Chapter 6

1. a. R_2 and R_3
   b. E and R_3
   c. R_2 and R_3
   d. R_2 and R_3

2. a. E, R_1, R_2, R_3, and R_4
   b. E, R_1, R_2, and R_3
   c. E and R_1
   d. none

3. a. R_3 and R_4, R_5 and R_6
   b. E and R_1, R_6 and R_7

4. a. $R_T = \frac{(36\ \Omega)(18\Omega)}{36\ \Omega + 18\ \Omega} = \mathbf{12\ \Omega}$

   b. $R_T = \frac{1}{\frac{1}{1\ \text{k}\Omega} + \frac{1}{2\ \text{k}\Omega} + \frac{1}{30\ \text{k}\Omega}} + \frac{1}{1\times 10^{-3}\text{S} + 0.5\times 10^{-3}\text{S} + 33.33\times 10^{-6}\text{S}}$
   $= \frac{1}{1.533\times 10^{-3}\text{S}} = \mathbf{0.652\ k\Omega}$

   c. $R_T = \frac{1}{\frac{1}{1.2\ \Omega} + \frac{1}{120\ \text{k}\Omega} + \frac{1}{12\ \text{k}\Omega}} = \frac{1}{8.33.33\times 10^{-6}\text{S} + 8.33\times 10^{-3}\text{S} + 83.33\times 10^{-3}\text{S}} = \frac{1}{92.49\times 10^{-3}\text{S}}$
   $= \mathbf{10.81\ \Omega}$

5. a. $R'_T = \frac{18\ \text{k}\Omega}{3} = 6\ \text{k}\Omega$
   $R_T = \frac{(6\ \text{k}\Omega)(6\ \text{k}\Omega)}{6\ \text{k}\Omega + 6\ \text{k}\Omega} = \mathbf{3\ k\Omega}$

   b. $R'_T = \frac{22\ \Omega}{4} = 5.5\ \Omega$, $R_{T''} = \frac{10\ \Omega}{2} = 5\ \Omega$
   $R_T = \frac{(5.5\ \Omega)(5\ \Omega)}{5.5\ \Omega + 5\ \Omega} = \mathbf{2.62\ \Omega}$

   c. $R_T = \frac{1}{\frac{1}{1\ \Omega} + \frac{1}{1\ \text{k}\Omega} + \frac{1}{1\ \text{M}\Omega}} = \frac{1}{1000\times 10^{-3}\text{S} + 1\times 10^{-3}\text{S} + 0.001\times 10^{-3}\text{S}}$
   $= \frac{1}{1001.001\times 10^{-3}\text{S}} = \mathbf{0.99\ \Omega}$

6. a. $R_T = \frac{1}{\frac{1}{1\ \text{k}\Omega} + \frac{1}{1.2\ \text{k}\Omega} + \frac{1}{0.3\ \text{k}\Omega}} = \frac{1}{1\times 10^{-3}\text{S} + 0.833\times 10^{-3}\text{S} + 3.333\times 10^{-3}\text{S}}$

$$= \frac{1}{5.166\times10^{-3}\text{S}} = \mathbf{193.57\ \Omega}$$

b. $$R_T = \frac{1}{\frac{1}{1\text{ k}\Omega}+\frac{1}{1.2\text{ k}\Omega}+\frac{1}{2.2\text{ k}\Omega}+\frac{1}{1\text{ k}\Omega}} = \frac{1}{1\times10^{-3}\text{S}+0.833\times10^{-3}\text{S}+0.455\times10^{-3}\text{S}+1\times10^{-3}\text{S}}$$

$$= \frac{1}{3.288\times10^{-3}\text{S}} = \mathbf{304.14\ \Omega}$$

7. a. $R_T' = 3\ \Omega \parallel 6\ \Omega = 2\ \Omega$

$R_T = 1.61\ \Omega = \dfrac{(2\ \Omega)(R)}{2\ \Omega + R}$, $R = \mathbf{8\ \Omega}$

b. $R_T' = \dfrac{6\text{ k}\Omega}{3} = 2\text{ k}\Omega$

$R_T = 1.8\text{ k}\Omega = \dfrac{(2\text{ k}\Omega)(R)}{2\text{ k}\Omega + R}$, $R = \mathbf{18\text{ k}\Omega}$

c. $R_T = 5.08\text{ k}\Omega = \dfrac{(20\text{ k}\Omega)(R)}{20\text{ k}\Omega + R}$, $R = \mathbf{6.8\text{ k}\Omega}$

