1.19 The energy absorbed by the BOX in Fig. P1.19 is shown in the graph below. Calculate and sketch the current flowing into the BOX between 0 and 10 milliseconds.

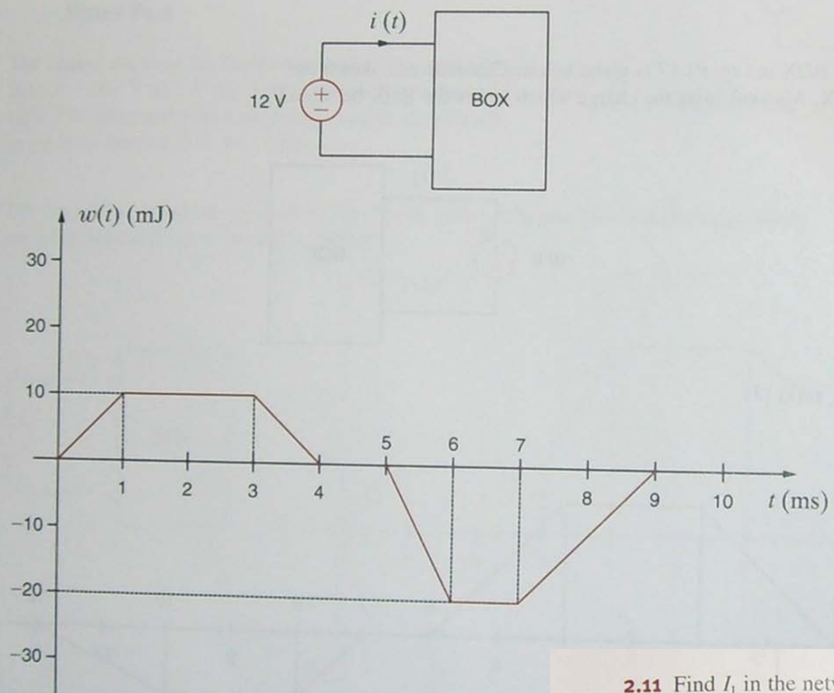


Figure P1.19

1.38 Find the power absorbed or supplied by element 3 in Fig. P1.38.

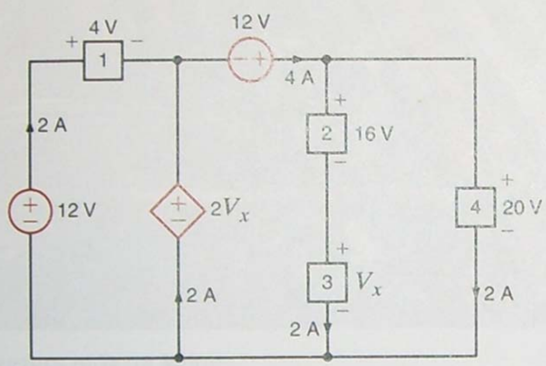


Figure P1.38

2.11 Find I_1 in the network in Fig. P2.11.

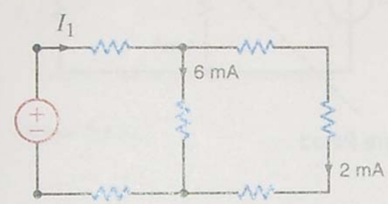


Figure P2.11

2.39 Find V_{ab} in the network in Fig. P2.39.

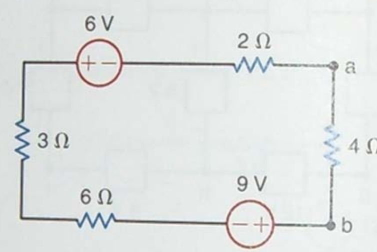


Figure P2.39

1.42 Is the source V_s in the network in Fig. P1.42 absorbing or supplying power, and how much?

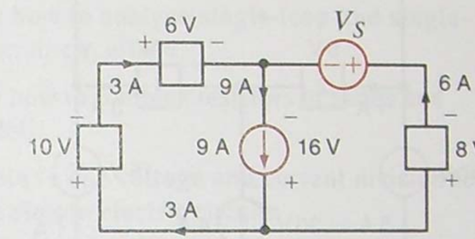


Figure P1.42

2.61 Find R_{AB} in the circuit in Fig. P2.61.

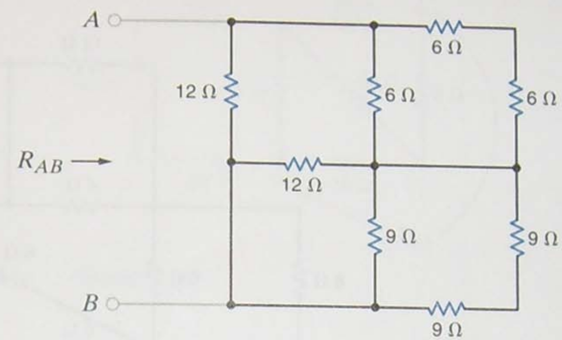


Figure P2.61

2.62 Find R_{AB} in the network in Fig. P2.62.

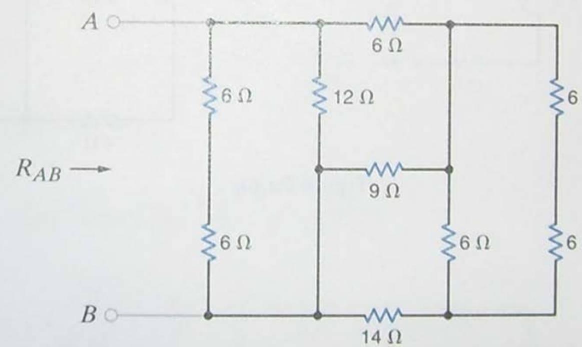
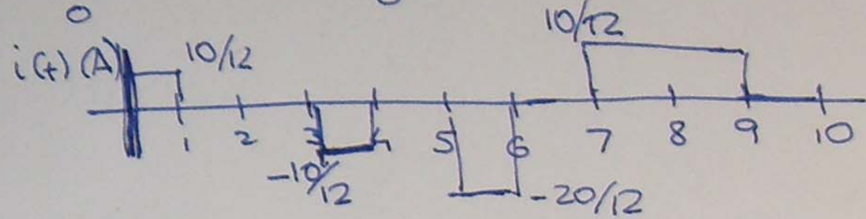


Figure P2.62

EEE 202 HW #1 SOLUTIONS

1.19 $w(t) = \int_0^t p(\tau)d\tau = \int_0^t vi(\tau) \Rightarrow \frac{dw}{dt} = 12\,i(t)$

$\Rightarrow$



1.38 $V_x = 20 - 16 = 4\,(V)$ (KVL), $I_x = 2(A) \Rightarrow$ ABSORBS $\boxed{8(W)}$

Alt. Using Tellegen, $24 + 4V_x + 48 = 8 + 32 + 40 + 2V_x \Rightarrow 2V_x = 8(W)$

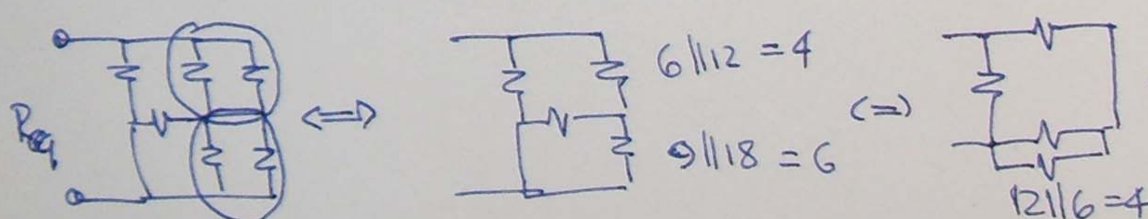
1.42 Sum ABSORBED powers:

$30 + 18 - 16 + 9 + 6V_s + 48 = 0 \Rightarrow 6V_s = 144 - 96 = \boxed{48\,(W)}$ (ABSORBED)

2.11 $I_1 = 6 + 2 = \boxed{8\,mA}$ (KCL)

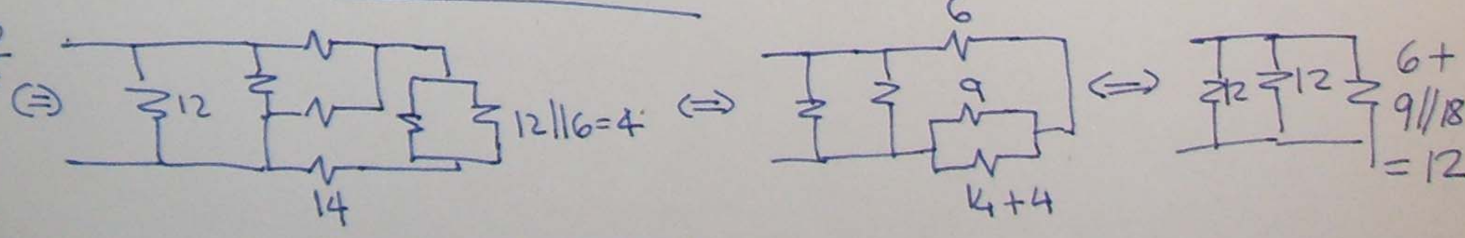
2.39 $V_{ab} = I \times 4$; $3I + 6 + 2I + 4I + 9 + 6I = 0 \Rightarrow I = -1 \Rightarrow \boxed{V_{ab} = -4(V)}$

