frac{V_o}{2} + \frac{V_o - V_1}{4} = 0$$

MULT by 4

$$4V_o - 120 + 2V_o + V_o - V_1 = 0$$

$$\boxed{7V_o - V_1 = 120}$$

NODE "$V_1 V_2$ Super NODE":

$$\frac{V_1 - V_o}{4} + \frac{V_2}{16} = 3$$

MULT by 16

$$\boxed{4V_1 - 4V_o + V_2 = 48}$$

SOLUTION #1. Substitution

FROM NODE V_o $\longrightarrow$ $\boxed{V_1 = 7V_o - 120}$

Substitute INTO RELATIONSHIP: $2V_o - (7V_o - 120) + V_2 = 0$

$$-5V_o + 120 + V_2 = 0 \Longrightarrow \boxed{V_2 = 5V_o - 120}$$

Substitute INTO SUPERNODE:

$$4(7V_o - 120) - 4V_o + 5V_o - 120 = 48$$

$$28V_o - 480 - 4V_o + 5V_o - 120 = 48$$

$$29V_o - 600 = 48$$

$$\boxed{V_o = \frac{648}{29} = 22.34V}$$

Solution #2

Set up as 3×3 matrix: $A\hat{x} = \hat{b}$ find $\hat{x} = A^{-1}\hat{b}$

$$\begin{bmatrix} 7 & -1 & 0 \\ -4 & 4 & 1 \\ 2 & -1 & 1 \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 120 \\ 48 \\ 0 \end{bmatrix} \Longrightarrow x = A^{-1}\hat{b} = \begin{bmatrix} 22.34 \\ 36.41 \\ -8.28 \end{bmatrix}$$

using MATLAB or calculator or any other matrix solver

$$\boxed{V_0 = 22.34}$$

3.51 Apply mesh analysis to find v_o in the circuit of Fig. 3.96.

NOTE $i_2 = 5A$!

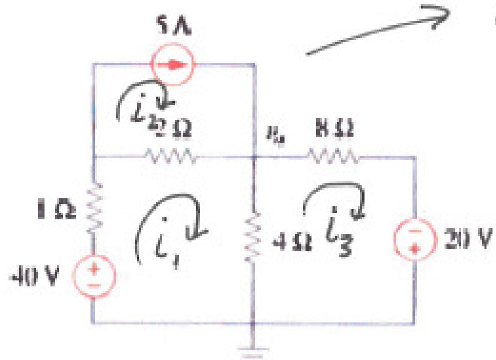


Figure 3.96
For Prob. 3.51.

LOOP i_1:

$$-40 + 1(i_1) + 2(i_1 - i_2) + 4(i_1 - i_3) = 0$$

$$-40 + i_1 + 2i_1 - 2(5) + 4i_1 - 4i_3 = 0$$

$$\boxed{7i_1 - 4i_3 = 50}$$

LOOP i_3:

$$4(i_3 - i_1) + 8i_3 - 20 = 0$$

$$\boxed{-4i_1 + 12i_3 = 20} \Rightarrow i_1 = 3i_3 - 5$$

Substituting Loop 3 into Loop 1 Result

$$7(3i_3 - 5) - 4i_3 = 50$$

$$21i_3 - 35 - 4i_3 = 50$$

$$17i_3 = 85 \Rightarrow \boxed{i_3 = 5}$$

$$\boxed{i_1 = 3(5) - 5 = 10}$$

VOLTAGE V_o:

