Instructor's Resource Manual
to accompany

Electronics Fundamentals and Electric Circuits Fundamentals

Seventh Edition

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PART ONE

Solutions to End-of-Chapter Problems

CHAPTER 1
QUANTITIES AND UNITS

SECTION 1-1 Scientific and Engineering Notation

1. (a) $3000 = \mathbf{3 \times 10^3}$ (b) $75{,}000 = \mathbf{7.5 \times 10^4}$ (c) $2{,}000{,}000 = \mathbf{2 \times 10^6}$

2. (a) $\dfrac{1}{500} = 0.002 = \mathbf{2 \times 10^{-3}}$

   (b) $\dfrac{1}{2000} = 0.0005 = \mathbf{5 \times 10^{-4}}$

   (c) $\dfrac{1}{5{,}000{,}000} = 0.0000002 = \mathbf{2 \times 10^{-7}}$

3. (a) $8400 = \mathbf{8.4 \times 10^3}$ (b) $99{,}000 = \mathbf{9.9 \times 10^4}$ (c) $0.2 \times 10^6 = \mathbf{2 \times 10^5}$

4. (a) $0.0002 = \mathbf{2 \times 10^{-4}}$ (b) $0.6 = \mathbf{6 \times 10^{-1}}$

   (c) $\mathbf{7.8 \times 10^{-2}}$ (already in scientific notation)

5. (a) $2.5 \times 10^{-6} = \mathbf{0.0000025}$ (b) $5.0 \times 10^2 = \mathbf{500}$ (c) $3.9 \times 10^{-1} = \mathbf{0.39}$

6. (a) $4.5 \times 10^{-6} = \mathbf{0.0000045}$

   (b) $8 \times 10^{-9} = \mathbf{0.000000008}$

   (c) $4.0 \times 10^{-12} = \mathbf{0.0000000000040}$

7. (a) $9.2 \times 10^6 + 3.4 \times 10^7 = 9.2 \times 10^6 + 34 \times 10^6 = \mathbf{4.32 \times 10^7}$

   (b) $5 \times 10^3 + 8.5 \times 10^{-1} = 5 \times 10^3 + 0.00085 \times 10^3 = \mathbf{5.00085 \times 10^3}$

   (c) $5.6 \times 10^{-8} + 4.6 \times 10^{-9} = 56 \times 10^{-9} + 4.6 \times 10^{-9} = \mathbf{6.06 \times 10^{-8}}$

8. (a) $3.2 \times 10^{12} - 1.1 \times 10^{12} = \mathbf{2.1 \times 10^{12}}$

   (b) $2.6 \times 10^8 - 1.3 \times 10^7 = 26 \times 10^7 - 1.3 \times 10^7 = \mathbf{24.7 \times 10^7}$

   (c) $1.5 \times 10^{-12} - 8 \times 10^{-13} = 15 \times 10^{-13} - 8 \times 10^{-13} = \mathbf{7 \times 10^{-13}}$

9. (a) $(5 \times 10^3)(4 \times 10^5) = 5 \times 4 \times 10^{3+5} = 20 \times 10^8 = \mathbf{2 \times 10^9}$

(b) $(1.2 \times 10^{12})(3 \times 10^2) = 1.2 \times 3 \times 10^{12+2} = \mathbf{3.6 \times 10^{14}}$

(c) $(2.2 \times 10^{-9})(7 \times 10^{-6}) = 2.2 \times 7 \times 10^{-9-6} = 15.4 \times 10^{-15} = \mathbf{1.54 \times 10^{-14}}$

10. (a) $\dfrac{1.0 \times 10^3}{2.5 \times 10^2} = 0.4 \times 10^{3-2} = 0.4 \times 10^1 = \mathbf{4}$

(b) $\dfrac{2.5 \times 10^{-6}}{5.0 \times 10^{-8}} = 0.5 \times 10^{-6-(-8)} = 0.5 \times 10^2 = \mathbf{50}$

(c) $\dfrac{4.2 \times 10^8}{2 \times 10^{-5}} = 2.1 \times 10^{8-(-5)} = \mathbf{2.1 \times 10^{13}}$