2.61



$= 12 \| (4+4) = \boxed{4.8\,\Omega}$

2.62



$\Rightarrow R_{eq} = 12 \| 12 \| 12 = \boxed{4\,\Omega}$

3.10 Find I_o in the circuit in Fig. P3.10 using nodal analysis.

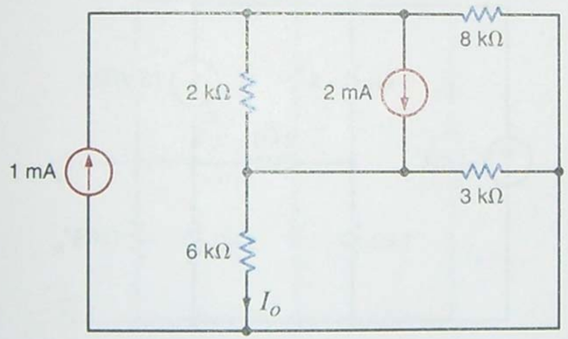


Figure P3.10

3.41 Use nodal analysis to find V_o in the circuit in Fig. P3.41.

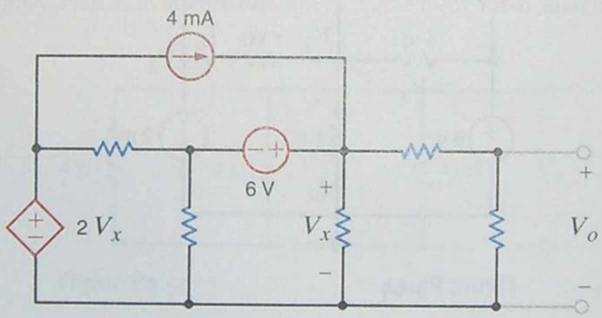


Figure P3.41

3.77 Find the mesh currents in the network in Fig. P3.77.

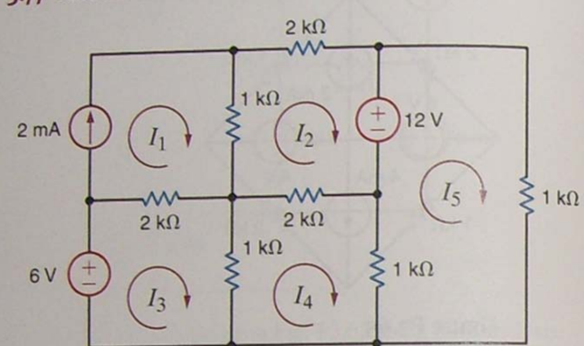


Figure P3.77

3.87 Using mesh analysis, find V_o in the circuit in Fig. P3.87.

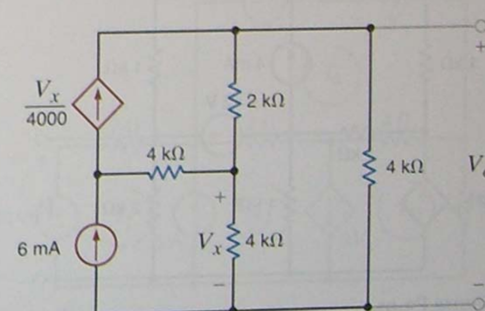


Figure P3.87

3.101 Using loop analysis, find I_o in the circuit in Fig. P3.101.

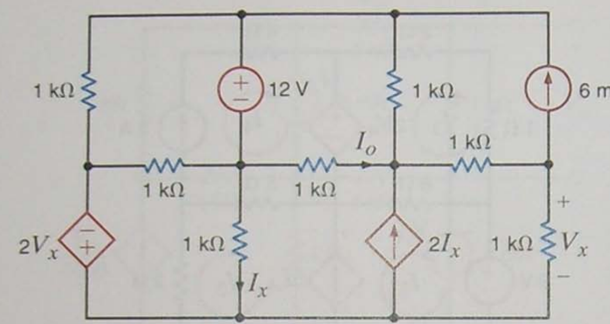


Figure P3.101

3.102 Use mesh analysis to determine the power delivered by the indepenent 3-V source in the network in Fig. P3.102.

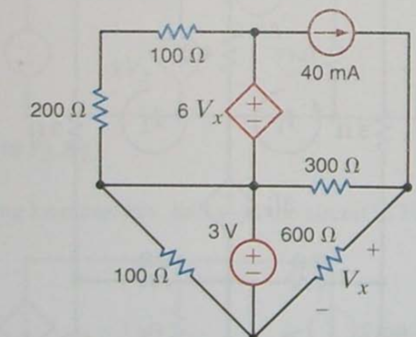
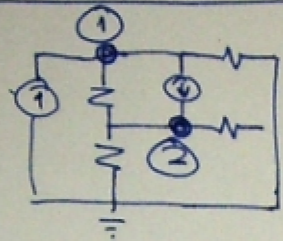


Figure P3.102

EEE202 HW 1.2 SOLUTIONS

3.10

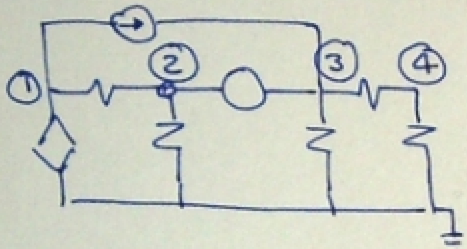


① $\frac{V_2 - V_1}{2k} + 1m - 2m + \frac{0 - V_1}{8k} = 0$

② $\frac{V_1 - V_2}{2k} + \frac{0 - V_2}{6k} + 2m + \frac{0 - V_2}{3k} = 0$

$$\Rightarrow \begin{bmatrix} -1/2k - 1/8k & 1/2k \\ 1/6k & -1/6k - 1/6k - 1/3k \end{bmatrix} V = \begin{pmatrix} 1m \\ -2m \end{pmatrix} \Rightarrow V = \begin{bmatrix} 0 \\ 2 \end{bmatrix}, \; I_0 = \frac{V_2}{6k} = \underline{\underline{1/3\,mA}}$$

3.41



① $V_1 = 2V_x \;,\; V_x = V_3$

② & ③ $\begin{cases} \frac{V_1 - V_2}{1k} + \frac{-V_2}{1k} + 4m + \frac{-V_3}{1k} + \frac{V_4 - V_3}{1k} = 0 \\ V_3 - V_2 = 6 \end{cases}$

④ $-\frac{V_4}{1k} + \frac{V_3 - V_4}{1k} = 0 \;;\; V_0 = V_4$

$$\Rightarrow \begin{bmatrix} 1 & 0 & -2 & 0 \\ 0 & -1 & 1 & 0 \\ 1/1k & -2/1k & -2/1k & 1/1k \\ 0 & 0 & 1/1k & -2/1k \end{bmatrix} V = \begin{bmatrix} 0 \\ 6 \\ -4m \\ 0 \end{bmatrix} \Rightarrow V = \begin{bmatrix} 64 \\ 14 \\ 52 \\ 16 \end{bmatrix} \cdot 1/3 \Rightarrow \boxed{V_0 = 5.33 \text{ or } 16/3\,V}$$

3.77

① $I_1 = 2m$

② $1k(I_2 - I_1) + 2kI_2 + 12 + 2k(I_2 - I_4) = 0$

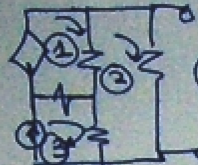
③ $-6 + 2k(I_3 - I_1) + 1k(I_3 - I_4) = 0$

④ $1k(I_4 - I_3) + 2k(I_4 - I_2) + 1k(I_4 - I_5) = 0$

⑤ $-12 + 1k(I_5) + 1k(I_5 - I_4) = 0$

$$\Rightarrow \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ -1k & 5k & 0 & -2k & 0 \\ -2k & 0 & 3k & -1k & 0 \\ 0 & -2k & -1k & 4k & -1k \\ 0 & 0 & 0 & -1k & 2k \end{bmatrix} I = \begin{bmatrix} 2m \\ -12 \\ 6 \\ 0 \\ 12 \end{bmatrix} \Rightarrow I = \begin{bmatrix} 2m \\ -\frac{78}{71}m \\ +\frac{290}{71}m \\ \frac{160}{71}m \\ \frac{506}{71}m \end{bmatrix} = \begin{bmatrix} 2 \\ -1.1 \\ 4.08 \\ 2.25 \\ 7.13 \end{bmatrix} mA$$

3.87



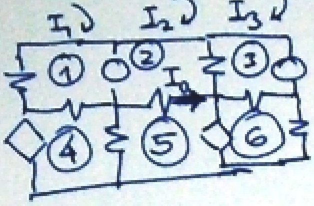
① $I_1 = \frac{V_x}{4000}$ $\quad V_x = (I_3 - I_2)\,4k \Rightarrow I_1 - I_3 + I_2 = 0$

② $2k(I_2 - I_1) + 4kI_2 + 4k(I_2 - I_3) = 0$

③ $I_3 = 6m \quad ; \quad V_o = 4kI_2$

$$\Rightarrow \begin{bmatrix} 1 & 1 & -1 \\ -2k & 10k & -4k \\ 0 & 0 & 1 \end{bmatrix} I = \begin{bmatrix} 0 \\ 0 \\ 6m \end{bmatrix} \Rightarrow I = \begin{bmatrix} 3 \\ 3 \\ 6 \end{bmatrix} mA \rightarrow \boxed{V_o = 12V}$$

3.101



① $1kI_1 + 12 + 1k(I_1 - I_4) = 0$

② $-12 + 1k(I_2 - I_3) + 1k(I_2 - I_5) = 0$

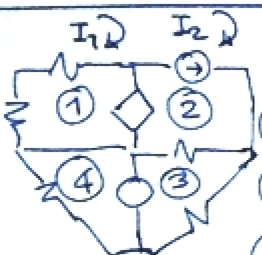
③ $I_3 = -6m$

④ $2V_x + 1k(I_4 - I_1) + 1k(I_4 - I_5) = 0 \; ; \; V_x = 1kI_6$

⑤ & ⑥ $\begin{cases} I_5 - I_6 + 2I_x = 0 \; ; \; I_x = I_4 - I_5 \\ 1k(I_5 - I_4) + 1k(I_5 - I_2) + 1k(I_6 - I_3) + 1kI_x = 0 \end{cases}$

$$\Rightarrow \begin{bmatrix} 2K & 0 & 0 & -1K & 0 & 0 \\ 0 & 2K & -1K & 0 & -1K & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ -1K & 0 & 0 & 2K & -1K & 2K \\ 0 & 0 & 0 & 2 & -1 & -1 \\ 0 & -1K & -1K & -1K & 2K & 2K \end{bmatrix} I = \begin{bmatrix} -12 \\ 12 \\ -6m \\ 0 \\ 0 \\ 0 \end{bmatrix} \Rightarrow I = \begin{bmatrix} -6.48 \\ 3.12 \\ -6.0 \\ -0.96 \\ 0.24 \\ -2.16 \end{bmatrix} mA \Rightarrow I_o = I_5 - I_2 = \boxed{-2.88\,mA}$$

3.102



① $I_1(200 + 100) + 6V_x = 0 \; ; \; V_x = I_3 \cdot 600$

② $I_2 = 40m$

③ $300(I_3 - I_2) + 600I_3 - 3 = 0$

④ $I_4 \cdot 100 + 3 = 0$

$$\begin{bmatrix} 300 & 0 & 3600 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & -300 & 900 & 0 \\ 0 & 0 & 0 & 100 \end{bmatrix} I = \begin{bmatrix} 0 \\ 40m \\ 3 \\ -3 \end{bmatrix} \Rightarrow I = \begin{bmatrix} -200m \\ 40m \\ 16.67m \\ -30m \end{bmatrix} A$$

$\Rightarrow P_o = 3(I_4 - I_3) = \boxed{-0.14\,W}$ (supplies)

5.22 Use superposition to find I_o in the network in Fig. P5.22.

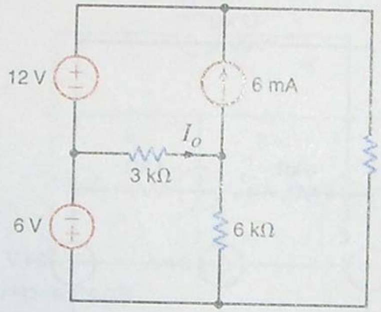


Figure P5.22

5.34 Use Thévenin's theorem to find V_o in the circuit using Fig. P5.34.

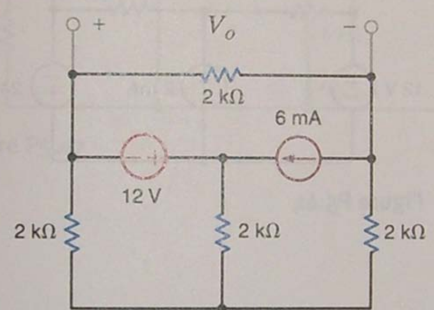


Figure P5.34

5.50 If an 8-kΩ load is connected to the terminals of the network in Fig. P5.50, $V_{AB} = 16\ \Omega$. If a 2-kΩ load is connected to the terminals, $V_{AB} = 8$ V. Find V_{AB} if a 20-kΩ load is connected to the terminals.