$$\boxed{V_o = 4(i_1 - i_3) = 4(10 - 5) = 20\ V}$$

4.41 Find the Thevenin and Norton equivalents at terminals *a-b* of the circuit shown in Fig. 4.108.

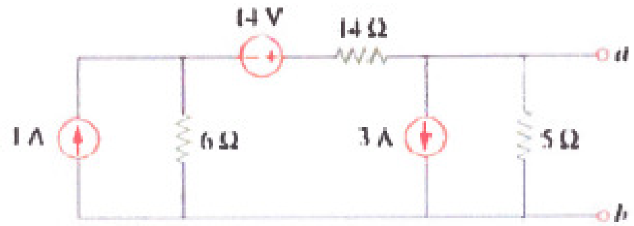
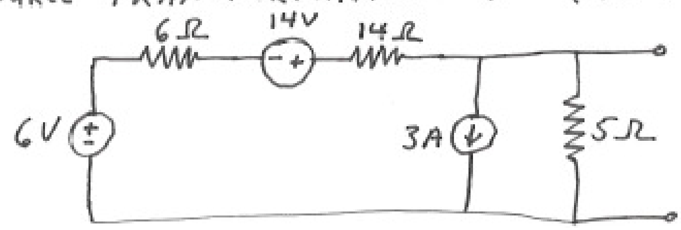
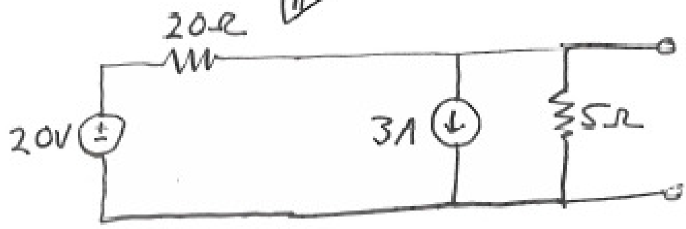


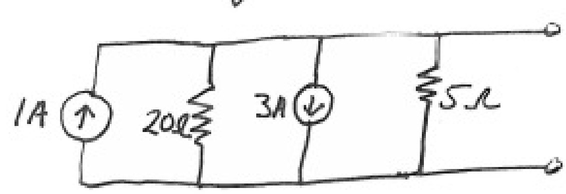
Figure 4.108
For Prob. 4.41.

SOURCE TRANSFORMATION $V = (1)(6) = 6\ V$



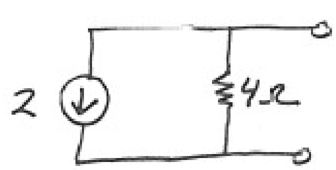


$I = \frac{20V}{20\Omega} = 1\ A$



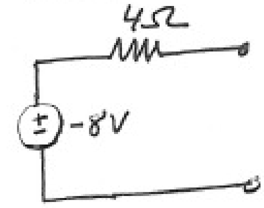
$$\boxed{\begin{aligned} V_{TH} &= (-2)(4) = -8V \\ R_{TH} &= R_N = 4\Omega \end{aligned}}$$

$I = 1 - 3 = -2$ $\quad R = \frac{20(5)}{20+5} = 4\Omega$



$$\boxed{\begin{aligned} I_N &= -2A \\ R_N &= 4\Omega \end{aligned}}$$

$\Longrightarrow$



5.27 Find v_o in the op amp circuit of Fig. 5.65.

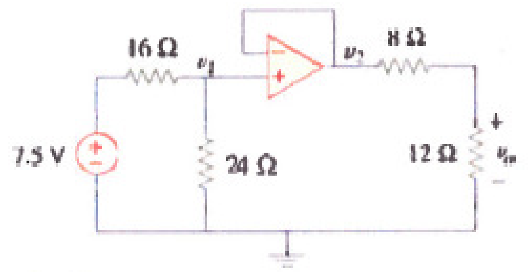


Figure 5.65
For Prob. 5.27.

VOLTAGE DIVIDER EQ.

$$V_1 = 7.5\frac{24}{(24+16)} = 4.5V$$

Remember $i \to$ op-amp $= 0$

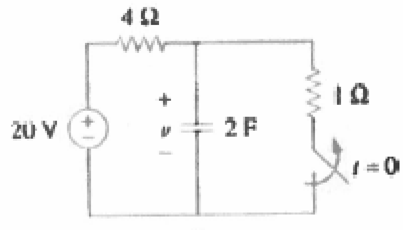
$$V_2 = V_1 = 4.5V$$

SAME VOLTAGE A +/- terminals

VOLTAGE FOLLOWER

$$\boxed{V_o = V_2\frac{12}{(12+8)} = 2.7V}$$

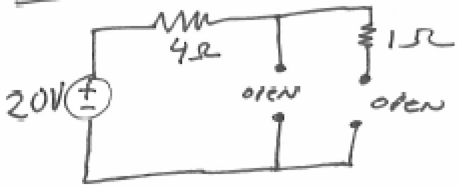
7.39 Calculate the capacitor voltage for $t < 0$ and $t > 0$ for each of the circuits in Fig. 7.106.