8. a. $$R_T = 1.02\ \Omega = \frac{1}{\frac{1}{2.4\text{ k}\Omega}+\frac{1}{R}+\frac{1}{6.8\text{ k}\Omega}} = \frac{1}{416.67\times10^{-6}\text{S}+\frac{1}{R}+147.06\times10^{-6}\text{ S}}$$

$$1.02\text{ k}\Omega = \frac{1}{563.73\times10^{-6}+\frac{1}{R}}$$

$$575\times10^{-3} + \frac{1.020\text{ k}\Omega}{R} = 1$$

$$R = \frac{1.020\text{ k}\Omega}{425\times10^{-3}} = \mathbf{2.4\text{ k}\Omega}$$

b. $R_T = 6\text{ k}\Omega = \dfrac{R_1}{4}$

$R_1 = \mathbf{24\text{ k}\Omega}$

c. $$\frac{1}{1.11\text{ k}\Omega} = \frac{1}{R}+\frac{1}{8.2\text{ k}\Omega}+\frac{1}{10\text{ k}\Omega}+\frac{1}{2\text{ k}\Omega}$$

$$900.9\times10^{-6}\text{S} = \frac{1}{R} + 121.95\times10^{-6}\text{S} + 100\times10^{-6}\text{S} + 500\times10^{-6}\text{S}$$

$$\frac{1}{R} = 178.95\times10^{-6}\text{S}$$

$$R = \frac{1}{178.95\times10^{-6}\text{S}} = 5.588\text{ k}\Omega \cong \mathbf{5.6\text{ k}\Omega}$$

9. a. 1.2 kΩ

b. about 1 kΩ

c. $R_T = \dfrac{1}{\dfrac{1}{1.2\text{ k}\Omega}+\dfrac{1}{22\text{ k}\Omega}+\dfrac{1}{220\text{ k}\Omega}+\dfrac{1}{2.2\text{ M}\Omega}}$

$= \dfrac{1}{833.333\times10^{-6}\text{S}+45.455\times10^{-6}\text{S}+4.545\times10^{-6}\text{S}+0.455\times10^{-6}\text{S}}$

$= \dfrac{1}{883.788\times10^{-6}\text{S}}$ = **1.131 kΩ**

d. 220 kΩ, 2.2 MΩ: $R_T = \dfrac{(1.2\text{ k}\Omega)(22\text{ k}\Omega)}{1.2\text{ k}\Omega+22\text{ k}\Omega}$ = **1.138 kΩ**

e. R_T reduced.

10. a. $R_T = \dfrac{1}{\dfrac{1}{4\ \Omega}+\dfrac{1}{2\ \Omega}+\dfrac{1}{10\ \Omega}} = \dfrac{1}{0.25\text{ S}+0.50\text{ S}+0.10\text{ S}} = \dfrac{1}{0.85\text{ S}}$ = **1.18 Ω**

b. **∞ Ω**

c. R_T = 3 Ω || 6 Ω = **2 Ω**

11. 24 Ω || 24 Ω = 12 Ω

$\dfrac{1}{R_T} = \dfrac{1}{R_1}+\dfrac{1}{12\ \Omega}+\dfrac{1}{120\ \Omega}$ (Two of the 24 Ω resistors "shorted" out.)

0.1 S = $\dfrac{1}{R_1}$ + 0.08333 S + 0.00833 S

0.1 S = $\dfrac{1}{R_1}$ + 0.09167 S

$\dfrac{1}{R_1}$ = 0.1 S – 0.09167 S = 0.00833 S

$R_1 = \dfrac{1}{0.00833\text{ S}}$ = **120 Ω**

12. a. $R_T = \dfrac{(8\ \Omega)(24\ \Omega)}{8\ \Omega+24\ \Omega}$ = **6 Ω**

b. $V_{R_1} = V_{R_2}$ = **36 V**

c. $I_s = \dfrac{E}{R_T} = \dfrac{36\text{ V}}{6\ \Omega}$ = **6 A**

$I_1 = \dfrac{V_{R_1}}{R_1} = \dfrac{36\text{ V}}{8\ \Omega}$ = **4.5 A**

$I_2 = \dfrac{V_{R_2}}{R_2} = \dfrac{36\text{ V}}{24\ \Omega}$ = **1.5 A**

d. $I_s = I_1 + I_2$
6 A = 4.5 A + 1.5 A = 6 A (checks)

13. a. $I_1 = \dfrac{V_{R_1}}{R_1} = \dfrac{18\text{ V}}{3\ \Omega}$ = **6 A**, $I_2 = \dfrac{V_{R_2}}{R_2} = \dfrac{18\text{ V}}{9\ \Omega}$ = **2 A**, $I_3 = \dfrac{V_{R_3}}{R_3} = \dfrac{18\text{ V}}{36\ \Omega}$ = **0.5 A**

b. $R_T = \dfrac{1}{\dfrac{1}{3\ \Omega}+\dfrac{1}{9\ \Omega}+\dfrac{1}{36\ \Omega}} = \dfrac{1}{0.333\text{ S}+0.111\text{ S}+0.028\text{ S}}$