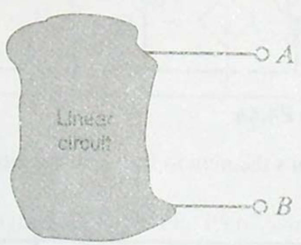


Figure P5.50

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

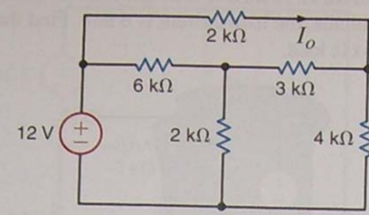


Figure P5.53

5.55 Use Norton's theorem to find I_o in the circuit in Fig. P5.55.

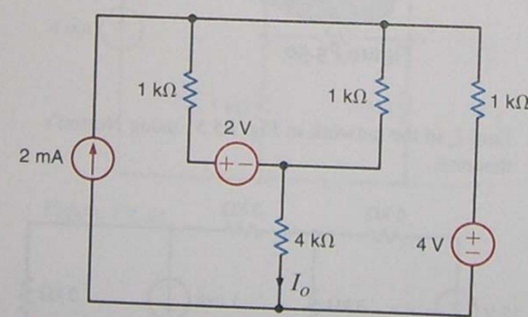
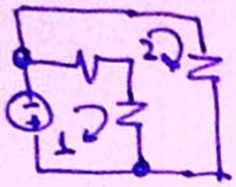


Figure P5.55

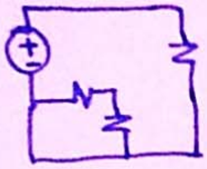
EEE 202 HW #2 SOLUTIONS

5.22 Applying superposition:

1. 

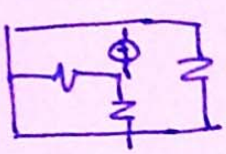
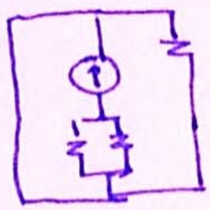
V across the 3k-6k series is 6V

$\Rightarrow I_{o1} = -\frac{6}{9k} = -\frac{2}{3}$ mA

2. 

V across the 3k-6k series is 0V

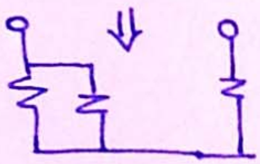
$\Rightarrow I_{o2} = 0$ mA.

3.  $\equiv$  $\equiv$ 

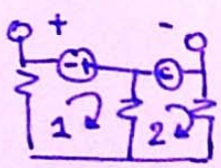
$I_{o3} = 6m \dfrac{1/3k}{2/6k + 1/6k}$

$= 4mA$

$\Rightarrow I_o = I_{o1} + I_{o2} + I_{o3} = 4m - 2/3 m = \boxed{10/3 \text{ mA.}}$

5.34 R_{TH}: 

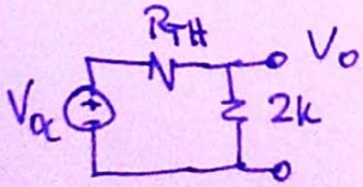
$R_{TH} = (2k \parallel 2k) + 2k = 3k\Omega$

V_{OC}: 

$I_2 = -6m$

$-12 + 2kI_1 + 2k(I_1 - I_2) = 0 \Rightarrow I_1 = 0$

$\Rightarrow V_{OC} + 2kI_2 + 2kI_1 = 0 \Rightarrow V_{OC} = 12(V)$

$\Rightarrow$ 

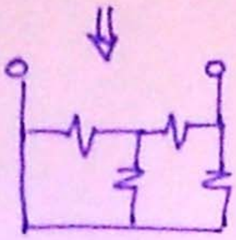
$V_o = V_{oc} \dfrac{2k}{2k + R_{TH}} = \boxed{\dfrac{24}{5}(V)}$

5.50 $V_{AB} = \dfrac{R}{R + R_{TH}} \cdot V_{oc} \Rightarrow [R, -V_{AB}] \begin{bmatrix} V_{OC} \\ R_{TH} \end{bmatrix} = RV_{AB} \Rightarrow$

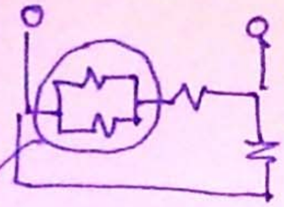
$\begin{bmatrix} 8k & -16 \\ 2k & -8 \end{bmatrix} \begin{bmatrix} V_{oc} \\ R_{TH} \end{bmatrix} = \begin{bmatrix} 8k \cdot 16 \\ 2k \cdot 8 \end{bmatrix} \Rightarrow \begin{array}{l} V_{OC} = 24V \\ R_{TH} = 4k\Omega \end{array} \Rightarrow V_{AB,20} = 24 \cdot \dfrac{20k}{20k + 4k}$

$\boxed{= 20(V)}$

5.53 R_{TH} :



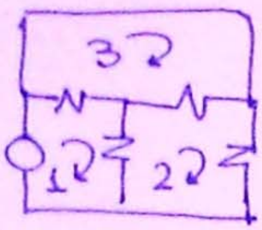
$\equiv$



$6k \,||\, 2k = \frac{3}{2}k$

$\Rightarrow R_{TH} = \left(\frac{3}{2}k + 3k\right) \,||\, 4k = \underline{\frac{36}{17} k\Omega}$

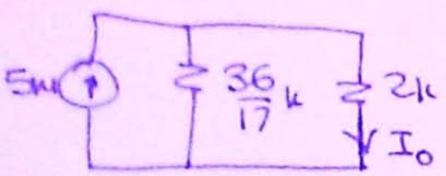
I_{SC} :



$$-12 + 6k(I_1 - I_3) + 2k(I_1 - I_2) = 0$$
$$6k(I_3 - I_1) + 3k(I_3 - I_2) = 0$$
$$2k(I_2 - I_1) + 3k(I_2 - I_3) + 4kI_2 = 0$$

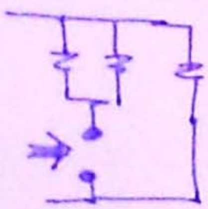
$$\Rightarrow I = \begin{pmatrix} 6 \\ 3 \\ 5 \end{pmatrix} mA \quad \Rightarrow \quad I_{SC} = I_3 = 5mA.$$

$\Rightarrow$



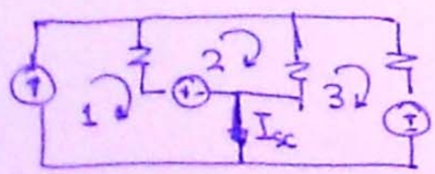
$$I_o = 5m \cdot \frac{1/2k}{1/2k + 17/36k} = \boxed{\frac{18}{7} mA}$$

5.55 R_{TH} :



$R_{TH} = (1k \,||\, 1k) + 1k = \underline{3/2 \, k(\Omega)}$

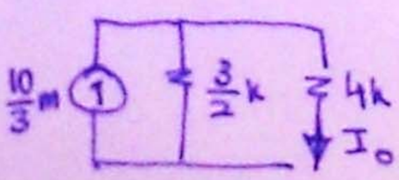
I_{SC} :



$$I_1 = 2m$$
$$-2 + 1k(I_2 - I_1) + 1k(I_2 - I_3) = 0$$
$$1k\, I_3 + 4 + 1k(I_3 - I_2) = 0$$
$$\Rightarrow \begin{Bmatrix} I_2 \\ I_3 \end{Bmatrix} = \begin{pmatrix} 4/3 \\ -4/3 \end{pmatrix} mA$$

$$I_{SC} = I_1 - I_3 = \underline{10/3 \; mA}$$

$\Rightarrow$



$$I_o = \frac{10}{3} m \frac{1/4k}{1/4k + 2/3k} = \boxed{\frac{10}{11} mA}$$

6.11 If the voltage waveform across a 100-μF capacitor is shown in Fig. P6.11, determine the waveform for the current.

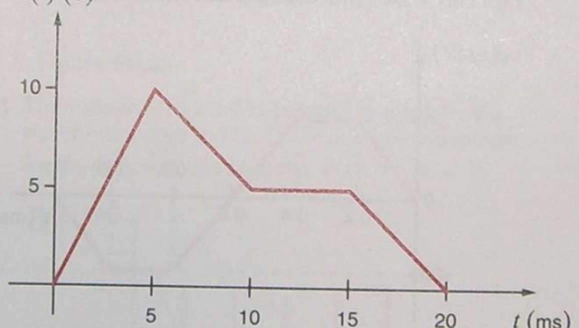


Figure P6.11

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.