11. (a) $89{,}000 = \mathbf{89 \times 10^3}$

(b) $450{,}000 = \mathbf{450 \times 10^3}$

(c) $12{,}040{,}000{,}000{,}000 = \mathbf{12.04 \times 10^{12}}$

12. (a) $2.35 \times 10^5 = \mathbf{235 \times 10^3}$

(b) $7.32 \times 10^7 = \mathbf{73.2 \times 10^6}$

(c) $\mathbf{1.333 \times 10^9}$ (already in engineering notation)

13. (a) $0.000345 = \mathbf{345 \times 10^{-6}}$

(b) $0.025 = \mathbf{25 \times 10^{-3}}$

(c) $0.00000000129 = \mathbf{1.29 \times 10^{-9}}$

14. (a) $9.81 \times 10^{-3} = \mathbf{9.81 \times 10^{-3}}$

(b) $4.82 \times 10^{-4} = \mathbf{482 \times 10^{-6}}$

(c) $4.38 \times 10^{-7} = \mathbf{438 \times 10^{-9}}$

15. (a) $2.5 \times 10^{-3} + 4.6 \times 10^{-3} = (2.5 + 4.6) \times 10^{-3} = \mathbf{7.1 \times 10^{-3}}$

(b) $68 \times 10^6 + 33 \times 10^6 = (68 + 33) \times 10^6 = \mathbf{101 \times 10^6}$

(c) $1.25 \times 10^6 + 250 \times 10^3 = 1.25 \times 10^6 + 0.25 \times 10^6 = (1.25 + 0.25) \times 10^6 = \mathbf{1.50 \times 10^6}$

16. (a) $(32 \times 10^{-3})(56 \times 10^3) = 1792 \times 10^{(-3+3)} = 1792 \times 10^0 = \mathbf{1.792 \times 10^3}$

(b) $(1.2 \times 10^{-6})(1.2 \times 10^{-6}) = 1.44 \times 10^{(-6-6)} = \mathbf{1.44 \times 10^{-12}}$

(c) $(100)(55 \times 10^{-3}) = 5500 \times 10^{-3} = \mathbf{5.5}$

17. (a) $\dfrac{50}{2.2\times10^3} = \mathbf{22.7 \times 10^{-3}}$

(b) $\dfrac{5\times10^3}{25\times10^{-6}} = 0.2 \times 10^{(3-(-6))} = 0.2 \times 10^9 = \mathbf{200 \times 10^6}$

(c) $\dfrac{560\times10^3}{660\times10^3} = 0.848 \times 10^{(3-3)} = 0.848 \times 10^0 = \mathbf{848 \times 10^{-3}}$

SECTION 1-2 Units and Metric Prefixes

18. (a) $89{,}000\ \Omega = 89 \times 10^3 = \mathbf{89\ k\Omega}$

(b) $450{,}000\ \Omega = 450 \times 10^3 = \mathbf{450\ k\Omega}$

(c) $12{,}040{,}000{,}000{,}000\ \Omega = 12.04 \times 10^{12} = \mathbf{12.04\ T\Omega}$

19. (a) $0.000345\text{ A} = 345 \times 10^{-6}\text{ A} = \mathbf{345\ \mu A}$

(b) $0.025\text{ A} = 25 \times 10^{-3}\text{ A} = \mathbf{25\ mA}$

(c) $0.00000000129\text{ A} = 1.29 \times 10^{-9}\text{ A} = \mathbf{1.29\ nA}$

20. (a) $31 \times 10^{-3}\text{ A} = \mathbf{31\ mA}$ (b) $5.5 \times 10^3\text{ V} = \mathbf{5.5\ kV}$ (c) $20 \times 10^{-12}\text{ F} = \mathbf{20\ pF}$

21. (a) $3 \times 10^{-6}\text{ F} = \mathbf{3\ \mu F}$ (b) $3.3 \times 10^6\ \Omega = \mathbf{3.3\ M\Omega}$ (c) $350 \times 10^{-9}\text{ A} = \mathbf{350\ nA}$

22. (a) $5\ \mu\text{A} = \mathbf{5 \times 10^{-6}\ A}$ (b) $43\text{ mV} = \mathbf{43 \times 10^{-3}\ V}$

