Chapter 8

1. a. $I_1 = \dfrac{8\ \Omega(6\text{A})}{8\ \Omega + 2\ \Omega} = \mathbf{4.8\ A}$ $\quad I_2 = 6\text{ A} - I_1 = 6\text{ A} - 4.8\text{ A} = \mathbf{1.2\ A}$

   b. $V_s = I_1R_1 = (4.8\text{ A})(2\ \Omega) = \mathbf{9.6\ V}$

2. a. $I_1 = I_2 = \mathbf{20\ mA}$

   b. $V_2 = I_2R_2 = (20\text{ mA})(3.3\text{ k}\Omega) = \mathbf{66\ V}$
   $V_s = IR_T = (20\text{ mA})((1.2\text{ k}\Omega + 3.3\text{ k}\Omega) = 20\text{ mA}(4.5\text{ k}\Omega) = \mathbf{90\ V}$

3. $E + V_{R_1} - V_s = 0,\ V_{R_1} = (8\text{ mA})(2.7\text{ k}\Omega) = 21.6\text{ V}$
   $V_s = E + V_{R_1} = 10\text{ V} + 21.6\text{ V} = \mathbf{31.6\ V}$ (+ –)

4. a. $V_s = E = \mathbf{24\ V}$
   b. $I_2 = \dfrac{E}{R_1 + R_2} = \dfrac{24\text{ V}}{1\ \Omega + 3\ \Omega} = \dfrac{24\text{ V}}{4\ \Omega} = \mathbf{6\ A}$
   c. $I + I_s = I_2,\ \ I_s = I_2 - I = 6\text{ A} - 2\text{ A} = \mathbf{4\ A}$

5. $V_1 = V_2 = V_s = IR_T = 0.6\text{ A}[6\ \Omega \parallel 24\ \Omega \parallel 24\ \Omega] = 0.6\text{ A}[6\ \Omega \parallel 12\ \Omega] = 2.4\text{ V}$
   $I_2 = \dfrac{V_2}{R_2} = \dfrac{2.4\text{ V}}{24\ \Omega} = \mathbf{0.1\ A}$
   $V_3 = \dfrac{R_3V_s}{R_3 + R_4} = \dfrac{16\ \Omega(2.4\text{ V})}{24\ \Omega} = \mathbf{1.6\ V}$

6. a. $I_1 = \dfrac{E}{R_1} = \dfrac{24\text{ V}}{2\ \Omega} = \mathbf{12\ A},\ I_{R_2} = \dfrac{E}{R_2 + R_3} = \dfrac{24\text{ V}}{6\ \Omega + 2\ \Omega} = \dfrac{24\ \Omega}{8\ \Omega} = 3\text{ A}$
   KCL: $I + I_s - I_1 - I_{R_2} = 0$
   $I_s = I_1 + I_{R_2} - I = 12\text{ A} + 3\text{ A} - 4\text{ A} = \mathbf{11\ A}$

   b. $V_s = E = 24\text{ V}$
   VDR: $V_3 = \dfrac{R_3E}{R_2 + R_3} = \dfrac{2\ \Omega(24\text{ V})}{6\ \Omega + 2\ \Omega} = \dfrac{48\text{ V}}{8\ \Omega} = \mathbf{6\ V}$

7. a. $I = \dfrac{E}{R_s} = \dfrac{22\text{ V}}{4.7\ \Omega} = \mathbf{4.68\ A}$, $R_p = R_s = \mathbf{4.7\ \Omega}$

   b. $I = \dfrac{E}{R_T} = \dfrac{E}{R_1 + R_2} = \dfrac{9\text{ V}}{1.2\text{ k}\Omega + 2.2\text{ k}\Omega} = \dfrac{9\text{ V}}{3.4\text{ k}\Omega} = \mathbf{2.65\ A}$
   $R_p = \mathbf{3.4\ k\Omega}$

8. a. $E = IR_p = (6\text{ A})(12\ \Omega) = \mathbf{72\ V}$, $R_s = \mathbf{12\ \Omega}$

b. $R_p = R_1 \parallel R_2 = 2.7\ \text{k}\Omega \parallel 8.1\ \text{k}\Omega = 2.03\ \text{k}\Omega$
$E = IR_p = (18\text{ mA})(2.03\ \text{k}\Omega) = \mathbf{36.54\ V}$, $R_s = \mathbf{2.03\ k\Omega}$

9. a. CDR: $I_L = \dfrac{R_s(I)}{R_s + R_L} = \dfrac{(91\ \Omega)(12\text{ mA})}{91\ \Omega + 10\ \Omega} = \mathbf{10.81\ mA}$

b. $E_s = IR = (12\text{ mA})(91\ \Omega) = \mathbf{1.092\ V}$
$R_s = 91\ \Omega$
$I = \dfrac{E_s}{R_s + R_L} = \dfrac{1.092\text{ V}}{91\ \Omega + 10\ \Omega} = \mathbf{10.81\ mA}$