$= \dfrac{1}{472\times10^{-3}\text{S}}$ = **2.12 Ω**

c. $I_s = \dfrac{E}{R_T} = \dfrac{18\text{ V}}{2.12\ \Omega}$ = **8.5 A**

d. $I_s = I_1 + I_2 + I_3 =$ 6 A + 2 A + 0.5 A = **8.5 A**

e. they match

14. a. $I_{R_1} = \dfrac{V_{R_1}}{R_1} = \dfrac{24\text{ V}}{10\text{ k}\Omega}$ = **2.4 mA**, $I_{R_2} = \dfrac{V_{R_2}}{R_2} = \dfrac{24\text{ V}}{1.2\text{ k}\Omega}$ = **20 mA**,

$I_{R_3} = \dfrac{V_{R_3}}{R_3} = \dfrac{24\text{ V}}{6.8\text{ k}\Omega}$ = **3.53 mA**

b. $R_T = \dfrac{1}{\dfrac{1}{10\text{ k}\Omega}+\dfrac{1}{1.2\text{ k}\Omega}+\dfrac{1}{6.8\text{ k}\Omega}} = \dfrac{1}{100\times10^{-6}\text{S}+833.333\times10^{-6}\text{S}+147.06\times10^{-6}\text{S}}$

$= \dfrac{1}{1.08\times10^{-3}\text{S}}$ = **925.93 Ω**

c. $I_s = \dfrac{E}{R_T} = \dfrac{24\text{ V}}{925.93\ \Omega}$ = **25.92 mA**

d. $I_s = I_1 + I_2 + I_3$ = 2.4 mA + 20 mA + 3.53 mA = **25.93 mA**

e. they match

15. a. $R_T \cong 900\ \Omega$

b. $R_T = \dfrac{1}{\dfrac{1}{20\text{ k}\Omega}+\dfrac{1}{10\text{ k}\Omega}+\dfrac{1}{1\text{ k}\Omega}+\dfrac{1}{91\text{ k}\Omega}}$

$= \dfrac{1}{50\times10^{-6}\text{S}+100\times10^{-6}\text{S}+1\times10^{-3}\text{S}+10.99\times10^{-6}\text{S}}$

$= \dfrac{1}{1.16\times10^{-3}\text{S}}$ = **862.07 Ω**, very close

c. I_3 the most, I_4 the least

d. $I_{R_1} = \dfrac{V_{R_1}}{R_1} = \dfrac{60\text{ V}}{20\text{ k}\Omega} = \mathbf{3.0\text{ mA}}$, $I_{R_2} = \dfrac{V_{R_2}}{R_2} = \dfrac{60\text{ V}}{10\text{ k}\Omega} = \mathbf{6\text{ mA}}$

$I_{R_3} = \dfrac{V_{R_3}}{R_3} = \dfrac{60\text{ V}}{1\text{ k}\Omega} = \mathbf{60.0\text{ mA}}$, $I_{R_4} = \dfrac{V_{R_4}}{R_4} = \dfrac{60\text{ V}}{91\text{ k}\Omega} = \mathbf{0.659\text{ mA}}$

e. $I_s = \dfrac{E}{R_T} = \dfrac{60\text{ V}}{862.07\text{ k}\Omega} = \mathbf{69.6\text{ mA}}$

I_s = 3 mA + 6 mA + 60 mA + 0.659 mA = **69.66 mA** (checks)

f. always greater

16. a. $R_T = 6\ \Omega = \dfrac{(18\ \Omega)(R_2)}{18\ \Omega + R_2}$

$108\ \Omega + 6R_2 = 18R_2$

$12R_2 = 108\ \Omega$

$R_2 = \dfrac{108\ \Omega}{12} = \mathbf{9\ \Omega}$

b. $P = 81\text{ W} = \dfrac{V^2}{R} = \dfrac{E^2}{R} = \dfrac{E^2}{9\ \Omega}$

and $E^2 = (9)(81)$

or $E = \sqrt{729} = \mathbf{27\text{ V}}$

17. a. $P = \dfrac{V^2}{R} = \dfrac{E^2}{R}$ and $E = \sqrt{PR} = \sqrt{(100\text{ W})(4\ \Omega)} = \sqrt{400} = \mathbf{20\text{ V}}$

b. $R_2 = \dfrac{E}{I_2} = \dfrac{20\text{ V}}{2\text{ A}} = \mathbf{10\ \Omega}$

c. $I_1 = \dfrac{V_1}{R_1} = \dfrac{E}{R_1} = \dfrac{20\text{ V}}{10\ \Omega} = \mathbf{2\text{ A}}$

d. $I_s = I_1 + I_2 + I_3 = 2\text{ A} + 2\text{ A} + \dfrac{20\text{ V}}{4\ \Omega} = 4\text{ A} + 5\text{ A} = \mathbf{9\text{ A}}$

e. $P_s = EI_s = (20\text{ V})(9\text{ A}) = \mathbf{180\text{ W}}$

f. $P_{R_1} = \dfrac{E^2}{R_1} = \dfrac{(20\text{ V})^2}{10\ \Omega} = \mathbf{40\text{ W}}$, $P_{R_2} = \dfrac{E^2}{R_2} = \dfrac{(20\text{ V})^2}{\left(\dfrac{20\text{ V}}{2\text{ A}}\right)} = \dfrac{400\text{ W}}{10} = \mathbf{40\text{ W}}$,

g. $P_s = P_1 + P_2 + P_3$

180 W = 40 W + 40 W + 100 W = 180 W (checks)

18. $I_3 = \dfrac{(20\ \Omega)(10.8\ \text{A})}{20\ \Omega + 4\ \Omega} = \mathbf{9\ A}$