(c) $275\text{ k}\Omega = \mathbf{275 \times 10^3\ \Omega}$ (d) $10\text{ MW} = \mathbf{10 \times 10^6\ W}$

SECTION 1-3 Metric Unit Conversions

23. (a) $(5\text{ mA})(1 \times 10^3\ \mu\text{A/mA}) = 5 \times 10^3\ \mu\text{A} = \mathbf{5000\ \mu A}$

(b) $(3200\ \mu\text{W})(1 \times 10^{-3}\text{ W}/\mu\text{W}) = \mathbf{3.2\ mW}$

(c) $(5000\text{ kV})(1 \times 10^{-3})\text{ MV/kV} = \mathbf{5\ MV}$

(d) $(10\text{ MW})(1 \times 10^3\text{ kW/MW}) = 10 \times 10^3\text{ kW} = \mathbf{10{,}000\ kW}$

24. (a) $\dfrac{1\text{ mA}}{1\text{ μA}} = \dfrac{1\times10^{-3}\text{A}}{1\times10^{-6}\text{A}} = 1 \times 10^3 = \mathbf{1000}$

(b) $\dfrac{0.05\text{ kV}}{1\text{ mV}} = \dfrac{0.05\times10^{3}\text{ V}}{1\times10^{-3}\text{ V}} = 0.05 \times 10^6 = \mathbf{50{,}000}$

(c) $\dfrac{0.02\text{ k}\Omega}{1\text{ M}\Omega} = \dfrac{0.02\times10^{3}\ \Omega}{1\times10^{6}\ \Omega} = 0.02 \times 10^{-3} = \mathbf{2 \times 10^{-5}}$

(d) $\dfrac{155\text{ mW}}{1\text{ kW}} = \dfrac{155\times10^{-3}\text{ W}}{1\times10^{3}\text{ W}} = 155 \times 10^{-6} = \mathbf{1.55 \times 10^{-4}}$

25. (a) 50 mA + 680 μA = 50 mA + 0.68 mA = **50.68 mA**

(b) 120 kΩ + 2.2 MΩ = 0.12 MΩ + 2.2 MΩ = **2.32 MΩ**

(c) 0.02 μF + 3300 pF = 0.02 μF + 0.0033 μF = **0.0233 μF**

26. (a) $\dfrac{10\text{ k}\Omega}{2.2\text{ k}\Omega + 10\text{ k}\Omega} = \dfrac{10\text{ k}\Omega}{12.2\text{ k}\Omega} = \mathbf{0.8197}$

(b) $\dfrac{250\text{ mV}}{50\text{ μV}} = \dfrac{250\times10^{-3}}{50\times10^{-6}} = \mathbf{5000}$

(c) $\dfrac{1\text{ MW}}{2\text{ kW}} = \dfrac{1\times10^{6}}{2\times10^{3}} = \mathbf{500}$

SECTION 1-4 Measured Numbers

27. (a) 1.00×10^3 has 3 significant digits.
(b) 0.0057 has 4 significant digits.
(c) 1502.0 has 5 significant digits.
(d) 0.000036 has 6 significant digits.
(e) 0.105 has 3 significant digits.
(f) 2.6×10^2 has 2 significant digits.

28. (a) 50,505 ≅ $\mathbf{50.5 \times 10^3}$
(b) 220.45 ≅ **220**
(c) 4646 ≅ $\mathbf{4.65 \times 10^3}$
d) 10.99 ≅ **11.0**
(e) 1.005 ≅ **1.00**

CHAPTER 2
VOLTAGE, CURRENT, AND RESISTANCE

BASIC PROBLEMS

SECTION 2-2 Electrical Charge

1. Q = (charge per electron)(number of electrons) = $(1.6 \times 10^{-19}$ C/e$)(50 \times 10^{31}$e$)$ = $\mathbf{80 \times 10^{12}}$ **C**

2. $(6.25 \times 10^{18}$ e/C$)(80 \times 10^{-6}$ C$)$ = $\mathbf{5 \times 10^{14}}$ **e**