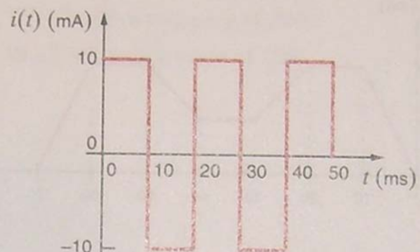


Figure P6.20

6.34 The current in a 10-mH inductor is shown in Fig. P6.34. Determine the waveform for the voltage across the inductor.

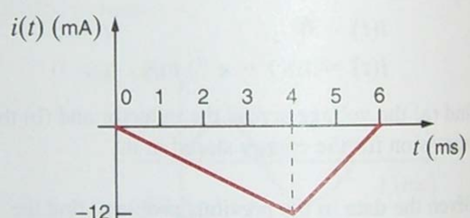


Figure P6.34

6.55 Determine C_T in the circuit in Fig. P6.55 if all capacitors in the network are 6 μF.

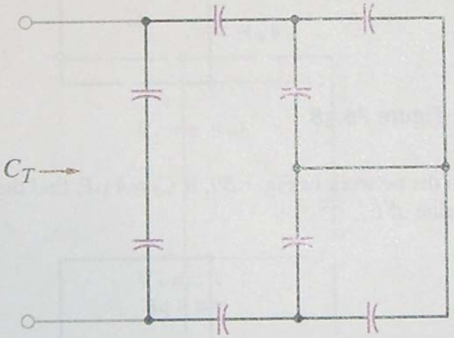


Figure P6.55

6.62 Find the total capacitance C_T shown in the network in Fig. P6.62.

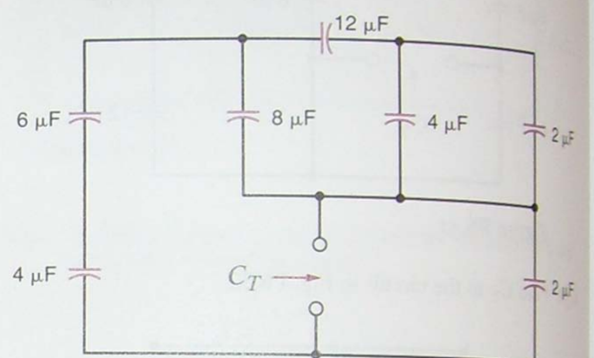


Figure P6.62

7.15 Use the step-by-step technique to find $i_o(t)$ for $t > 0$ in the network in Fig. P7.15.

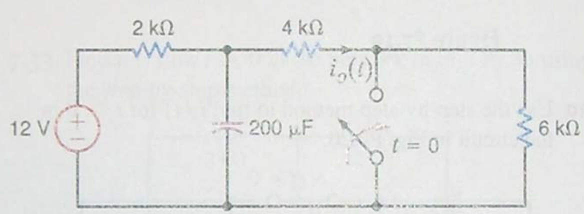


Figure P7.15

7.33 Find $v_c(t)$ for $t > 0$ in the network in Fig. P7.33 using the step-by-step method.

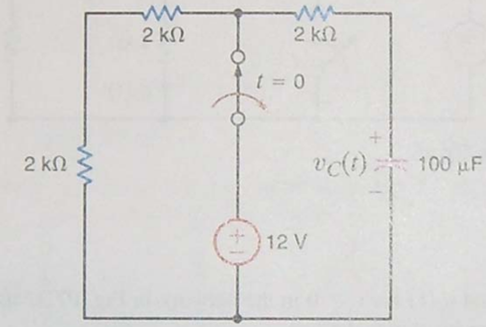


Figure P7.33

7.46 Find $i_o(t)$ for $t > 0$ in the network in Fig. P7.46 using the step-by-step method.

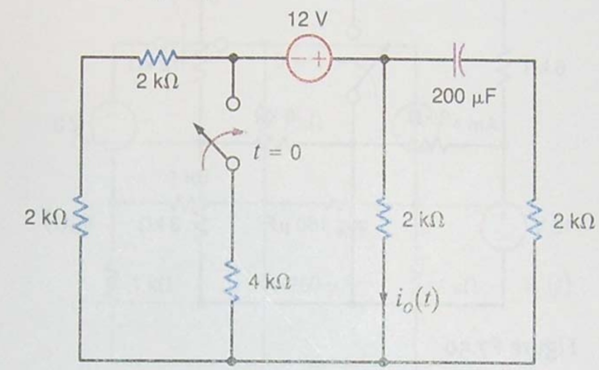


Figure P7.46

7.63 Find $i_o(t)$ for $t > 0$ in the network in Fig. P7.63.

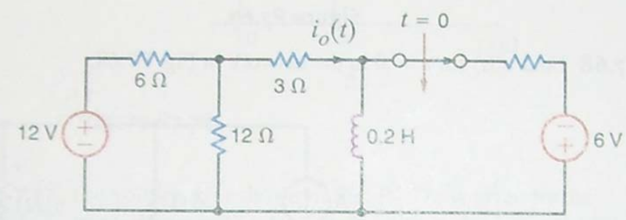


Figure P7.63

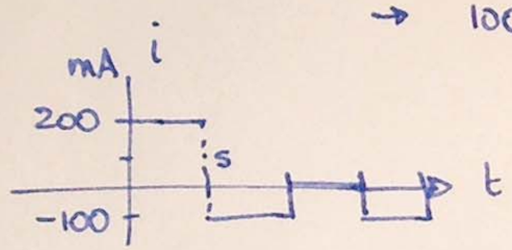
EEE 202 HW 3 SOLUTIONS

6.11 $i = C\frac{dV}{dt}$; Graphical evaluation of slopes:

$\frac{10}{5}$ V/ms , $-\frac{5}{5}$ V/ms

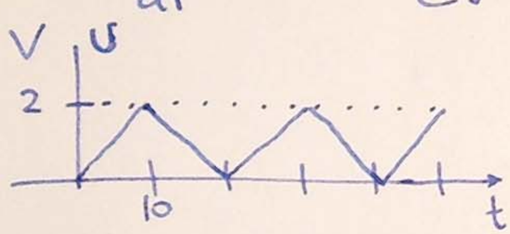
$\rightarrow$ $100\,E{-6}\ \frac{10}{5}\ 10^3 = 200$ mA

$\rightarrow$ $100\,E{-6}\left(-\frac{5}{5}\right)10^3 = -100$ mA



6.20 $i = C\frac{dV}{dt} \Rightarrow V = \frac{1}{C}\int i$ Graphical Evaluation of end-points

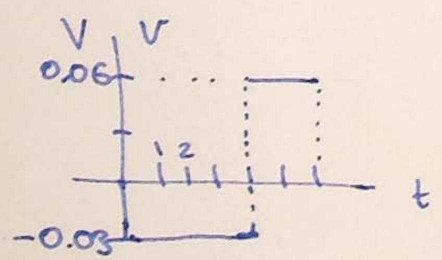
$V(10) = \frac{1}{50}E6 \cdot 100\,E{-6} = 2\ (V)$



6.34 $V = L\frac{di}{dt}$ Graphical evaluation of slopes

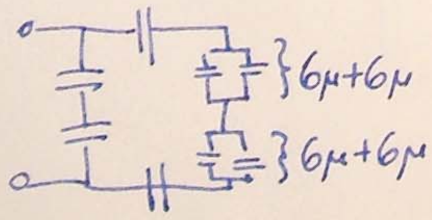
$10\,E{-3}\left(-\frac{12\,E{-3}}{4\,E{-3}}\right) = -0.03\ (V)$

$10\,E{-3}\left(\frac{12\,E{-3}}{2\,E{-3}}\right) = 0.06\ (V)$

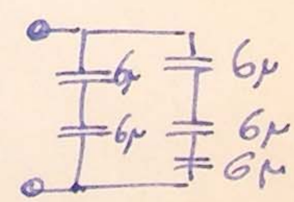


6.55

$\Longleftrightarrow$



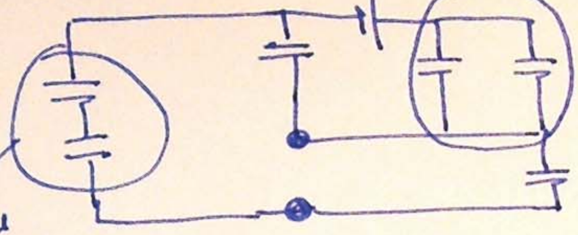
} $12\mu \parallel 12\mu = 6\mu$ $\Longleftrightarrow$



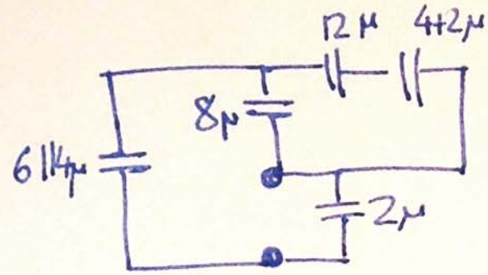
$\therefore C_{eq} = (6\mu \parallel 6\mu) + (6\mu \parallel 6\mu \parallel 6\mu) = \boxed{5\mu F}$

* where $x \parallel y \triangleq 1/\left(\frac{1}{x}+\frac{1}{y}\right)$

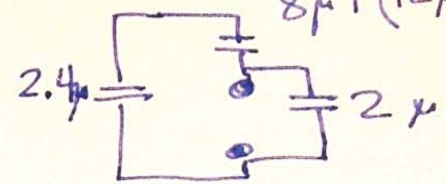
6.62



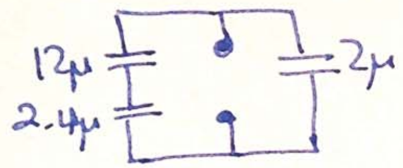
$\Longleftrightarrow$



$\Longleftrightarrow$

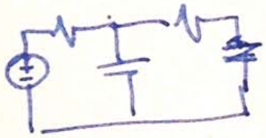


$\Longleftrightarrow$



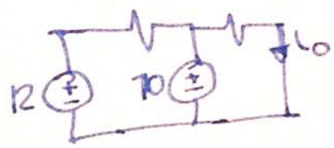
$\Rightarrow C_T = (12\mu \| 2.4\mu) + 2\mu = \boxed{4\mu F}$

7.15 $t < 0$



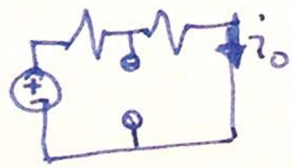
$V_c(0^-) = 12 \cdot \frac{6k+4k}{6k+4k+2k} = 12 \frac{10}{12} = 10\,(V)$

$t > 0$: $V_c(0^+) = V_c(0^-)$



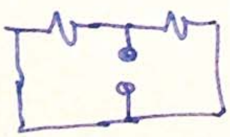
$i_o(0^+) = \frac{10}{4k} = 2.5m\,(A)$

$t > 0$:



$i_o(\infty) = \frac{12}{2k+4k} = 2m(A)$

$t > 0$ R_{TH}:



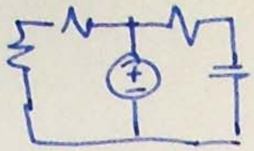
$R_{TH} = 2k \| 4k = 1.33k(\Omega)$

$\Rightarrow \tau = R_{TH} \cdot C = 1.33k \cdot 200\mu = 0.267(s)$

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

$= \boxed{\left[2 + 0.5\, e^{-t/0.267}\right] m\,(A).}$

7.33 $t<0$



$v_c(0^-) = 12\,(V)$

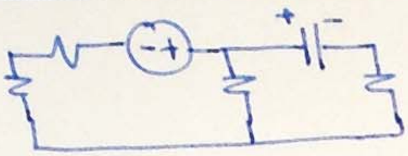
$t>0$

$v_c(\infty) = 0\,(V)$

$R_{TH} = 6k(\Omega) \Rightarrow \tau = 100\mu \cdot 6k = 0.6\,(s.)$

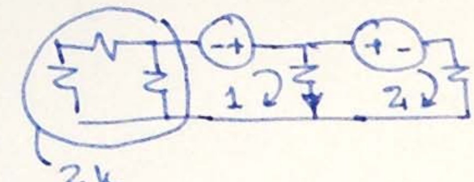
$$\Rightarrow v_c(t) = v_c(\infty) + \left[v_c(0) - v_c(\infty)\right] e^{-t/\tau} = \boxed{12e^{-t/0.6}\,(V)}$$

7.46 $t<0$



$v_c(0^-) = 12\,\frac{2k}{6k} = 4\,(V)$

$t>0$, $i(0^+)$:

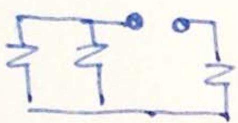


$$\begin{bmatrix} 4k & -2k \\ -2k & 4k \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -4 \end{bmatrix};\ i_o(0) = I_1 - I_2 = 2.67\,mA$$

$t>0$, $i(\infty)$:

$i_o(\infty) = \frac{12}{4k} = 3m(A)$

$t>0$, R_{TH}:

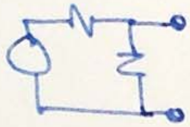


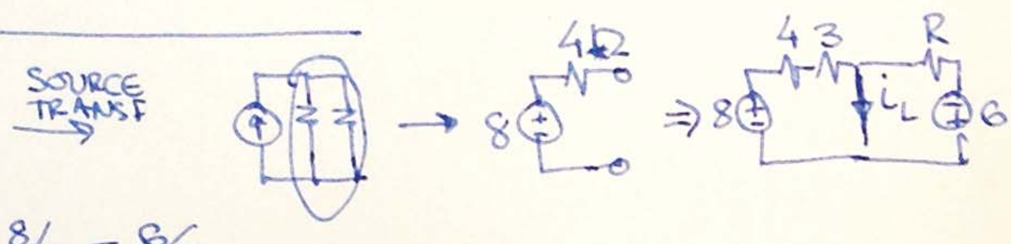
$R_{TH} = 2k + (2k \| 2k) = 3k$

$\tau = (3k)(200\mu F) = 0.6s$

$$\Rightarrow \boxed{i_o(t) = 3 - 0.33e^{-t/0.6}\ m(A)}$$

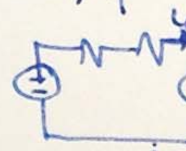
7.63 $t<0$





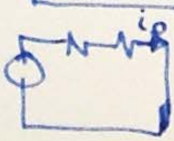
$\Rightarrow i_L(0^-) = 8/7 - 6/R$

$t>0$, $i_o(0^+)$:



$\Rightarrow i_o(0^+) = 8/7 - 6/R\ (A)$

$t>0$ $i_o(\infty)$:



$i_o(\infty) = \frac{8}{7}\ (A)$; $R_{TH} = 4+3 = 7\,\Omega$

$\tau = \frac{L}{R} = \frac{0.2}{7} = \frac{1}{35}\,s$

$$\Rightarrow \boxed{i_o(t) = \frac{8}{7} - \frac{6}{R}e^{-35t}\ (A)}$$

8.24 Determine the value of ω in Fig. 8.24 such that the peak value of $i(t)$ is 2 A.

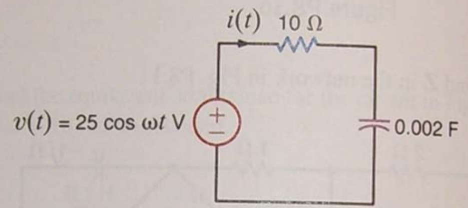


Figure P8.24

8.31 Calculate $v_1(t)$ if $i_1(t) = 7 \cos 100t$ A and $i_2(t) = 3\cos(100t + 45°)$ in Fig. P8.31.

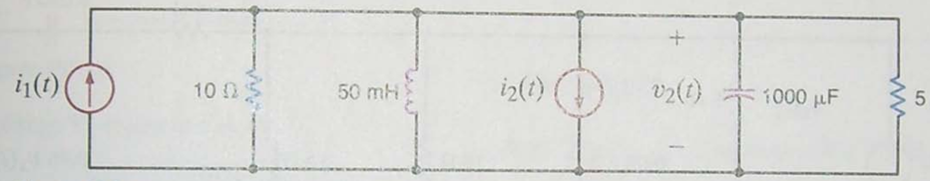


Figure P8.31

8.34 Calculate $i_1(t)$, $i_2(t)$, and $v_x(t)$ in Fig. P8.34.

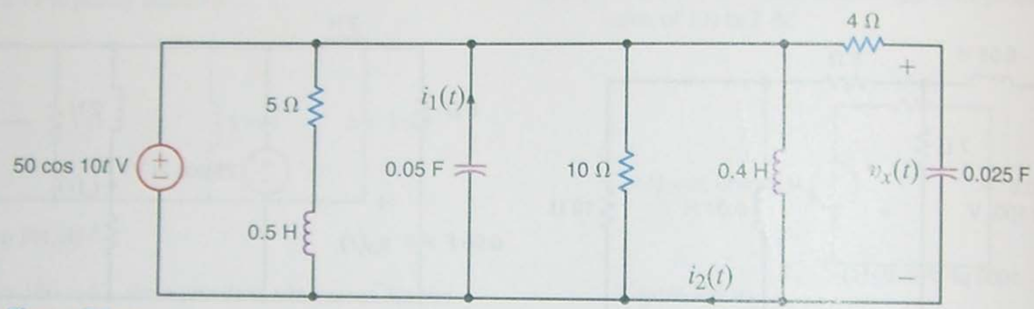


Figure P8.34

8.43 Find V_o in the network in Fig. P8.43.

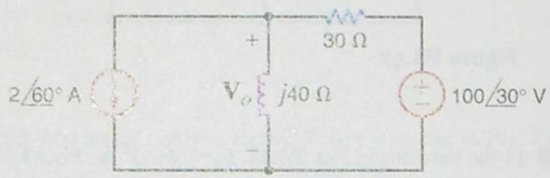


Figure P8.43

8.54 Use the supernode technique to find I_o in the circuit in Fig. P8.54.

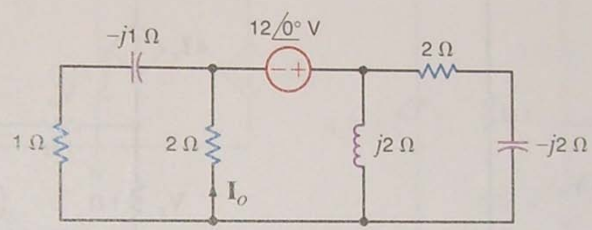


Figure P8.54

8.70 Use loop analysis to find V_o in the circuit in Fig. P8.70.

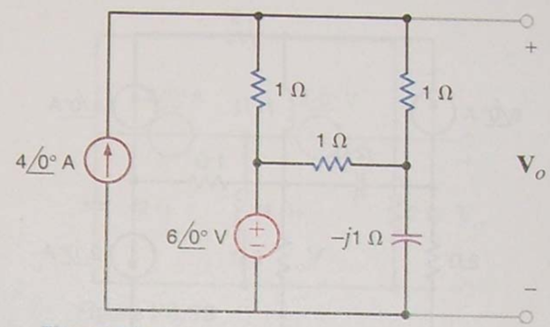


Figure P8.70

BEE 202 HW#4 SOLUTIONS

8.24 $V = 25\angle 0,\quad Z_R = 10,\quad Z_C = \frac{1}{j\omega C} = -j\,\frac{500}{\omega}$

$$\Rightarrow I = \frac{V}{Z_R + Z_C} = \frac{25}{10 - j\frac{500}{\omega}} \Rightarrow |I| = \frac{25}{\sqrt{100 + \frac{500^2}{\omega^2}}} = 2 \Rightarrow$$

$$\Rightarrow \frac{500^2}{\omega^2} + 100 = \frac{25^2}{2^2} \Rightarrow \omega = \frac{500}{\sqrt{\frac{25^2}{4} - 100}} = \boxed{66.7\ (\text{rad/s})}$$

8.31 Single Node-Pair $\underset{7\angle 0}{I_1} - \underset{3\angle 45}{I_2} - \frac{V_1}{10} - \frac{V_1}{j100\cdot 50m} - \frac{V_1}{1/j100\cdot 1m} - \frac{V_1}{5}$

$$\Rightarrow V_1 = 16.76 - 1.49j = 16.8\angle -5.1 \Rightarrow \boxed{V_1(t) = 16.8\cos(100t - 5.1^\circ)\,(V)}$$