$E = V_{R_3} = I_3 R_3 = (9\ \text{A})(4\ \Omega) = \mathbf{36\ V}$

$I_{R_1} = 12.3\ \text{A} - 10.8\ \text{A} = 1.5\ \text{A}$

$R_1 = \dfrac{V_{R_1}}{I_{R_1}} = \dfrac{36\ \text{V}}{1.5\ \text{A}} = \mathbf{24\ \Omega}$

19. a. $V = \mathbf{48\ V}$

b. $I_2 = \dfrac{48\ \text{V}}{18\ \text{k}\Omega} = \mathbf{2.67\ mA}$

c. $I_s = \dfrac{48\ \text{V}}{3\ \text{k}\Omega} + \dfrac{48\ \text{V}}{12\ \text{k}\Omega} + I_2 = 16\ \text{mA} + 4\ \text{mA} + 2.67\ \text{mA} = \mathbf{22.67\ mA}$

d. $P = \dfrac{V^2}{R} = \dfrac{E^2}{R} = \dfrac{(48\ \text{V})^2}{12\ \text{k}\Omega} = \mathbf{192\ mW}$

20. a. $I_{R_2}\uparrow = 4\ \text{A} - 1\ \text{A} = 3\ \text{A},\ R_2 = \dfrac{V_{R_2}}{I_2} = \dfrac{E}{I_2} = \dfrac{12\ \text{V}}{3\ \text{A}} = \mathbf{4\ \Omega}$

b. $R_3 = \dfrac{V_{R_3}}{I_3} = \dfrac{E}{I_3} = \dfrac{12\ \text{V}}{1\ \text{A}} = \mathbf{12\ \Omega}$

c. $I_1\uparrow = \dfrac{12\ \text{V}}{2\ \Omega} = 6\ \text{A},\ I_s = I_1 + 4\ \text{A} = 6\ \text{A} + 4\ \text{A} = \mathbf{10\ A}$

21. –

22. a. $R_T = \dfrac{1}{\dfrac{1}{1\ \text{k}\Omega} + \dfrac{1}{4.7\ \text{k}\Omega} + \dfrac{1}{10\ \text{k}\Omega}} = \dfrac{1}{1000\times10^{-6}\text{S} + 212.77\times10^{-6}\text{S} + 100\times10^{-6}\text{S}}$

$= \dfrac{1}{1.313\times10^{-3}\text{S}} = \mathbf{761.61\ \Omega}$

$I_{R_1} = \dfrac{V_{R_1}}{R_1} = \dfrac{60\ \text{V}}{1\ \text{k}\Omega} = \mathbf{60\ mA},\ I_{R_2} = \dfrac{V_{R_2}}{R_2} = \dfrac{60\ \text{V}}{4.7\ \text{k}\Omega} = \mathbf{12.77\ mA}$

$I_{R_3} = \dfrac{V_{R_3}}{R_3} = \dfrac{60\ \text{V}}{10\ \text{k}\Omega} = \mathbf{6\ mA}$

b. $P_{R_1} = V_{R_1} \cdot I_{R_1} = (60\ \text{V})(60\ \text{mA}) = \mathbf{3.6\ W}$

$P_{R_2} = V_{R_2} \cdot I_{R_2} = (60\ \text{V})(12.77\ \text{mA}) = \mathbf{766.2\ mW}$

$P_{R_3} = V_{R_3} \cdot I_{R_3} = (60\ \text{V})(6\ \text{mA}) = \mathbf{360\ W}$

c. $I_s = \dfrac{E}{R_T} = \dfrac{60\text{ V}}{761.61\ \Omega}$ = **78.78 mA**

$P_s = E_s I_s$ = (60 V)(78.78 mA) = **4.73 W**

d. P_s = **4.73 W** = 3.6 W + 766.2 mW + 360 mW = **4.73 W** (checks)

e. R_1 = the smallest parallel resistor

23. a. $I_{\text{bulb}} = \dfrac{E}{R_{\text{bulb}}} = \dfrac{120\text{ V}}{1.8\text{ k}\Omega}$ = **66.667 mA**