3. $(1.6 \times 10^{-19}$ C/e$)(29$ e$)$ = $\mathbf{4.64 \times 10^{-18}}$ **C**

4. $(1.6 \times 10^{-19}$ C/e$)(17$ e$)$ = $\mathbf{2.72 \times 10^{-18}}$ **C**

SECTION 2-3 Voltage

5. (a) $V = \dfrac{W}{Q} = \dfrac{10\text{ J}}{1\text{ C}} = \mathbf{10\ V}$ (b) $V = \dfrac{W}{Q} = \dfrac{5\text{ J}}{2\text{ C}} = \mathbf{2.5\ V}$

   (c) $V = \dfrac{W}{Q} = \dfrac{100\text{ J}}{25\text{ C}} = \mathbf{4\ V}$

6. $V = \dfrac{W}{Q} = \dfrac{500\text{ J}}{100\text{ C}} = \mathbf{5\ V}$

7. $V = \dfrac{W}{Q} = \dfrac{800\text{ J}}{40\text{ C}} = \mathbf{20\ V}$

8. $W = VQ = (12\text{ V})(2.5\text{ C}) = \mathbf{30\ J}$

SECTION 2-4 Current

9. (a) $I = \dfrac{Q}{t} = \dfrac{75\text{ C}}{1\text{ s}} = \mathbf{75\ A}$ (b) $I = \dfrac{Q}{t} = \dfrac{10\text{ C}}{0.5\text{ s}} = \mathbf{20\ A}$

(c) $I = \dfrac{Q}{t} = \dfrac{5\,\text{C}}{2\,\text{s}} = \mathbf{2.5\ A}$

10. $I = \dfrac{Q}{t} = \dfrac{0.6\,\text{C}}{3\,\text{s}} = \mathbf{0.2\ A}$

11. $I = \dfrac{Q}{t}$; $t = \dfrac{Q}{I} = \dfrac{10\,\text{C}}{5\,\text{A}} = \mathbf{2\ s}$

12. $Q = I \times t = (1.5\ \text{A})(0.1\ \text{s}) = \mathbf{0.15\ C}$

SECTION 2-5 Resistance

13. A: Blue, gray, red, silver: **6800 Ω ± 10%**
B: Orange, orange, black, silver: **33 Ω ± 10%**
C: Yellow, violet, orange, gold: **47,000 Ω ± 5%**

14. A: R_{min} = 6800 Ω – 0.1(6800 Ω) = 6800 Ω – 680 Ω = **6120 Ω**
R_{max} = 6800 Ω + 680 Ω = **7480 Ω**
B: R_{min} = 33 Ω – 0.1(33 Ω) = 33 Ω – 3.3 Ω = **29.7 Ω**
R_{max} = 33 Ω + 3.3 Ω = **36.3 Ω**
C: R_{min} = 47,000 Ω – (0.05)(47,000 Ω) = 47,000 Ω – 2350 Ω = **44,650 Ω**
R_{max} = 47,000 Ω + 2350 Ω = **49,350 Ω**

15. (a) 1st band = **red**, 2nd band = **violet**, 3rd band = **brown**, 4th band = **gold**

(b) 330 Ω; **orange, orange, brown, (B)**
2.2 kΩ: **red, red, red (D)**
39 kΩ: **orange, white, orange (A)**
56 kΩ: **green, blue, orange (L)**
100 kΩ: **brown, black, yellow (F)**

16. (a) **36.5 Ω ± 2%**

(b) **2.74 kΩ ± 0.25%**

(c) **82.5 kΩ ± 1%**

17. (a) Brown, black, black, gold: **10 Ω ± 5%**

(b) Green, brown, green, silver: 5,100,000 Ω ± 10% **= 5.1 MΩ ± 10%**

(c) Blue, gray, black, gold: **68 Ω ± 5%**

18. (a) 0.47 Ω ± 5%: **yellow, violet, silver, gold**

(b) 270 kΩ ± 5%: **red, violet, yellow, gold**

(c) 5.1 MΩ ± 5%: **green, brown, green, gold**

19. (a) Red, gray, violet, red, brown: 28,700 Ω ± 1% = **28.7 kΩ ± 1%**

(b) Blue, black, yellow, gold, brown: **60.4 Ω ± 1%**

(c) White, orange, brown, brown, brown: 9310 ± 1% = **9.31 kΩ ± 1%**

20. (a) 14.7 kΩ ± 1%: **brown, yellow, violet, red, brown**

(b) 39.2 Ω ± 1%: **orange, white, red, gold, brown**

(c) 9.76 kΩ ± 1%: **white, violet, blue, brown, brown**

21. (a) 220 = **22 Ω** (b) 472 = **4.7 kΩ**

(c) 823 = **82 kΩ** (d) 3K3 = **3.3 kΩ**

(e) 560 = **56 Ω** (f) 10M = **10 MΩ**

22. **500 Ω**, equal resistance on each side of the contact.