10. a. $E = IR_2 = (2\text{ A})(5.6\ \Omega) = \mathbf{11.2\ V}$, $R = \mathbf{5.6\ \Omega}$

b. $E_T = 12\text{ V} + 11.2\text{ V} = \mathbf{23.2\ V}$, $R_T = 10\ \Omega + 5.6\ \Omega = \mathbf{15.6\ \Omega}$

c. $I_3 = \dfrac{E_T}{R_T + 91\ \Omega} = \dfrac{23.2\text{ V}}{15.6\ \Omega + 91\ \Omega} = \mathbf{217.64\ mA}$

11. a. $I_T = 6.2\text{ A} - 1.2\text{ A} + 0.8\text{ A} = 7\text{ A} - 1.2\text{ A} = \mathbf{5.8\ A}$

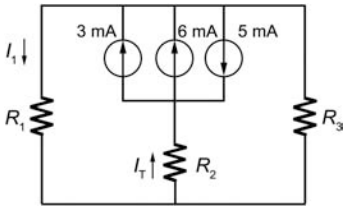
b. $V_s = I_T R = (5.8\text{ A})(4\ \Omega) = \mathbf{23.2\ V}$

12. $I_T\uparrow = 7\text{ A} - 3\text{ A} = 4\text{ A}$
CDR: $I_1 = \dfrac{R_2(I_T)}{R_1 + R_2} = \dfrac{6\ \Omega(4\text{ A})}{4\ \Omega + 6\ \Omega} = \mathbf{2.4\ A}$
$V_2 = I_1R_1 = (2.4\text{ A})(4\ \Omega) = \mathbf{9.6\ V}$

13. a. $I_T = \dfrac{E_2}{R_2} - \dfrac{E_1}{R_1} = \dfrac{20\text{ V}}{2\ \Omega} - \dfrac{9\text{ V}}{3\ \Omega}$
$= 10\text{ A} - 3\text{ A} = \mathbf{7\ A}\downarrow$

b. $V_{ab} = -I_T\,(R_1 \parallel R_2 \parallel R_3)$
$= -7\text{A}\ (3\ \Omega \parallel 6\ \Omega \parallel 2\ \Omega)$
$= -7\text{ A}\ (1\ \Omega)$
$= \mathbf{-7\ V}$

c. $I_3 = \dfrac{7\text{ V}}{6\ \Omega} = \mathbf{1.17\ A}\uparrow$

14. a. 

$I_T = 3\text{ mA} + 6\text{ mA} - 5\text{ mA} = 4\text{ mA}\uparrow$
$I_{R_1} = \dfrac{R_3 I_T}{R_1 + R_3} = \dfrac{1\ \text{k}\Omega\ (4\text{ mA})}{2.2\ \text{k}\Omega + 1\ \text{k}\Omega} = 1.25\text{ mA}$
$V_1 = I_{R_1}(R_1) = (1.25\text{ mA})(2.2\ \text{k}\Omega) = \mathbf{2.75\ V}$

15. a. I_1, I_3, I_2

$4 - 4I_1 - 8I_3 = 0$
$6 - 2I_2 - 8I_3 = 0$
$I_1 + I_2 = I_3$

$$I_1 = -\frac{\mathbf{1}}{\mathbf{7}}\,\mathbf{A}, I_2 = \frac{\mathbf{5}}{\mathbf{7}}\,\mathbf{A}, I_3 = \frac{\mathbf{4}}{\mathbf{7}}\,\mathbf{A}$$

$$I_{R_1} = I_1 = -\frac{\mathbf{1}}{\mathbf{7}}\,\mathbf{A}, I_{R_2} = I_2 = \frac{\mathbf{5}}{\mathbf{7}}\,\mathbf{A}, I_{R_3} = I_3 = \frac{\mathbf{4}}{\mathbf{7}}\,\mathbf{A}$$

b. $V_a = I_3R_3 = \left(\frac{4}{7}\text{A}\right)(8\ \Omega) = \mathbf{4.57\ V}$

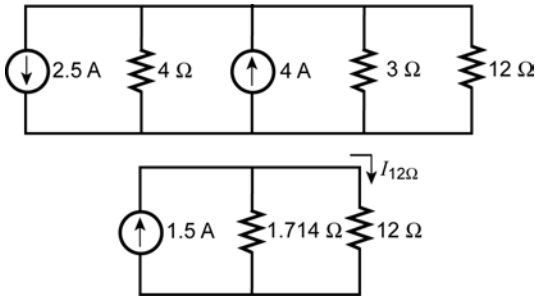
16. a. I_1, I_3, I_2

$10 + 12 - 3I_3 - 4I_1 = 0$
$12 - 3I_3 - 12I_2 = 0$
$I_1 + I_2 = I_3$

$I_1 = \mathbf{3.06\ A}$
$I_2 = \mathbf{0.19\ A}$
$I_3 = \mathbf{3.25\ A}$

$I_{R_1} = I_1 = 3.06$ A, $I_{R_3} = I_2 = \mathbf{0.19\ A} = I_{12\Omega}$
$I_{R_2} = I_3 = 3.25$ A

b.