8.34 $I_1 = -\frac{50\angle 0}{Z_C} = \frac{-50}{\left(\frac{1}{j10\,0.05}\right)} = 25\angle -90^\circ\ (A) \Rightarrow$

$$\boxed{i_1(t) = 25\cos(10t - 90^\circ)\ (A).}$$

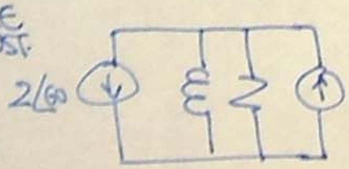
$$I_2 = \frac{+50\angle 0}{Z_{LCR}} = \frac{+50\angle 0}{\left[\frac{1}{j\omega 0.4} + \frac{1}{4 + \frac{1}{j\omega 0.025}}\right]^{-1}} = \frac{50}{4+4j} = 6.25 - 6.25j = 8.84\angle -45^\circ$$

$$\Rightarrow \boxed{i_2(t) = 8.84\cos(10t - 45^\circ)\ (A)}$$

$$V_x = \frac{50\angle 0}{4 + \frac{1}{j\omega 0.025}} \cdot \frac{1}{j\omega 0.025} = 25 - 25j = 35.4\angle -45^\circ \Rightarrow$$

$$\boxed{V_x(t) = 35.4\cos(10t - 45^\circ)\ (V)}$$

8.43 SOURCE TRANSF. $\Leftrightarrow$



$$\Rightarrow V_0 = \left(\frac{10}{3}\angle 30 - 2\angle 60\right)\cdot\left[\frac{1}{j40} + \frac{1}{30}\right]^{-1}$$

$$= 37.2 + 25.9j = \boxed{45.3\angle 34.9^\circ\ (V)}$$

8.54

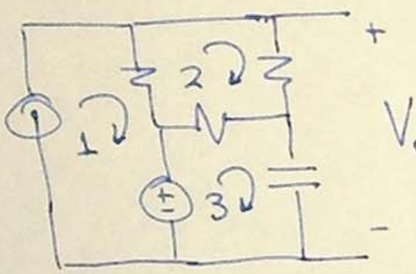
$$V_2 - V_1 = 12\angle 0$$

$$\frac{-V_1}{1-j} + \frac{-V_1}{2} + \frac{-V_2}{2j} + \frac{-V_2}{2-2j} = 0 \Rightarrow \begin{bmatrix} -1 & 1 \\ \frac{1}{1-j}+\frac{1}{2} & \frac{1}{2j}+\frac{1}{2-2j} \end{bmatrix} V = \begin{bmatrix} 12 \\ 0 \end{bmatrix}$$

$$I_0 = -\frac{V_1}{2} = \begin{bmatrix} -\frac{1}{2} & 0 \end{bmatrix} V$$

$$\Rightarrow I_0 = 0.92 - 1.38j = \boxed{1.66\angle -56.3^\circ \text{ (A)}}$$

8.70



$$I_1 = 4\angle 0$$

$$(I_2 - I_1)1 + I_2 \cdot 1 + (I_2 - I_3) \cdot 1 = 0$$

$$-6\angle 0 + (I_3 - I_2) \cdot 1 + I_3(-j) = 0$$

$$V_0 = I_2 \cdot 1 + I_3(-j)$$

$$\Rightarrow \begin{bmatrix} 1 & 0 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 1-j \end{bmatrix} I = \begin{bmatrix} 4 \\ 0 \\ +6 \end{bmatrix}$$

$$V_0 = \begin{bmatrix} 0 & 1 & -j \end{bmatrix} I = 7.5 - 1.7j$$

$$\boxed{= 7.7\angle -12.7^\circ \text{ (V)}}$$

12.4 Find the driving point impedance at the input terminals of the circuit in Fig. P12.4 as a function of s.

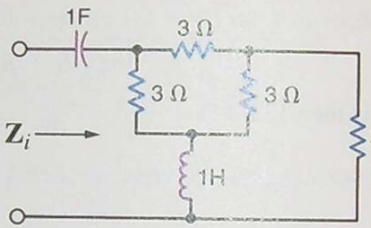


Figure P12.4

12.7 Determine the driving point impedance at the input terminals of the network shown in Fig. P12.7 as a function of s.

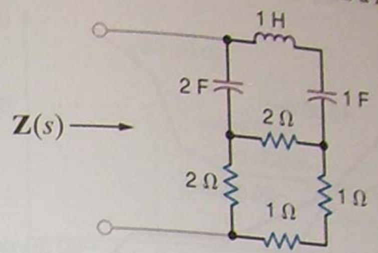


Figure P12.7

12.11 Sketch the magnitude characteristic of the Bode plot for the transfer function

$$\mathbf{H}(j\omega) = \frac{100(j\omega)}{(j\omega + 1)(j\omega + 10)(j\omega + 50)}$$

12.12 Draw the Bode plot for the network function

$$\mathbf{H}(j\omega) = \frac{10j\omega + 1}{j\omega(0.01j\omega + 1)}$$

12.24 Sketch the magnitude of the Bode plot for the transfer function

$$\mathbf{H}(j\omega) = \frac{250(j\omega + 10)}{(j\omega)^2(j\omega + 100)^2}$$

12.28 Determine $\mathbf{H}(j\omega)$ from the magnitude characteristic shown in Fig. P12.28.

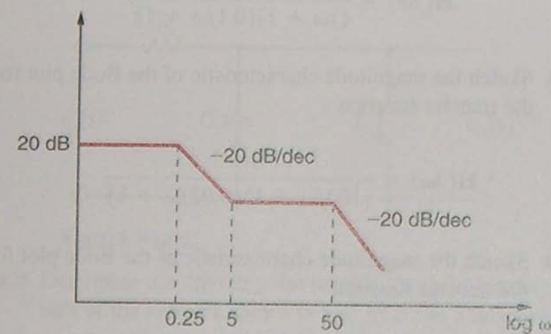


Figure P12.28

12.29 Determine $\mathbf{H}(j\omega)$ from the magnitude characteristic of the Bode plot shown in Fig. P12.29.

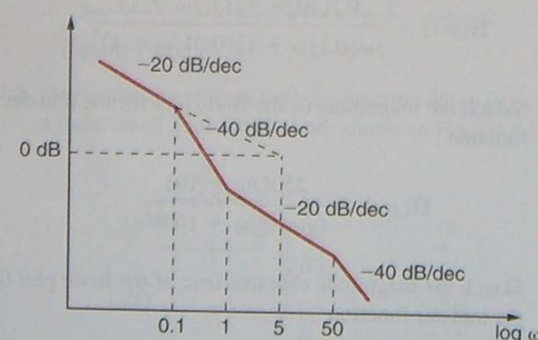


Figure P12.29

12.54 Determine the value of C in the network shown in Fig. P12.54 for the circuit to be in resonance.

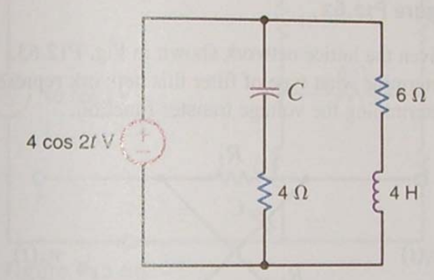
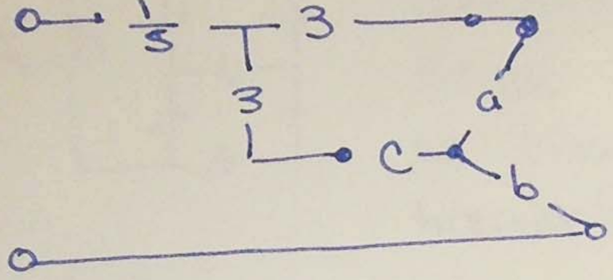


Figure P12.54

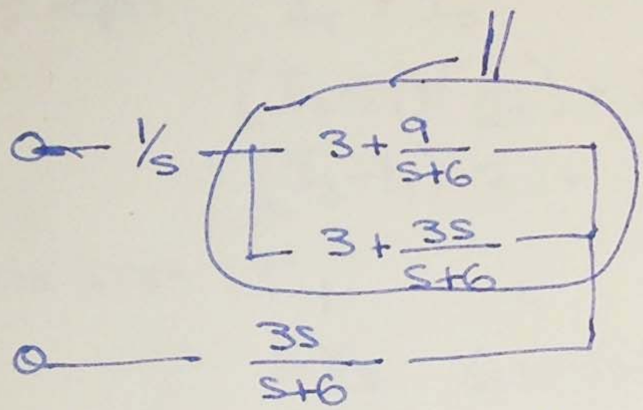
EEE 202 HW # 5 SOLUTIONS

12.4 Apply $\Delta \rightarrow Y$ transform



$$R_a = \frac{9}{s+6} \qquad R_b = \frac{3s}{s+6} \qquad R_c = \frac{3s}{s+6}$$

$$\left(R_1 = 3,\ R_2 = 3,\ R_3 = s \right)$$



$$\equiv \frac{1}{s} + \frac{2(s+9)(s+3)}{(s+5)(s+6)} + \frac{3s}{s+6}$$

$$\Rightarrow Z_{TOT} = \frac{5(s+1)^2}{s(s+5)}$$

NOTE: Depending on the sequence of derivations, other equivalent expressions may be obtained with different pole-zero cancellations

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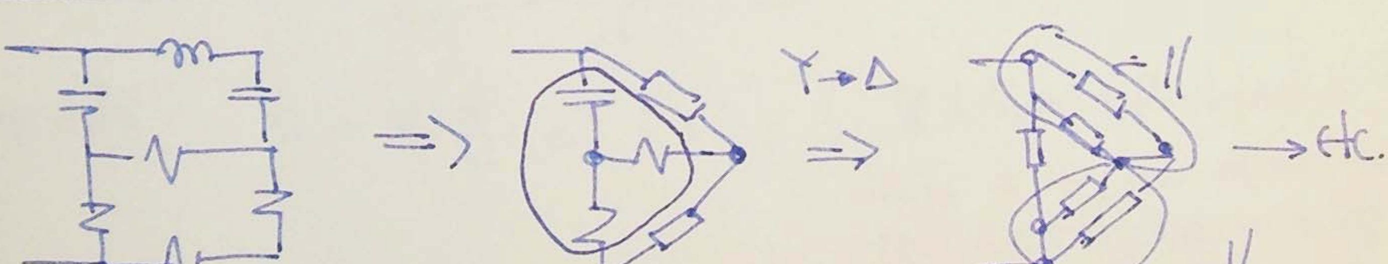
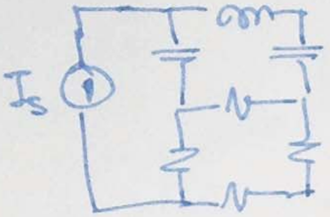
12.7



Here, for demonstration purposes, we will use an alternative derivation that is easy to compute using MATLAB's LTI toolbox. This toolbox allows the "symbolic" manipulation of transfer functions (symbolic in the Laplace variable "s").