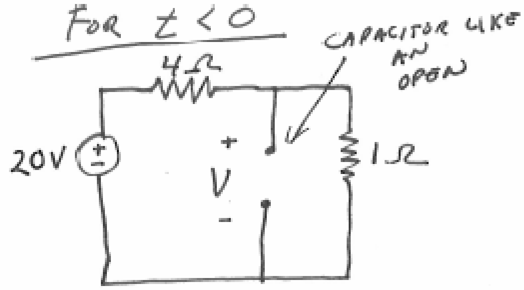
(a)

FOR $t \to \infty$

$V(\infty) = 20\,V$



FOR $t < 0$

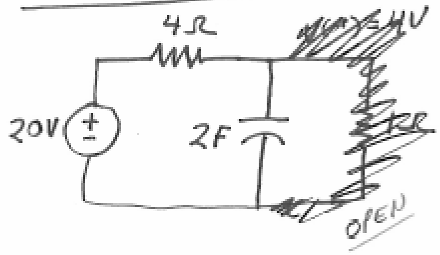


VOLTAGE DIVIDER

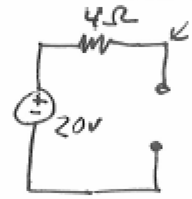
$$V = \frac{1}{4+1}(20V) = 4V$$

$$\boxed{V(0^-) = 4V}$$

FOR $t = 0$



FOR $t \to \infty$



$V(\infty) = 20V$

$\Downarrow$

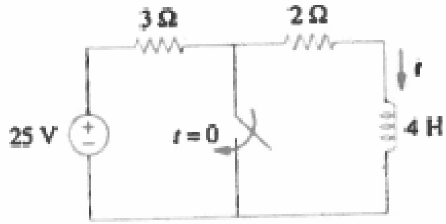
$$v(t) = v(\infty) + [v(0) - v(\infty)]e^{-1/\tau}$$

$$\tau = RC = (4)(2) = 8$$

$$v(t) = 20 + [4 - 20]e^{-1/8}$$

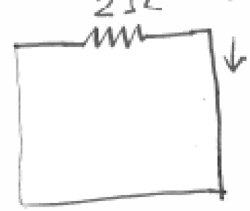
$$\boxed{v(t) = 20 - 16e^{-t/8}\ V}$$

7.53 Determine the inductor current $i(t)$ for both $t < 0$ and $t > 0$ for each of the circuits in Fig. 7.119.



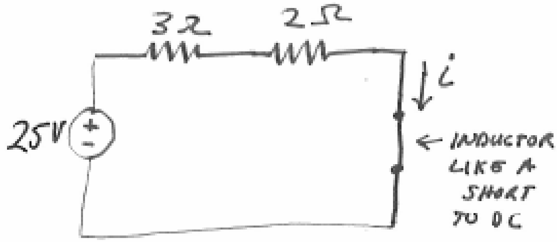
(a)

FOR $t \to \infty$



$i(\infty) = 0$

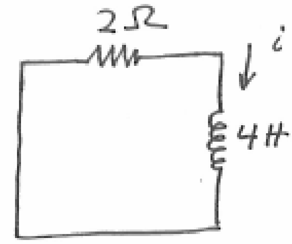
FOR $t < 0$



INITIAL INDUCTOR CURRENT

$$i(0^-) = \frac{25V}{3+2} = 5A$$

FOR $t > 0$



$i(0^+) = 5A$

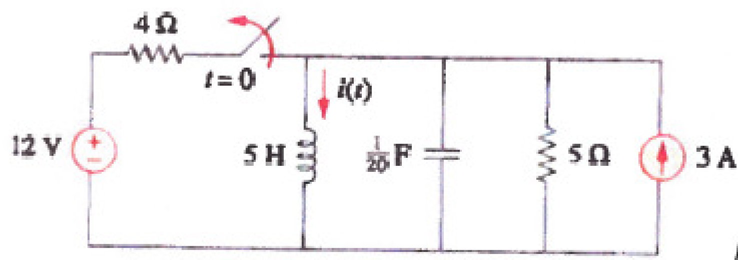
$$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$$

$$\tau = \frac{L}{R} = \frac{4}{2} = 2$$

$$i(t) = 0 + [5 - 0]e^{-t/2}$$

$$\boxed{i(t) = 5e^{-t/2} \text{ for } t > 0}$$

8.49 Determine $i(t)$ for $t > 0$ in the circuit of Fig. 8.96.



PARALLEL RLC

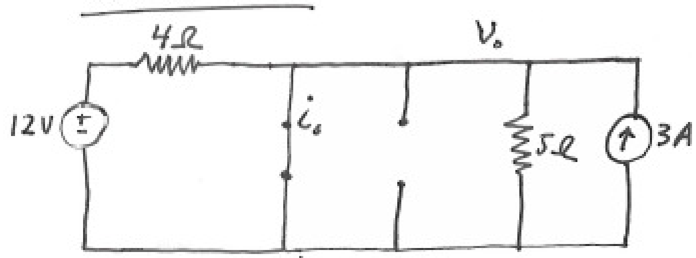
$$\alpha = \frac{1}{2RC} = \frac{1}{2(5)(\frac{1}{20})} = 2$$