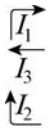
$$I_{12\Omega} = \frac{(1.714\ \Omega)(1.5\ \text{A})}{1.714\ \Omega + 12\ \Omega} = \mathbf{0.19\ A}$$

c. the same

17. I_1, I_3, I_2

$10 - I_1\ 5.6\ \text{k}\Omega - I_3\ 2.2\ \text{k}\Omega + 20 = 0$
$-20 + I_3\ 2.2\ \text{k}\Omega + I_2\ 3.3\ \text{k}\Omega - 30 = 0$
$I_1 + I_2 = I_3$

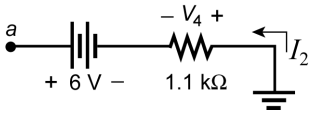
$I_1 = I_{R_1} = \mathbf{1.45\ mA}$, $I_2 = I_{R_2} = \mathbf{8.51\ mA}$, $I_3 = I_{R_3} = \mathbf{9.96\ mA}$

18. a. 

$-1.2\ \text{k}\Omega\ I_1 + 9 - 8.2\ \text{k}\Omega\ I_3 = 0$
$-10.2\ \text{k}\Omega\ I_2 + 8.2\ \text{k}\Omega\ I_3 + 6 = 0$
$I_2 + I_3 = I_1$

I_1 = **2.03 mA**, I_2 = **1.23 mA**, I_3 = **0.8 mA**

$I_{R_1} = I_1 = 2.03\ \text{mA}$
$I_{R_2} = I_3 = 0.8\ \text{mA}$
$I_{R_3} = I_{R_4} = I_2 =$ **1.23 mA** $= I_{9.1\text{k}\Omega}$

b. 

19. $V_4 = I_2R_4 = (1.23\ \text{mA})(1.1\ \text{k}\Omega) = 1.35\ \text{V}$
$V_a = 6\ \text{V} - V_4 = 6\ \text{V} - 1.35\ \text{V} =$ **4.65 V**

$I_1 = I_{R_1}$ (CW), $I_2 = I_{R_2}$ (down), $I_3 = I_{R_3}$ (CW), $I_4 = I_{R_4}$ (down)
$I_5 = I_{R_5}$ (CW)

a. $E_1 - I_1R_1 - I_2R_2 = 0$
$I_2R_2 - I_3R_3 - I_4R_4 = 0$
$I_4R_4 - I_5R_5 - E_2 = 0$
$I_1 = I_2 + I_3$
$I_3 = I_4 + I_5$

b. $E_1 - I_2(R_1 + R_2) - I_3R_1 = 0$
$I_2R_2 - I_3(R_3 + R_4) + I_5R_4 = 0$
$I_3R_4 - I_5(R_4 + R_5) - E_2 = 0$

c. $I_2(R_1 + R_2) + I_3R_1 + 0 = E_1$
$I_2(R_2) - I_3(R_3 + R_4) + I_5R_4 = 0$
$0 + I_3R_4 - I_5(R_4 + R_5) = E_2$

$3I_2 + 2I_3 + 0 = 10$
$1I_2 - 9I_3 + 5I_5 = 0$
$0 + 5I_3 - 8I_5 = 6$

d. $I_3 = I_{R_3} =$ **−63.69 mA** (CW)

20. a. $\overrightarrow{I_1}\ \overrightarrow{I_2}$

$$4 - 4I_1 - 8(I_1 - I_2) = 0$$
$$-8(I_2 - I_1) - 2I_2 - 6 = 0$$

$I_1 = -\frac{1}{7}\text{ A}$, $I_2 = \mathbf{-\frac{5}{7}\ A}$

$I_{R_1} = I_1 = \mathbf{-\frac{1}{7}\ A}$

$I_{R_2} = I_2 = \mathbf{-\frac{5}{7}\ A}$

$I_{R_3} = I_1 - I_2 = \left(-\frac{1}{7}\text{A}\right) - \left(-\frac{5}{7}\text{A}\right) = \mathbf{\frac{4}{7}\ A}\ (\text{dir. of } I_1)$

b. $V_a = I_{R_3}R_3 = \left(\frac{4}{7}\text{A}\right)(8\ \Omega) = \mathbf{4.57\ V}$

21 a. $\overrightarrow{I_1}\ \overrightarrow{I_2}$

$$-10 - 4I_1 - 3(I_1 - I_2) - 12 = 0$$
$$12 - 3(I_2 - I_1) - 12I_2 = 0$$

$I_1 = -3.06$ A, $I_2 = 0.19$ A

$I_{E_1} = \mathbf{3.06\ A}$ (CCW)

$I_{E_2} = 3.06\text{ A} + 0.19\text{ A} = \mathbf{3.25\ A\ (up)}$

$I_{R_2} = I_1 - I_2 = (-3.06\text{ A}) - (0.19\text{ A}) = \mathbf{-3.25\ A}$

b. $P_{E_2} = I_{E_2}E_2 = (3.25\text{ A})(12\text{ V}) = \mathbf{39\ W}$

$P_{R_3} = I_{R_3}^2 R_3 = (0.19\text{ A})^2\ 12\ \Omega = \mathbf{433.2\ mW}$

22. a. $\overrightarrow{I_1}\ \overrightarrow{I_2}$

$$10 - I_1(5.6\text{ k}\Omega) - 2.2\text{ k}\Omega(I_1 - I_2) + 20 = 0$$
$$-20 - 2.2\text{ k}\Omega(I_2 - I_1) - I_2\ 3.3\text{ k}\Omega - 30 = 0$$