b. $R_T = \dfrac{R}{N} = \dfrac{1.8\text{ k}\Omega}{8}$ = **225 Ω**

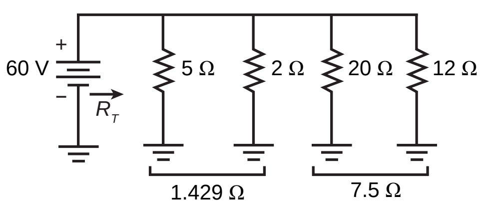
c. $I_s = \dfrac{E}{R_T} = \dfrac{120\text{ V}}{225\ \Omega}$ = **0.533 A**

d. $P = \dfrac{V^2}{R} = \dfrac{(120\text{ V})^2}{1.8\text{ k}\Omega}$ = **8 W**

e. P_s = 8(8 W) = **64 W**

f. none, I_s drops by 66.667 mA

24. Network redrawn:



R_T = 1.429 Ω ∥ 7.5 Ω = 1.2 Ω

$P_s = \dfrac{E^2}{R_T} = \dfrac{(60\text{ V})^2}{1.2\ \Omega}$ = **3 kW**

25. a. 5 × 60 W = 300 W

$I_{\text{bulbs}} = \dfrac{300\text{ W}}{120\text{ V}}$ = **2.5 A**

$I_{\text{micro}} = \dfrac{1200\text{ W}}{120\text{ V}}$ = **10 A**

$I_{\text{TV}} = \dfrac{320\text{ W}}{120\text{ V}}$ = **2.67 A**

$I_{\text{DVD}} = \dfrac{25\text{ W}}{120\text{ V}}$ = **208.33 mA**

b. $I_s = \Sigma I$ = 2.5 A + 10 A + 2.67 A + 208.33 mA = **15.38 A**

No

c. $R_T = \frac{E}{I_s} = \frac{120\text{ V}}{15.38\text{ A}}$ = **7.8 Ω**

d. $P_s = E\,I_s$ = (120 V)(15.38 A) = **1,845.60 W**

e. P_s = 1845.60 W = 300 W + 1200 W + 320 W + 25 W = **1845 W** (checks)

26. a. 8 Ω ‖ 12 Ω = 4.8 Ω, 4.8 Ω ‖ 4 Ω = 2.182 Ω

$I_1 = \frac{24\text{ V} + 8\text{ V}}{2.182\ \Omega}$ = **14.67 A**

b. $P_4 = \frac{V^2}{R} = \frac{(24\text{ V} + 8\text{ V})^2}{4\ \Omega}$ = **256 W**

c. $I_2 = I_1$ = **14.67 A**

27. I_s = 8 mA + 6 mA = **14 mA**
I_2 = 6 mA – 2 mA = **4 mA**

28. a. $\Sigma I_i = \Sigma I_o$
5 A + 7 A + 3 A = 9 A + I
15 A = 9 A + I
6 A = I

b. $\Sigma I_i = \Sigma I_o$
8 mA = 2 mA + I_1
I_1 = 8 mA − 2 m A = **6 mA**
$\Sigma I_i = \Sigma I_o$
I_1 + 9 mA = I_2
I_2 = 6 mA + 9 mA = **15 mA**
$\Sigma I_i = \Sigma I_o$
I_2 = 10 mA + I_3
I_3 = 15 mA − 10 mA = **5 mA**

29. a. $\Sigma I_i = \Sigma I_o$
8 A = 3 A + I_2
I_2 = 8 A − 3 A = **5 A**, I_3 = **3 A**
$\Sigma I_i = \Sigma I_o$
$I_2 + I_3 = I_4$
I_4 = 5 A + 3 A = **8 A**

b. $\Sigma I_i = \Sigma I_o$
I_s = 36 mA + 4 mA = **40 mA**
$\Sigma I_i = \Sigma I_o$
36 mA = I_3 + 20 mA
I_3 = 36 mA − 20 mA = **16 mA**
$\Sigma I_i = \Sigma I_o$
4 mA + 20 mA = I_4
I_4 = **24 mA**
$I_5 = I_s$ = **40 mA**

30. I_{R_2} = 5 mA – 2 mA = 3 mA

$E = V_{R_2}$ = (3 mA)(4 kΩ) = **12 V**

$R_1 = \frac{V_{R_1}}{I_{R_1}} = \frac{12\text{ V}}{(9\text{ mA} - 5\text{ mA})} = \frac{12\text{ V}}{4\text{ mA}}$ = **3 kΩ**