$$\omega = \sqrt{\frac{1}{LC}} = \sqrt{\frac{1}{5/20}} = 2$$

$\boxed{\text{CRITICALLY DAMPED}}$

INITIAL CONDITIONS

At $t < 0$



INDUCTOR LOOKS LIKE SHORT

CAPACITOR LOOKS LIKE OPEN

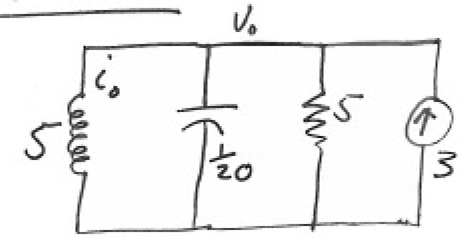
INITIAL CURRENT THROUGH INDUCTOR

$$i_o = \frac{12}{4} + 3 = 6A$$

INITIAL VOLTAGE ACROSS CAPACITOR

$$V_o = 0$$

At $t > 0$



At $t \to \infty$ $\quad i_{ss}(t) = 3A$

$$i(t) = i_t(t) + i_{ss}(t)$$

FOR CRITICALLY DAMPED

$$i(t) = (A_1 + A_2 t)e^{-\alpha t} + i_{ss}(t)$$

$$i(t) = (A_1 + A_2 t)e^{-2t} + 3$$

Apply INIT CONDITIONS:

$$i(0) = (A_1 + 0)e^{-2(0)} + 3 = \boxed{A_1 = 3}$$

$$\boxed{i(t) = (3 + 6t)e^{-2t} + 3}$$

SINCE INITIAL VOLTAGE = 0

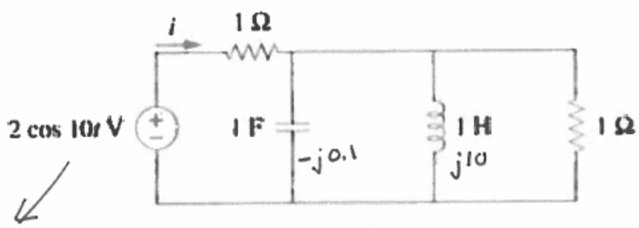
$$V = L\frac{di(0)}{dt} = 0 \Rightarrow \frac{di(0)}{dt} = 0$$

FIND DERIVITIVE:

$$\frac{di(t)}{dt} = -2(A_1 + A_2 t)e^{-2t} + A_2 e^{-2t}$$

AT $t=0$ $\quad \frac{di(0)}{dt} = -2(3)\cancel{e^{-2(0)}} + A_2\cancel{e^{-2(0)}} = 0 \Rightarrow \boxed{A_2 = 6}$

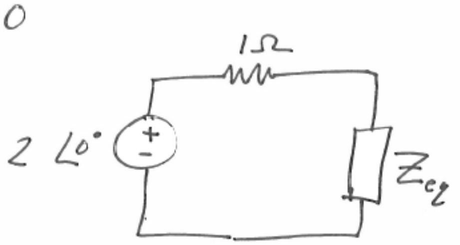
10.1 Determine i in the circuit of Fig. 10.50.



$$Z_c = \frac{1}{j\omega C} = \frac{1}{j10(1)} = -j0.1$$

$$Z_L = j\omega L = j10$$

$\omega = 10$



$$\frac{1}{Z_{eq}} = \frac{1}{Z_c} + \frac{1}{Z_L} + \frac{1}{R}$$

$$= \frac{1}{-j0.1} + \frac{1}{j10} + \frac{1}{1}$$

$$= j10 - j0.1 + 1$$

$$= 1 + j9.9$$

$$Z_{eq} = (1 + j9.9)^{-1} = 0.0101 - j0.1$$

$$i = \frac{2\angle 0}{1 + Z_{eq}} = \frac{2\angle 0^\circ}{1 + 0.0101 - j0.1} = 1.96 + j0.194$$

CONVERT TO POLAR

$$\boxed{i = 1.97\angle 5.65^\circ}$$