$I_1 = 1.45$ mA, $I_2 = 8.51$ mA

$I_{R_1} = I_1 = \mathbf{1.45\ mA}$, $I_{R_2} = I_2 = \mathbf{8.51\ mA}$

$I_{R_3} = I_2 - I_1 = \mathbf{7.06\ mA}$ (direction of I_2)

b. $V_{3.3\text{k}\Omega} = I_2R_2 = (8.51\text{ mA})(3.3\text{ k}\Omega) = \mathbf{28.1\ V}$

23. a. $\overrightarrow{I_1}$, $\overrightarrow{I_2}$

$$-I_1(1.2\text{ k}\Omega) + 9 - 8.2\text{ k}\Omega(I_1 - I_2) = 0$$
$$-I_2(1.1\text{ k}\Omega) + 6 - I_2\ (9.1\text{ k}\Omega) - 8.2\text{ k}\Omega(I_2 - I_1) = 0$$

$I_1 = 2.03$ mA, $I_2 = 1.23$ mA

$I_{R_1} = I_1 = \mathbf{2.03\ mA}$, $I_{R_3} = I_{R_4} = I_2 = \mathbf{1.23\ mA}$

$I_{R_2} = I_1 - I_2 = 2.03\text{ mA} - 1.23\text{ mA} = \mathbf{0.80\ mA}$ (direction of I_1)

b. $V_a = 6\text{ V} - I_2(1.1\text{ k}\Omega) = 6\text{ V} - (1.23\text{ mA})(1.1\text{ k}\Omega) = 6\text{ V} - 1.35\text{ V} = \mathbf{4.65\ V}$

24. a. $I_1 \downarrow\ I_2 \downarrow\ I_3 \downarrow$

$$10 - I_1 2 - 1(I_1 - I_2) = 0$$
$$-1(I_2 - I_1) - I_2 4 - 5(I_2 - I_3) = 0$$
$$-5(I_3 - I_2) - I_3 3 - 6 = 0$$

$$3I_1 - 1I_2 + 0 = 10$$
$$-1I_1 + 10I_2 - 5I_3 = 0$$
$$0 - 5I_2 + 8I_3 = -6$$

I_1 = **3.31 A**, I_2 = **−63.69 mA,** I_3 = **−789.8 mA**

b, c. Ignore

d. $I_{10V}\uparrow = I_1 =$ **3.31 A**
$I_{6V}\uparrow = -I_3 = -(-789.8\text{ mA}) =$ **789.8 mA**

25. a. $I_1 \downarrow\ I_2 \downarrow\ I_3 \downarrow$

$$-I_1\ 2.2\ \text{k}\Omega - (I_1 - I_2)9.1\ \text{k}\Omega + 18\ \text{V} = 0$$
$$-18\ \text{V} - (I_2 - I_1)9.1\ \text{k}\Omega - 7.5\ \text{k}\Omega\ I_2 - (I_2 - I_3)6.8\ \text{k}\Omega = 0$$
$$-6.8\ \text{k}\Omega(I_3 - I_2) - 3\ \text{V} - 3.3\ \text{k}\Omega\ I_3 = 0$$

with

$$11.3\ \text{k}\Omega\ I_1 - 9.1\ \text{k}\Omega I_2 = 18\ \text{V}$$
$$23.4\ \text{k}\Omega\ I_2 - 9.1\ \text{k}\Omega I_1 - 6.8\ \text{k}\Omega\ I_3 = -18\ \text{V}$$
$$10.1\ \text{k}\Omega\ I_3 - 6.8\ \text{k}\Omega\ I_2 = -3\ \text{V}$$

or

$$11.3\ \text{k}\Omega\ I_1 - 9.1\ \text{k}\Omega\ I_2 = 18\ \text{V}$$
$$-9.1\ \text{k}\Omega\ I_2 + 23.4\ \text{k}\Omega\ I_2 - 6.8\ \text{k}\Omega\ I_3 = -18\ \text{V}$$
$$-6.8\ \text{k}\Omega\ I_2 + 10.1\ \text{k}\Omega\ I_3 = -3\ \text{V}$$

b. I_1 = **1.21 mA**, I_2 = **−0.48 mA**, I_3 = **−0.62 mA**

c. $I_{E_1}\downarrow = I_1 - I_2 = 1.21\text{ mA} - (-0.48\text{ mA}) =$ **1.69 mA**
$I_{E_2}\uparrow = -I_3 = -(-0.62\text{ mA}) =$ **0.62 mA**