$R_3 = \frac{V_{R_3}}{I_{R_3}} = \frac{12\text{ V}}{2\text{ mA}}$ = **6 kΩ**

$R_T = \frac{E}{I_T} = \frac{12\text{ V}}{9\text{ mA}}$ = **1.33 kΩ**

31. a. $R_1 = \frac{E}{I_1} = \frac{10\text{ V}}{2\text{ A}}$ = **5 Ω**

$I_2 = I - I_1$ = 3 A – 2 A = **1 A**

$R = \frac{E}{I_2} = \frac{10\text{ V}}{1\text{ A}}$ = **10 Ω**

b. $E = I_1R_1$ = (2 A)(6 Ω) = **12 V**

$I_2 = \frac{E}{R_2} = \frac{12\text{ V}}{9\ \Omega}$ = **1.33 A**

$I_3 = \frac{P}{V} = \frac{12\text{ W}}{12\text{ V}}$ = **1 A**

$R_3 = \frac{E}{I_3} = \frac{12\text{ V}}{1\text{ A}}$ = **12 Ω**

$I = I_1 + I_2 + I_3$ = 2 A + 1.33A + 1 A = **4.33 A**

32. a. $I_1 = \frac{64\text{ V}}{1\text{ k}\Omega}$ = **64 mA**

$I_3 = \frac{64\text{ V}}{4\text{ k}\Omega}$ = **16 mA**

$I_s = I_1 + I_2 + I_3$

$I_2 = I_s - I_1 - I_3$ = 100 mA – 64 mA – 16 mA = **20 mA**

$R = \frac{E}{I_2} = \frac{64\text{ V}}{20\text{ mA}}$ = **3.2 kΩ**

$I = I_2 + I_3$ = 20 mA + 16 mA = **36 mA**

b. $P = \frac{V_1^2}{R_1} \Rightarrow V_1 = \sqrt{PR_1} = \sqrt{(30\text{ W})(30\,\Omega)}$ = **30 V**

$E = V_1$ = **30 V**

$I_1 = \frac{E}{R_1} = \frac{30\text{ V}}{30\,\Omega}$ = **1 A**

Because $R_3 = R_2$, $I_3 = I_2$, and $I_s = I_1 + I_2 + I_3 = I_1 + 2I_2$

$2\text{ A} = 1\text{ A} + 2I_2$

$I_2 = \frac{1}{2}(1\text{ A}) = 0.5\text{ A}$

I_3 = **0.5 A**

$R_2 = R_3 = \frac{E}{I_2} = \frac{30\text{ V}}{0.5\text{ A}}$ = **60 Ω**

$P_{R_2} = I_2^2 R_2 = (0.5\text{ A})^2 \cdot 60\,\Omega$ = **15 W**

33. $I_2 = \frac{6\,\Omega}{12\,\Omega} I_1 = \frac{1}{2} I_1 = \frac{1}{2}(9\text{ A})$ = **4.5 A**

$I_3 = \frac{6\,\Omega}{2\,\Omega} I_1 = 3I_1 = 3(9\text{ A})$ = **27 A**

$I_4 = \frac{6\,\Omega}{18\,\Omega} I_1 = \frac{1}{3} I_1 = \frac{1}{3}(9\text{ A}) = 3\text{ A}$

$I_T = I_1 + I_2 + I_3 + I_4 = 9\text{ A} + 4.5\text{ A} + 27\text{ A} + 3\text{ A}$ = **43.5 A**

34. a. $I_1 = \frac{8\text{ k}\Omega(20\text{ mA})}{2\text{ k}\Omega + 8\text{ k}\Omega}$ = **16 mA**

$I_2 = 20\text{ mA} - 16\text{ mA}$ = **4 mA**

b. $I_{2.4\text{k}\Omega} = 2.5\text{ A} = \frac{1\text{ k}\Omega(I_T)}{1\text{ k}\Omega + 2.4\text{ k}\Omega} = \frac{1\text{ k}\Omega(I_T)}{3.4\text{ k}\Omega}$

and $I_T = \frac{3.4\text{ k}\Omega(2.5\text{ A})}{1\text{ k}\Omega}$ = **8.5 A**

$I_1 = I_T - 2.5\text{ A} = 8.5\text{ A} - 2.5\text{ A}$ = **6 A**

35. a. $R_T = \frac{1}{\frac{1}{4\,\Omega} + \frac{1}{8\,\Omega} + \frac{1}{12\,\Omega}} = \frac{1}{250\times10^{-3}\text{S} + 125\times10^{-3}\text{S} + 83.333\times10^{-3}\text{S}}$

$= \frac{1}{458.333\times10^{-3}} = 2.18\,\Omega$

$I_x = \frac{R_T}{R_x} I$, $I_1 = \frac{2.18\,\Omega}{4\,\Omega}(6\text{ A})$ = **3.27 A**