This formulation starts with applying a current source to the network:



Computing the voltage across the current source (e.g. through Loop or nodal analysis) we have $V_s = Z_{TOT} I_s$, i.e. Z_{TOT} is the transfer function connecting V_s and I_s:

Loop eqn's: $I_1 = I_s$

$$(I_2-I_1)\left(\frac{1}{2s}\right) + I_2 s + I_2\frac{1}{s} + (I_2-I_3)2 = 0$$

$$(I_3-I_1)2 + (I_3-I_2)\cdot 2 + (I_3\cdot 1) + I_3(1) = 0$$

Matrix form:

$$\underbrace{\begin{bmatrix} 1 & 0 & 0 \\ -1/2s & 1/2s+s+1/s+2 & -2 \\ -2 & -2 & 6 \end{bmatrix}}_{A} I = \underbrace{\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}}_{B} I_s$$

$$V_s = (I_1 - I_2)\left(\frac{1}{2s}\right) + (I_1 - I_3)2 = Z_{TOT} I_s$$

$$\Rightarrow Z_{TOT} = \underbrace{\left[\frac{1}{2s}+2, \ -\frac{1}{2s}, \ -2\right]}_{C} A^{-1}\cdot B$$

Entering data: `s = tf([1,0],[1]);` % define t.f. object s

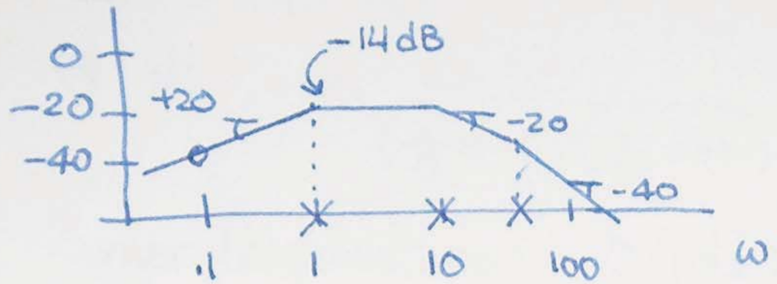
then *, +, inv operation have the expected meaning as transfer function.

```
A = [1,0,0; -1/2/s, 1/2/s+s+1/s+2, -2; -2,-2,6]
B = [1;0;0], C=[1/2/s+2, -1/2/s, -2]
ZT = C * inv(A) * B ; ZT = minreal(ZT), % to remove pole-zero cancellations
```

$$\therefore Z_T = \frac{6(8s^3+11s^2+12s+3)}{6(6s^3+8s^2+9s+0)} \ (\Omega)$$

12.11 Corner frequencies: 0 (zero), 1, 10, 50 (poles)

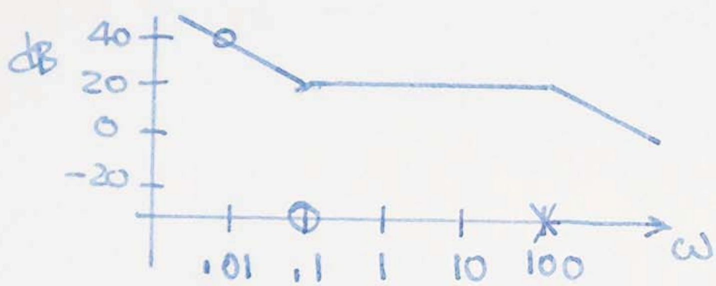
Asymptote intercept at 0.1 : $\left.\dfrac{100\,(\omega)}{(1)(10)(50)}\right|_{\omega=0.1} = \dfrac{1}{50} = -34\text{ dB}$

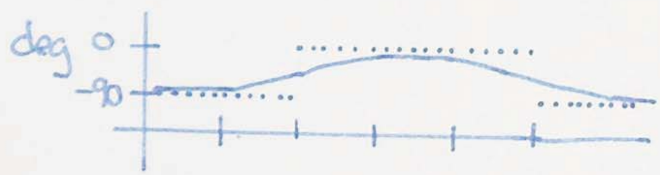


± 20 dB/dec slopes

12.12 Corner frequencies: 0 (pole) 0.1 (zero) 100 (pole)

Asymptote intercept at 0.01 $= \dfrac{1}{0.01} = 40$ dB



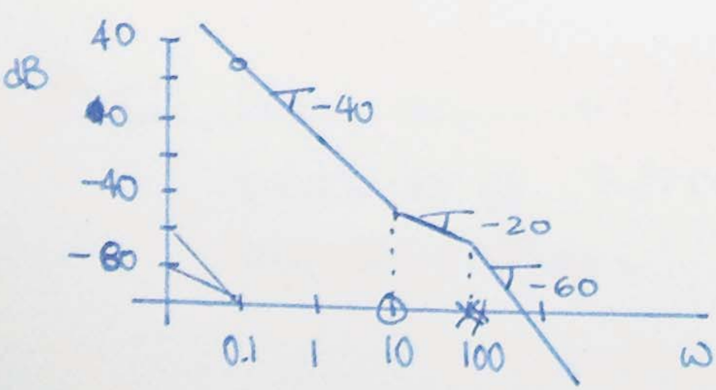


$\angle H$ starts at $-90°$

Asymptotes @ $-90°$, $0°$, $-90°$.

12.24 Corner Frequencies: 0 (2 poles), 10 (zero), 100 (2 poles)

Asymptote intercept at 0.1 $= \dfrac{250\,(10)}{(0.1)^2(100)^2} = 25 = 28$ dB



12.28 Assume a "minimum-phase" transfer function, where poles and zeros have negative real parts.

Corner frequencies (from plot): 0.25 (pole), 5 (zero), 50 (pole)

DC : 20 dB = 10

$$\Rightarrow H(s) = 10 \frac{\frac{1}{0.25}s+1}{\left(\frac{1}{5}s+1\right)\left(\frac{1}{50}s+1\right)}$$

12.29 Corner frequencies: 0 (pole), 0.1 (pole), 1 (zero), 50 (pole)

Low frequency Asymptote intercept $\left|K \frac{1}{j\omega}\right| = 0\,dB$ @ $\omega=5$

$\Rightarrow K=5$

$$\Rightarrow H(s) = 5 \frac{s+1}{s\left(\frac{1}{0.1}s+1\right)\left(\frac{1}{50}s+1\right)}$$

12.54 Transfer function $\frac{V(s)}{I(s)} = \left(\frac{1}{sC}+4\right) \| (4s+6)$

$$= \frac{1}{\frac{sC}{4Cs+1}+\frac{1}{4s+6}} = \frac{(4s+6)(4Cs+1)}{4Cs^2+10Cs+1}$$

$\Rightarrow \omega_0^2 = \frac{1}{4C} = 2^2$ for resonance at 2 rad/s

$\Rightarrow C = \frac{1}{16}$ (F)

Note: After evaluation in MATLAB the actual resonance peak is at 2.4 rad/s, which is a fairly good approximation.

13.16 Given the following functions $\mathbf{F}(s)$, find $f(t)$.

(a) $\mathbf{F}(s) = \dfrac{s + 1}{(s + 2)(s + 6)}$

(b) $\mathbf{F}(s) = \dfrac{24}{(s + 2)(s + 3)}$

(c) $\mathbf{F}(s) = \dfrac{4}{(s + 3)(s + 4)}$

(d) $\mathbf{F}(s) = \dfrac{10s}{(s + 1)(s + 6)}$

13.46 Find the initial and final values of the time function $f(t)$ if $\mathbf{F}(s)$ is given as

(a) $\mathbf{F}(s) = \dfrac{10(s + 2)}{(s + 1)(s + 3)}$

(b) $\mathbf{F}(s) = \dfrac{s^2 + 2s + 4}{(s + 6)(s^3 + 4s^2 + 8s + 10)}$

(c) $\mathbf{F}(s) = \dfrac{2s}{s^2 + 2s + 2}$

13.56 In the network in Fig. P13.56, the switch opens at $t = 0$. Use Laplace transforms to find $i_L(t)$ for $t > 0$.

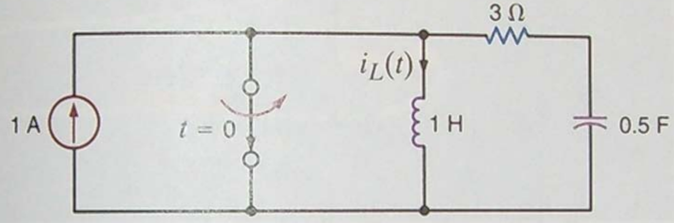


Figure P13.56

14.5 Find $v_o(t)$, $t > 0$, in the network in Fig. P14.5 using node equations.

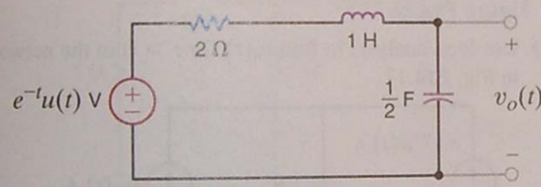


Figure P14.5

14.8 For the network shown in Fig. P14.8, find $i_o(t)$, $t > 0$.

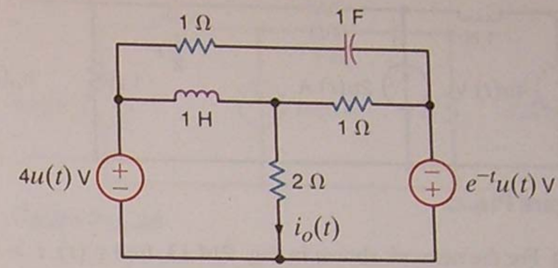


Figure P14.8

14.23 Use source transformation to find $v_o(t)$, $t > 0$, in the circuit in Fig. P14.23.

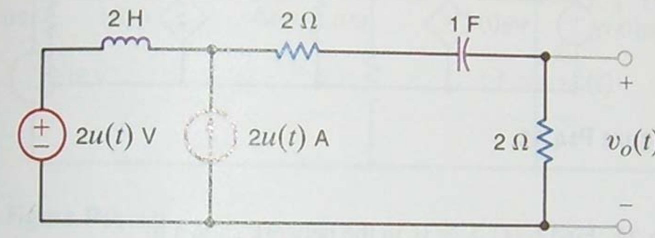


Figure P14.23

14.25 Use Thévenin's theorem to find $v_o(t)$, $t > 0$, in Fig. P14.25.

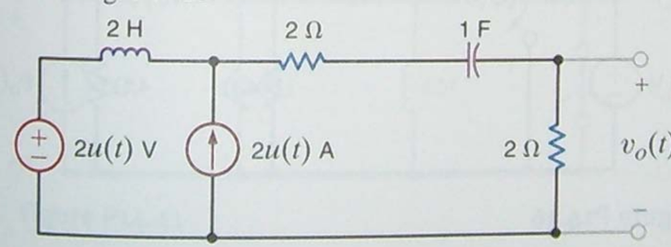


Figure P14.25

EEE 202 HW#6 SOLUTIONS

13.16

a. $F(s) = \dfrac{s+1}{(s+2)(s+6)} \overset{PFE}{=} \dfrac{1.25}{s+6} + \dfrac{-0.25}{s+2}$

$\overset{\mathcal{L}^{-1}}{\Rightarrow} f(t) = 1.25e^{-6t} - 0.25e^{-2t}$ for $t \geq 0$

(or $f(t) = 1.25e^{-6t}u(t) - 0.25e^{-2t}u(t)$)

b. $F(s) = \dfrac{24}{(s+2)(s+3)} \overset{PFE}{=} \dfrac{-24}{s+3} + \dfrac{24}{s+2}$

$\overset{\mathcal{L}^{-1}}{\Rightarrow} f(t) = -24e^{-3t} + 24e^{-2t}$ for $t \geq 0$

c. $F(s) = \dfrac{4}{(s+3)(s+4)} \overset{PFE}{=} \dfrac{-4}{s+4} + \dfrac{4}{s+3}$

$\overset{\mathcal{L}^{-1}}{\Rightarrow} f(t) = -4e^{-4t} + 4e^{-3t}$ for $t \geq 0$.

d. $F(s) = \dfrac{10s}{(s+1)(s+6)} \overset{PFE}{=} \dfrac{12}{s+6} + \dfrac{-2}{s+1}$

$\overset{\mathcal{L}^{-1}}{\Rightarrow} f(t) = 12e^{-6t} - 2e^{-t}$ for $t \geq 0$.