26. a. $I_1 \downarrow$, $I_3 \downarrow$, $I_2 \downarrow$

$$-4\ I_1 - 3(I_1 - I_2) - 4(I_1 - I_3) = 0$$
$$-3(I_2 - I_1) - 10\ I_2 - 15 - 4(I_2 - I_3) = 0$$
$$-7\ I_3 - 4(I_3 - I_1) - 4(I_3 - I_2) = 0$$

b. I_1 = **−430.4 mA**, I_2 = **−1.05 A**, I_3 = **−395.1 mA**

c. $I_{R_5} = I_1 =$ **−430.4 mA**

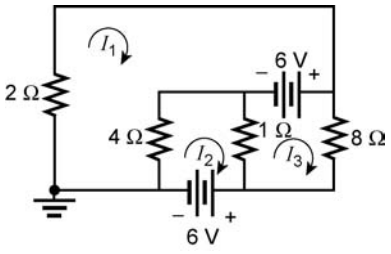
27. a. $I_1 \downarrow$, $I_2 \downarrow$, $I_4 \downarrow$, $I_3 \downarrow$

$$-6.8\ \text{k}\Omega\ I_1 - 4.7\ \text{k}\Omega(I_1 - I_2) + 6 - 2.2\ \text{k}\Omega(I_1 - I_4) = 0$$
$$-6 - 4.7\ \text{k}\Omega(I_2 - I_1) - 8.2\ \text{k}\Omega\ (I_2 - I_3) = 0$$
$$-1.1\ \text{k}\Omega\ I_3 - 22\ \text{k}\Omega(I_3 - I_4) - 8.2\ \text{k}\Omega(I_3 - I_2) - 9 = 0$$
$$-1.2\ \text{k}\Omega\ I_4 - 2\ \text{k}\Omega(I_4 - I_1) - 22\ \text{k}\Omega(I_4 - I_3) = 0$$

b. $I_1 = \mathbf{-0.597\ mA}$, $I_2 = \mathbf{-2.13\ mA}$, $I_3 = \mathbf{-2.27\ mA}$, $I_4 = \mathbf{-2.03\ mA}$

c. $I_{6V} = I_1 - I_2 = -0.597\ \text{mA} - (-2.13\ \text{mA}) = 1.53\ \text{mA}$
$P_{6V} = E\, I_{6V} = (6\ \text{V})(1.53\ \text{mA}) = \mathbf{9.18\ mW}$

28. a. Network redrawn:



b. $-2I_1 - 6 - 4I_1 + 4I_2 = 0$
$-4I_2 + 4I_1 - 1I_2 + 1I_3 - 6 = 0$
$-1I_3 + 1I_2 + 6 - 8I_3 = 0$

c. $I_1 = \mathbf{-3.8\ A}$, $I_2 = \mathbf{-4.20\ A}$, $I_3 = \mathbf{0.20\ A}$

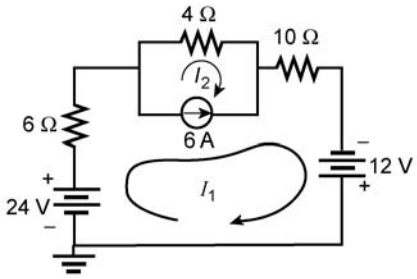
d. $P_{E_2} = E_2 I_3 = (6\ \text{V})(0.2\ \text{A}) = 1.2\ \text{W}$
$P_{E_1} = E_1 I_2 = (6\ \text{V})(4.2\ \text{A}) = 25.2\ \text{W}$
$P_T = P_{E_1} + P_{E_2} = 1.2\ \text{W} + 25.2\ \text{W} = \mathbf{26.4\ W}$

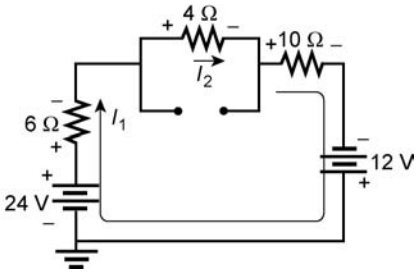
29. a. $20\ \text{V} - I_B(270\ \text{k}\Omega) - 0.7\ \text{V} - I_E(0.51\ \text{k}\Omega) = 0$
$I_E(0.51\ \text{k}\Omega) + 8\ \text{V} + I_C(2.2\ \text{k}\Omega) - 20\ \text{V} = 0$
$I_E = I_B + I_C$
———————————————————
$I_B = \mathbf{63.02\ \mu A}$, $I_C = \mathbf{4.42\ mA}$, $I_E = \mathbf{4.48\ mA}$

b. $V_B = 20\ \text{V} - I_B(270\ \text{k}\Omega) = 20\ \text{V} - (63.02\ \mu\text{A})(270\ \text{k}\Omega) = 20\ \text{V} - 17.02\ \text{V} = \mathbf{2.98\ V}$
$V_E = I_E R_E = (4.48\ \text{mA})(510\ \Omega) = \mathbf{2.28\ V}$
$V_C = 20\ \text{V} - I_C(2.2\ \text{k}\Omega) = 20\ \text{V} - (4.42\ \text{mA})(2.2\ \text{k}\Omega) = 20\ \text{V} - 9.72\ \text{V} = \mathbf{10.28\ V}$

c. $\beta \cong I_C/I_B = 4.42\ \text{mA}/63.02\ \mu\text{A} = \mathbf{70.14}$

30.