$I_2 = \frac{2.18\,\Omega}{8\,\Omega}(6\text{ A})$ = **1.64 A**

$I_3 = \frac{2.18\,\Omega}{12\,\Omega}(6\text{ A})$ = **1.09 A**

I_4 = **6 A**

b. $4\ \Omega \parallel 4\ \Omega = 2\ \Omega$

$$I_2 = \frac{20\ \Omega(8\ \text{A})}{20\ \Omega + 2\ \Omega + 8\ \Omega} = \frac{20\ \Omega(8\ \text{A})}{30\ \Omega} = \mathbf{5.33\ A}$$

$$I_1 = \frac{I_2}{2} = \frac{5.33\ \text{A}}{2} = \mathbf{2.67\ A}$$

$I_3 = 8\ \text{A} - I_2 = 8\ \text{A} - 5.33\ \text{A} = \mathbf{2.67\ A}$

$I_4 = \mathbf{8\ A}$

36. a. $I_1 \cong \frac{9}{10}(10\ \text{A}) = \mathbf{9\ A}$

b. $I_1/I_2 = 10\ \Omega/1\ \Omega = 10$, $\quad I_2 = \frac{I_1}{10} = \frac{9\ \text{A}}{10} \cong \mathbf{0.9\ A}$

c. $I_1/I_3 = 1\ \text{k}\Omega/1\ \Omega = 1000$, $I_3 = I_1/1000 = 9\ \text{A}/1000 \cong \mathbf{9\ mA}$

d. $I_1/I_4 = 100\ \text{k}\Omega/1\ \Omega = 100{,}000$, $\quad I_4 = I_1/100{,}000 = 9\ \text{A}/100{,}000 \cong \mathbf{90\ \mu A}$

e. very little effect, 1/100,000

f. $$R_T = \frac{1}{\frac{1}{1\ \Omega} + \frac{1}{10\ \Omega} + \frac{1}{1\ \text{k}\Omega} + \frac{1}{100\ \text{k}\Omega}}$$

$$= \frac{1}{1\ \text{S} + 0.1\ \text{S} + 1\times10^{-3}\ \text{S} + 10\times10^{-6}\ \text{S}}$$

$$= \frac{1}{1.10\ \text{S}} = 0.91\ \Omega$$

$I_x = \frac{R_T}{R_x} I$, $\quad I_1 = \frac{0.91\ \Omega}{1\ \Omega}(10\ \text{A}) = \mathbf{9.1\ A}$ excellent (9 A)

g. $I_2 = \frac{0.91\ \Omega}{10\ \Omega}(10\ \text{A}) = \mathbf{0.91\ A}$ excellent (0.9 A)

h. $I_3 = \frac{0.91\ \Omega}{1\ \text{k}\Omega}(10\ \text{A}) = \mathbf{9.1\ mA}$ excellent (9 mA)

i. $I_4 = \frac{0.91\ \Omega}{100\ \text{k}\Omega}(10\ \text{A}) = \mathbf{91\ \mu A}$ excellent (90 μA)

37. a. CDR: $I_{36\Omega} = \frac{3\ \Omega\, I}{3\ \Omega + 36\ \Omega} = 1\ \text{A}$, $\; I = \frac{39\ \Omega(1\ \text{A})}{3\ \Omega} = \mathbf{13\ A} = I_2$

$I_1 = I - 1\ \text{A} = 13\ \text{A} - 1\ \text{A} = \mathbf{12\ A}$

b. $I_3 = I = 24$ **mA**, $V_{12\text{k}\Omega} = IR = (4\ \text{mA})(12\ \text{k}\Omega) = 48\ \text{V}$

$$I_2 = \frac{V}{R} = \frac{48\ \text{V}}{4\ \text{k}\Omega} = \mathbf{12\ mA}$$

$I_1 = I - 4\ \text{mA} - I_2$
$= 24\ \text{mA} - 4\ \text{mA} - 12\ \text{mA}$
$= \mathbf{8\ mA}$

38. a. $R = 3(2\ \text{k}\Omega) = \mathbf{6\ k\Omega}$

b. $I_1 = \dfrac{6\text{ k}\Omega(32\text{ mA})}{6\text{ k}\Omega + 2\text{ k}}$ = **24 mA**

$I_2 = \dfrac{I_1}{3} = \dfrac{24\text{ mA}}{3}$ = **8 mA**

39. 84 mA = $I_1 + I_2 + I_3 = I_1 + 2I_1 + 2I_2 = I_1 + 2I_1 + 2(2I_1)$
84 mA = $I_1 + 2I_1 + 4I_1 = 7I_1$
and $I_1 = \dfrac{84\text{ mA}}{7}$ = 12 mA
$I_2 = 2I_1$ = 2(12 mA) = 24 mA
$I_3 = 2I_2$ = 2(24 mA) = 48 mA
$R_1 = \dfrac{V_{R_1}}{I_1} = \dfrac{24\text{ V}}{12\text{ mA}}$ = **2 kΩ**
$R_2 = \dfrac{V_{R_2}}{I_2} = \dfrac{24\text{ V}}{24\text{ mA}}$ = **1 kΩ**
$R_3 = \dfrac{V_{R_3}}{I_3} = \dfrac{24\text{ V}}{48\text{ mA}}$ = **0.5 kΩ**