13.46 FVT / IVT : $\lim_{t\to\infty} f(t) \overset{*}{=} \lim_{s\to 0} sF(s)$ (* if it exists)

$\lim_{t\to 0^+} f(t) = \lim_{s\to\infty} sF(s)$

a. $\lim sF(s) = \begin{cases} 0 & \text{as } s\to 0 \\ 10 & \text{as } s\to\infty \end{cases}$

$\Rightarrow \lim_{t\to\infty} f(t) = 0$, the limit exists because the poles of $F(s)$ have negative real parts.

$\lim_{t\to 0} f(t) = 10$

b. $\lim sF(s) = \begin{cases} 0 & \text{as } s\to 0 \\ 0 & \text{as } s\to\infty \end{cases} \Rightarrow \begin{cases} \lim_{t\to\infty} f(t) = 0 & \text{(All poles are in LHP)} \\ \lim_{t\to 0} f(t) = 0 \end{cases}$

c. $\lim sF(s) = \begin{cases} 0 \text{ as } s\to 0 \\ 2 \text{ as } s \to \infty \end{cases} \Rightarrow \begin{cases} \lim_{t\to\infty} f(t) = 0 & \text{All poles are in LHP} \\ \lim_{t\to 0} f(t) = 2 \end{cases}$

Note: The limit also exists if F(s) has a single pole at the origin.

13.56 Using current division:

$$I_L(s) = \frac{1/Ls}{1/Ls + 1/(R+1/Cs)} \cdot I_s(s) \qquad I_s = \frac{1}{s}$$

for t<0, the circuit has $I_L = 0$, $V_c = 0$ ⇒ zero initial conditions for the t≥0 circuit

$$\Rightarrow I_L(s) = \frac{RCs+1}{1+RCs+LCs^2} \cdot \frac{1}{s} = \frac{1.5s+1}{s(0.5s^2+1.5s+1)}$$

$$= \frac{3s+2}{s(s^2+3s+2)} \overset{PFE}{=} \frac{-2}{s+2} + \frac{1}{s+1} + \frac{1}{s}$$

$$\overset{\mathcal{L}^{-1}}{\Rightarrow} i_L(t) = -2e^{-2t} + e^{-t} + 1, \quad \text{for } t \geq 0.$$

14.5 $V_{1,2,3}$ left to right, $V_o = V_3$. Taking Laplace transforms,

$$\left.\begin{aligned} &V_1 = \mathcal{L}\{e^{-t}u(t)\} = \frac{1}{s+1} \\ &\frac{V_2-V_1}{2} + \frac{V_2-V_3}{Ls} = 0 \\ &\frac{V_3-V_2}{Ls} + \frac{V_3}{1/Cs} = 0 \end{aligned}\right\} \Rightarrow \underbrace{\begin{bmatrix} 1 & 0 & 0 \\ -\frac{1}{2} & \frac{1}{2}+\frac{1}{Ls} & -\frac{1}{Ls} \\ 0 & -\frac{1}{Ls} & \frac{1}{Ls}+Cs \end{bmatrix}}_{A} \begin{bmatrix} V \end{bmatrix} = \underbrace{\begin{bmatrix} \frac{1}{s+1} \\ 0 \\ 0 \end{bmatrix}}_{B}$$

$$\overset{PFE}{\Rightarrow} V_o(s) = \frac{-1}{s+1-j} + \frac{-1}{s+1+j} + \frac{2}{s+1}$$

$$V_o = [0\ 0\ 1]\, A^{-1}(s) B(s) = \frac{2}{s^3+3s^2+4s+2}$$

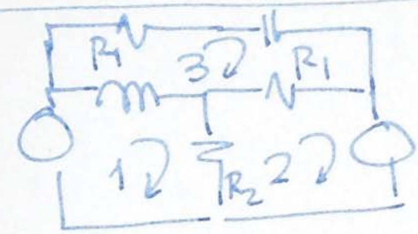
$$\overset{\mathcal{L}^{-1}}{\Rightarrow} V_o(t) = -\left[e^{-(1-j)t} + \left[e^{-(1-j)t}\right]^*\right] + 2e^{-t};\ t \geq 0$$

$$= -2\,\mathrm{Re}\left\{e^{-(1-j)t}\right\} + 2e^{-t};\ t \geq 0$$

$$= -2e^{-t}\ \mathrm{Re}\, e^{jt} + 2e^{-t};\ t \geq 0$$

$$= -2e^{-t}\cos t + 2e^{-t};\ t \geq 0$$

<u>14.8</u>.



$$-\frac{4}{s} + (I_1 - I_3)Ls + (I_1 - I_2)R_2 = 0$$

$$-\frac{1}{s+1} + (I_2 - I_1)R_2 + (I_2 - I_3)R_1 = 0$$

$$Ls(I_3 - I_1) + I_3\left(R_1 + \frac{1}{Cs}\right) + (I_3 - I_2)R_1 = 0$$

$$I_o = I_1 - I_2$$

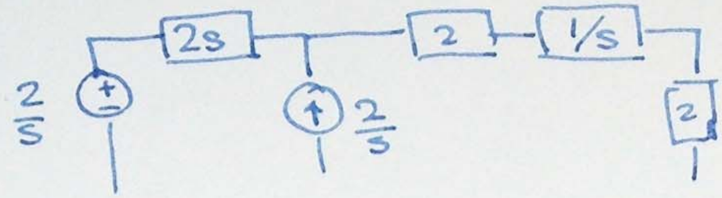
$$\Rightarrow \begin{bmatrix} Ls+R_2 & -R_2 & -Ls \\ -R_2 & R_2+R_1 & -R_1 \\ -Ls & -R_1 & Ls+R_1 +R_1+1/Cs \end{bmatrix} I = \begin{bmatrix} 4/s \\ 1/s+1 \\ 0 \end{bmatrix}$$

$$I_o = [1\ \ -1\ \ 0]\, I = [1, -1, 0]\, A^{-1}(s)\, B(s) = \frac{1}{3} \cdot \frac{-s^2+4s+4}{s^3 + 5/3\, s^2 + 2/3\, s}$$

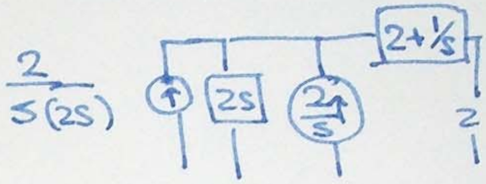
$$\overset{PFE}{=} \frac{-1}{s+1} + \frac{-4/3}{s+2/3} + \frac{2}{s}$$

$$\overset{\mathcal{L}^{-1}}{\Rightarrow} i_o(t) = -e^{-t}u(t) - \frac{4}{3}e^{-2/3\, t}u(t) + 2u(t).$$

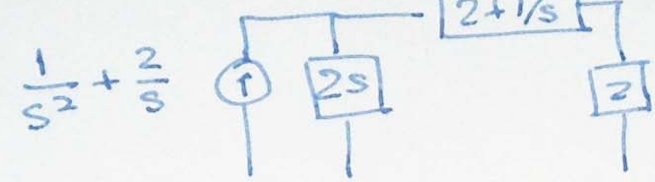
14.23



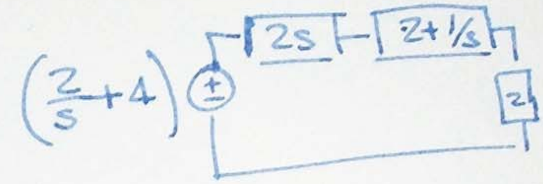
$\Leftrightarrow$



$\Leftrightarrow$



$\Leftrightarrow$



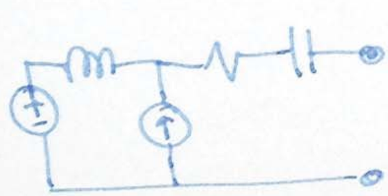
$\Leftrightarrow$ Voltage division $V_o(s) = \frac{4s+2}{s} \cdot \frac{2}{2+2s+2+1/s}$

$$= \frac{4s+2}{s} \cdot \frac{2s}{2s^2+4s+1} = \frac{4s+2}{s^2+2s+1/2}$$

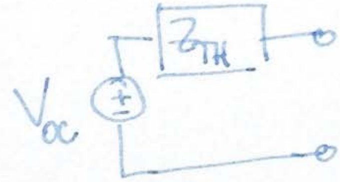
$$\overset{PFE}{=} \frac{3.41}{s+1.71} + \frac{0.59}{s+0.29}$$

$\Rightarrow V_o(t) = 3.41 e^{-1.71t} u(t) + 0.59 e^{-0.29t} u(t).$

14.25



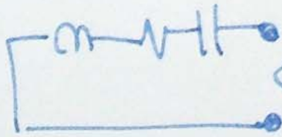
Thevenin $\Longleftrightarrow$



$I_1 = -\frac{2}{s}$

$-\frac{2}{s} + LsI_1 + (R + 1/Cs)\cancel{I_2}^{\,0} + V_{oc} = 0 \Rightarrow V_{oc} = \frac{2}{s} - LsI_1$

$$= \frac{2}{s} + 4$$



$\Leftarrow Z_{TH} = \frac{1}{Cs} + R + Ls = \frac{1}{s} + 2 + 2s$

$$= \frac{2s^2+2s+1}{s}$$

By voltagedivision, $V_{OT} = V_{oc} \cdot \frac{2}{2+Z_{TH}} = \frac{4s+2}{s} \cdot \frac{2}{2+\frac{2s^2+2s+1}{s}} = \frac{4s+2}{s^2+2s+1/2}$

etc, as in 14.23