$24\text{ V} - 6I_1 - 4I_2 - 10I_1 + 12\text{ V} = 0$

and $16I_1 + 4I_2 = 36$

$I_1 - I_2 = 6\text{ A}$

$I_1 = I_2 + 6\text{ A}$

$16[I_2 + 6\text{ A}] + 4I_2 = 36$

$16I_2 + 96 + 4I_2 = 36$

$20I_2 = -60$

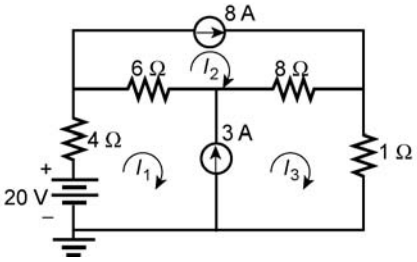
$I_2 = \mathbf{-3\text{ A}}$

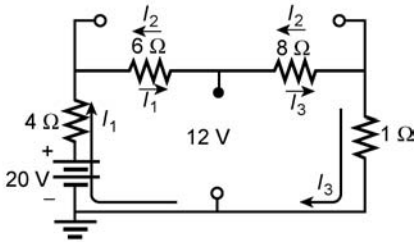
$I_1 = I_2 + 6\text{ A} = -3\text{ A} + 6\text{ A} = \mathbf{3\text{ A}}$

$I_{24V} = I_{6\Omega} = I_{10\Omega} = I_{12V} = \mathbf{3\text{ A}}$ (CW)

$I_{4\Omega} = \mathbf{3\text{ A}}$ (CCW)

31.





$20\text{ V} - 4I_1 - 6(I_1 - I_2) - 8(I_3 - I_2) - 1I_3 = 0$

$10I_1 - 14I_2 + 9I_3 = 20$

$I_3 - I_1 = 3\text{ A}$

$I_2 = 8\text{ A}$

$10I_1 - 14(8\text{ A}) + 9[I_1 + 3\text{ A}] = 20$

$19I_1 = 105$

$I_1 = 5.526\text{ A}$

$I_3 = I_1 + 3\text{ A} = 5.526\text{ A} + 3\text{ A} = 8.526\text{ A}$

$I_2 = 8\text{ A}$

$I_{20V} = I_{4\Omega} = \mathbf{5.53\text{ A}}$ (dir. of I_1)

$I_{6\Omega} = I_2 - I_1 = \mathbf{2.47\text{ A}}$ (dir. of I_2)

$I_{8\Omega} = I_3 - I_2 = \mathbf{0.53\text{ A}}$ (dir. of I_3)

$I_{1\Omega} = \mathbf{8.53\text{ A}}$ (dir. of I_3)

32. a. $\circlearrowright I_1 \quad \circlearrowright I_2$

$(4 + 8)I_1 - 8I_2 = 4$
$(8 + 2)I_2 - 8I_1 = -6$

b. $I_{8\Omega}\downarrow = I_1 - I_2 = \left(-\frac{1}{7}\text{A}\right) - \left(-\frac{5}{7}\text{A}\right) = \mathbf{\frac{4}{7}}\text{A}$

33. a. $\circlearrowright I_1 \quad \circlearrowright I_2$

$(4 + 3)I_1 - 3I_2 = -10 - 12$
$(3 + 12)I_2 - 3I_1 = 12$

b. $I_{3\Omega}\uparrow = I_2 - I_1 = 0.19\text{ A} - (-3.06\text{ A}) = \mathbf{3.25\text{ A}}$

34. a. $\circlearrowright I_1 \quad \circlearrowright I_2$

$I_1(5.6\text{ k}\Omega + 2.2\text{ k}\Omega) - 2.2\text{ k}\Omega\,(I_2) = 10 + 20$
$I_2(2.2\text{ k}\Omega + 3.3\text{ k}\Omega) - 2.2\text{ k}\Omega\,(I_1) = -20 - 30$

b. $I_{E_1} = I_1 = \mathbf{1.45\text{ mA}}$, $I_{E_2}\uparrow = \mathbf{8.51\text{ mA}}$,
$I_{E_3}\downarrow = I_1 - I_2 = (1.45\text{ mA}) - (-8.5\text{ mA}) = \mathbf{9.96\text{ mA}}$

35. a. $\circlearrowright I_1 \quad \circlearrowright I_2 \quad \circlearrowright I_3$

$I_1(2 + 1) - 1I_2 = 10$
$I_2(1 + 4 + 5) - 1I_1 - 5I_3 = 0$
$I_3(5 + 3) - 5I_2 = -6$

b. $I_1 = \mathbf{3.31\text{ A}}$, $I_2 = \mathbf{-63.69\text{ mA}}$, $I_3 = \mathbf{-789.8\text{ mA}}$

c. $I_{R_2} = I_1 - I_2 = (3.31\text{ A}) - (-63.69\text{ mA}) = \mathbf{3.37\text{ A}}$

36. a. $\circlearrowright I_1 \quad \circlearrowright I_2 \quad \circlearrowright I_3$