40. a. $P_L = V_L I_L$
72 W = 12 V · I_L
$I_L = \dfrac{72\text{ W}}{12\text{ V}}$ = 6 A
$I_1 = I_2 = \dfrac{I_L}{2} = \dfrac{6\text{ A}}{2}$ = **3 A**

b. $P_{\text{source}} = EI$ = (12 V)(3 A) = **36 W**

c. $P_{s_1} + P_{s_2}$ = 36 W + 36 W = **72 W** (the same)

d. I_{drain} = **6 A** (twice as much)

41. R_T = 8 Ω ‖ 56 Ω = 7 Ω
$I_2 = I_3 = \dfrac{E}{R_T} = \dfrac{12\text{ V}}{7\,\Omega}$ = **1.71 A**
$I_1 = \dfrac{1}{2}I_2 = \dfrac{1}{2}(1.71\text{ A})$ = **0.86 A**

42. $I_{8\,\Omega} = \dfrac{16\text{ V}}{8\,\Omega}$ = 2 A, I = 5 A – 2 A = **3 A**
I_R = 5 A + 3 A = 8 A, $R = \dfrac{V_R}{I_R} = \dfrac{16\text{ V}}{8\text{ A}}$ = **2 Ω**

43. a. $V_2 = \dfrac{22\text{ k}\Omega(20\text{ V})}{22\text{ k}\Omega + 4.7\text{ k}\Omega}$ = **16.48 V**

b. R'_T = 11 MΩ ‖ 22 kΩ = 21.956 kΩ

$V_2 = \dfrac{21.956\text{ k}\Omega(20\text{ V})}{21.956\text{ k}\Omega + 4.7\text{ k}\Omega}$ = **16.47 V** (very close to ideal)

c. R_m = 20 V[20,000 Ω/V] = 400 kΩ
R_T' = 400 kΩ ∥ 22 kΩ = 20.853 kΩ
$V_2 = \dfrac{20.853\text{ k}\Omega(20\text{ V})}{20.853\text{ k}\Omega + 4.7\text{ k}\Omega}$ = **16.32 V** (still very close to ideal)

d: a. $V_2 = \dfrac{200\text{ k}\Omega(20\text{ V})}{200\text{ k}\Omega + 100\text{ k}\Omega}$ = **13.33 V**

b. R_T' = 200 kΩ ∥ 11 MΩ = 196.429 kΩ
$V_2 = \dfrac{(196.429\text{ k}\Omega)(20\text{ V})}{196.429\text{ k}\Omega + 100\text{ k}\Omega}$ = **13.25 V** (very close to ideal)

c. R_m = 400 kΩ
R_T' = 400 kΩ ∥ 200 kΩ = 133.333 kΩ
$V_2 = \dfrac{(133.333\text{ k}\Omega)(20\text{ V})}{133.333\text{ k}\Omega + 100\text{ k}\Omega}$ = **11.43 V** (a 1.824 V drop from R_{int} = 11 MΩ level)

e. DMM level of 11 MΩ not a problem for most situations
VOM level of 400 kΩ can be a problem for some situations.

44. a. V_{ab} = **20 V**

b. $V_{ab} = \dfrac{11\text{ M}\Omega(20\text{ V})}{11\text{ M}\Omega + 1\text{ M}\Omega}$ = **18.33 V**

c. R_m = 200 V[20,000 Ω/V] = 4 MΩ
$V_{ab} = \dfrac{4\text{ M}\Omega(20\text{ V})}{4\text{ M}\Omega + 1\text{ M}\Omega}$ = 16.0 V (significant drop from ideal)
R_m = 20 V[20,000 Ω/V] = 400 kΩ
$V_{ab} = \dfrac{400\text{ k}\Omega(20\text{ V})}{400\text{ k}\Omega + 1\text{ M}\Omega}$ = **5.71 V** (significant error)

45. not operating properly, 6 kΩ not connected
$R_T = \dfrac{6\text{ V}}{3.5\text{ mA}}$ = 1.71 kΩ
R_T = 3 kΩ ∥ 4 kΩ = 1.71 kΩ

46. $V_{ab} = E + I_{4\text{ k}\Omega} \cdot R_{4\text{ k}\Omega}$
$I_{4\text{ k}\Omega} = \dfrac{12\text{ V} - 4\text{ V}}{1\text{ k}\Omega + 4\text{ k}\Omega} = \dfrac{8\text{ V}}{5\text{ k}\Omega}$ = 1.6 mA
V_{ab} = 4 V + (1.6 mA)(4 kΩ) = 4 V + 6.4 V = 10.4 V
4 V supply connected in reverse so that
$I = \dfrac{12\text{ V} + 4\text{ V}}{1\text{ k}\Omega + 4\text{ k}\Omega} = \dfrac{16\text{ V}}{5\text{ k}\Omega}$ = 3.2 mA
and V_{ab} = 12 V − (3.2 mA)(1 kΩ) = 12 V − 3.2 V = 8.8 V obtained