$(2.2\text{ k}\Omega + 9.1\text{ k}\Omega)I_1 - 9.1\text{ k}\Omega I_2 = 18$
$(9.1\text{ k}\Omega + 7.5\text{ k}\Omega + 6.8\text{ k}\Omega)I_2 - 9.1\text{ k}\Omega\ I_1 - 6.8\text{ k}\Omega I_3 = -18$
$(6.8\text{ k}\Omega + 3.3\text{ k}\Omega)I_3 - 6.8\text{ k}\Omega I_2 = -3$

b. $I_1 = \mathbf{1.21\text{ mA}}$, $I_2 = \mathbf{-0.48\text{ mA}}$, $I_3 = \mathbf{-0.62\text{ mA}}$

c. $I_{E_1}\downarrow = I_1 - I_2 = 1.21\text{ mA} - (-0.48\text{ mA}) = \mathbf{1.69\text{ mA}}$
$I_{E_2}\uparrow = -I_3 = -(-0.62\text{ mA}) = \mathbf{0.62\text{ mA}}$

37. a. $(3\ \Omega + 6\ \Omega)I_1 - 6\ \Omega\ I_2 = 9\ \text{V}$
$(6\ \Omega + 2\ \Omega)I_2 - 6\ \Omega\ I_1 = 20\ \text{V}$

$9\ \Omega\ I_1 - 6\ \Omega\ I_2 = 9\ \text{V}$
$-6\ \Omega\ I_1 + 8\ \Omega\ I_2 = 20\ \text{V}$

$I_1 = \mathbf{5.33\ A}$, $I_2 = \mathbf{6.5\ A}$

b. $V_{ab} = 2\ \Omega\ (I_2) - 20\ \text{V} = 2\ \Omega(6.5\ \text{A}) - 20\ \text{V} = 13\ \text{V} - 20\ \text{V} = \mathbf{-7\ V}$

38. a. 

$I_1(6.8\ \text{k}\Omega + 4.7\ \text{k}\Omega - 2.2\ \text{k}\Omega) - 4.7\ \text{k}\Omega\ (I_2) - 2.2\ \text{k}\Omega\ I_4 = 6$
$I_2(4.7\ \text{k}\Omega + 8.2\ \text{k}\Omega) - 4.7\ \text{k}\Omega(I_1) - 8.2\ \text{k}\Omega(I_3) = -6$
$I_3(8.2\ \text{k}\Omega + 1.1\ \text{k}\Omega + 22\ \text{k}\Omega) - 8.2\ \text{k}\Omega\ I_2 - 22\ \text{k}\Omega\ I_4 = -9$
$I_4(2.2\ \text{k}\Omega + 1.2\ \text{k}\Omega + 22\ \text{k}\Omega) - 22\ \text{k}\Omega(I_3) - 2.2\ \text{k}\Omega(I_1) = 0$

b. $I_1 = \mathbf{-0.597\ mA}$, $I_2 = \mathbf{-2.13\ mA}$, $I_3 = \mathbf{-2.27\ mA}$, $I_4 = \mathbf{-2.03\ mA}$

c. $I_{22\text{k}\Omega} = I_4 - I_3 = -2.03\ \text{mA} - (-2.27\ \text{mA}) = \mathbf{240\ \mu A}$
$V_{22\text{k}\Omega} = IR = (240 \times 10^{-6}\text{A})(22\ \text{k}\Omega) = \mathbf{5.28\ V}$

39. a. 

$I_1(1\ \Omega + 2\ \Omega) - I_2 2\ \Omega = 12$
$I_2(2\ \Omega + 10\ \Omega) - I_1 2\ \Omega - I_3 10\ \Omega = -20\ \text{V}$
$I_3(10\ \Omega + 8\ \Omega) - I_2 10\ \Omega = 20\ \text{V}$

$3I_1 - 2I_2 = 12$
$-2I_1 + 12I_2 - 10I_3 = -20$
$-10I_2 + 18I_3 = 20$

b. $I_1 = \mathbf{3.884\ A}$, $I_2 = \mathbf{-0.174\ A}$, $I_3 = \mathbf{1.01\ A}$

c. $V_a = \mathbf{0\ V}$
$V_b = I_3 8\ \Omega = (1.01\ \text{A})(8\ \Omega) = \mathbf{8.08\ V}$

d. $V_{ab} = V_a - V_b = 0\ \text{V} - 8.08\ \text{V} = \mathbf{-8.08\ V}$

40. a. 

$I_1(2\ \Omega + 4\ \Omega) - I_2 4\ \Omega = -6\ \text{V}$
$I_2(4\ \Omega + 1\ \Omega) - I_1 4\ \Omega - I_3 1\ \Omega = -6\ \text{V}$
$I_3(1\ \Omega + 8\ \Omega) - I_2 1\ \Omega = 6\ \text{V}$

$$\begin{aligned} 6I_1 - 4I_2 &= -6\ \text{V} \\ -4I_1 + 5I_2 - I_3 &= -6\ \text{V} \\ -1I_2 + 9I_3 &= 6\ \text{V} \end{aligned}$$

b. $I_1 = \mathbf{-3.8\ A}$, $I_2 = \mathbf{-4.20\ A}$, $I_3 = \mathbf{0.2\ A}$

$I_{R_1} = I_1 - I_2 = -3.8\ \text{A} - (-4.20\ \text{A})$
$= -3.8\ \text{A} + 4.20\ \text{A}$
$= \mathbf{0.4\ A}$

c. $I_{1\Omega} = I_2 - I_3 = -4.20\ \text{A} - 0.2\ \text{A}$
$= -4.4\ \text{A}$

$^{+}_{-}V_{1\Omega} = (I_{1\Omega})(1\ \Omega) = (-4.4\ \text{A})(1\ \Omega)$
$= \mathbf{-4.4\ V}$

41. a. 

At V_1: $\Sigma I_i = \Sigma I_o$

$$0 = \frac{V_1}{2\ \Omega} + 5\ \text{A} + \frac{V_1 - V_2}{8\ \Omega}$$

At V_2: $\Sigma I_i = \Sigma I_o$

$$\frac{V_1 - V_2}{8\ \Omega} = 3\ \text{A} + \frac{V_2}{4\ \Omega}$$

and $$V_1\left[\frac{1}{2} + \frac{1}{8}\right] - V_2\left[\frac{1}{8}\right] = -5$$

$$-V_1\left[\frac{1}{8}\right] + V_2\left[\frac{1}{8} + \frac{1}{4}\right] = -3$$

b. $V_1 = \mathbf{-10.27\ V}$, $V_2 = \mathbf{-11.36\ V}$

c. $V_{8\Omega} = V_1 - V_2 = -10.27\ \text{V} - (-11.36\ \text{V}) = \mathbf{1.09\ V}$

d. $I_{2\Omega}\uparrow = \dfrac{V_1}{2\ \Omega} = \dfrac{10.27\ \text{V}}{2\ \Omega} = \mathbf{5.14\ A}$

$I_{4\Omega}\uparrow = \dfrac{V_2}{4\ \Omega} = \dfrac{11.36\ \text{V}}{4\ \Omega} = \mathbf{2.84\ A}$

42. a. V_1 V_2

At V_1: $\Sigma I_i = \Sigma I_o$

$$0 = \frac{V_1}{8\ \Omega} + 12\ \text{A} + I_{6\Omega} \text{ and } V_1 - I6\Omega - 54\ \text{V} - V_2 = 0$$

$$\text{or } I = \frac{V_1 - V_2 - 54\ \text{V}}{6\ \Omega} = \frac{V_1}{6\ \Omega} + \frac{V_2}{6\ \Omega} - 9\ \text{A}$$

so that $0 = \frac{V_1}{8\ \Omega} + 12\ \text{A} + \frac{V_1}{6\ \Omega} - \frac{V_2}{6\ \Omega} - 9\ \text{A}$

or $V_1\left[\frac{1}{8\ \Omega} + \frac{1}{6\ \Omega}\right] - V_2\left[\frac{1}{6\ \Omega}\right] = -12\ \text{A} + 9\ \text{A} = -3\ \text{A}$

At V_2: $\Sigma I_i = \Sigma I_o$

$$I = \frac{V_2}{20\ \Omega} + \frac{V_2}{5\ \Omega}$$

or $\frac{V_1}{6\ \Omega} - \frac{V_2}{6\ \Omega} - 9\ \text{A} = \frac{V_2}{20\ \Omega} + \frac{V_2}{5\ \Omega}$

and $V_2\left[\frac{1}{6\ \Omega} + \frac{1}{20\ \Omega} + \frac{1}{5\ \Omega}\right] - V_1\left[\frac{1}{6\ \Omega}\right] = -9\ \text{A}$

resulting in $V_1\left[\frac{1}{8\ \Omega} + \frac{1}{6\ \Omega}\right] - V_2\left[\frac{1}{6\ \Omega}\right] = -3\ \text{A}$

$$-V_1\left[\frac{1}{6\ \Omega}\right] + V_2\left[\frac{1}{6\ \Omega} + \frac{1}{20\ \Omega} + \frac{1}{5\ \Omega}\right] = -9\ \text{A}$$

b. $V_1 = \mathbf{-29.29\ V}$, $V_2 = \mathbf{-33.34\ V}$

c. $I_{20\Omega}\uparrow = \frac{V_2}{20\ \Omega} - \frac{33.34\ \text{V}}{20\ \Omega} = \mathbf{1.67\ A}$

43. a. V_1 V_2

At V_1: $\Sigma I_i = \Sigma I_o$

$$4\ \text{A} = \frac{V_1}{2\ \Omega} + \frac{V_1 - V_2}{4\ \Omega} + 2\ \text{A}$$

At V_2: $\Sigma I_i = \Sigma I_o$

$$2\ \text{A} + \frac{V_1 - V_2}{4\ \Omega} = \frac{V_2}{20\ \Omega} + \frac{V_2}{5\ \Omega}$$

or $V_1\left[\frac{1}{2} + \frac{1}{4}\right] - V_2\left[\frac{1}{4}\right] = 2$

$$-V_1\left[\frac{1}{4}\right] + V_2\left[\frac{1}{4} + \frac{1}{20} + \frac{1}{5}\right] = 2$$

b. $V_1 = \mathbf{4.8\ V}$, $V_2 = \mathbf{6.4\ V}$