SECTION 2-6 The Electric Circuit

23. There is current through **Lamp 2.**

24. See Figure 2-1.

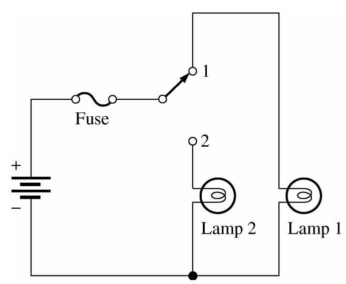

Figure 2-1

SECTION 2-7 Basic Circuit Measurements

25. See Figure 2-2(a).

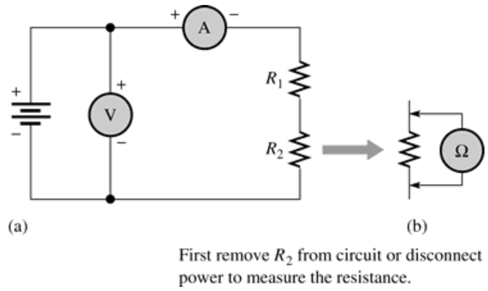

Figure 2-2

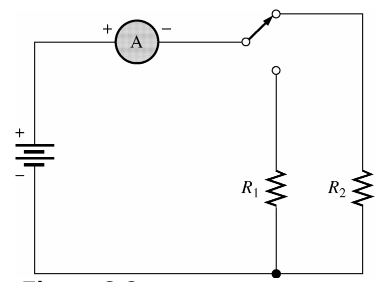

Figure 2-3

26. See Figure 2-2(b).

27. Position 1: V1 = **0 V**, V2 = $\boldsymbol{V}_S$
    Position 2: V1 = $\boldsymbol{V}_S$, V2 = **0 V**

28. See Figure 2-3.

29. On the 600 V DC scale: **250 V**

30. R = (10)(10 Ω) = **100 Ω**

31. (a) 2(100 Ω) = **200 Ω** (b) 15(10 MΩ) = **150 MΩ**
    (c) 45(100 Ω) = **4500 Ω**

32. See Figure 2-4.

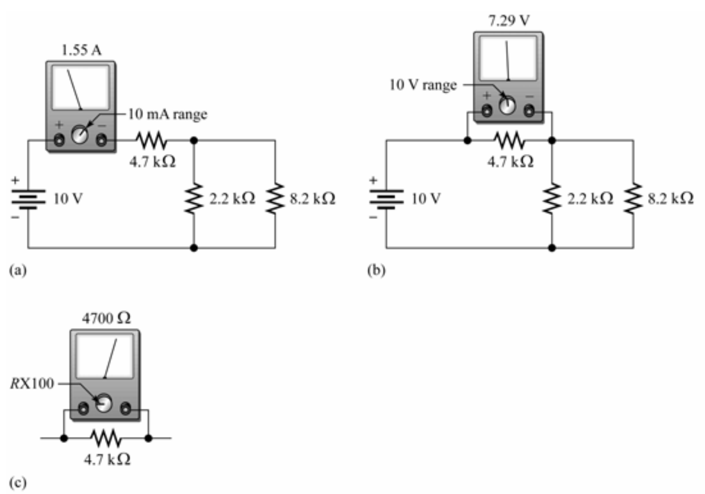

Figure 2-4

ADVANCED PROBLEMS

33. $I = \dfrac{Q}{t}$

$Q = I \times t = (2\text{ A})(15\text{ s}) = 30\text{ C}$

$V = \dfrac{W}{Q} = \dfrac{1000\text{ J}}{30\text{ C}} = \mathbf{33.3\text{ V}}$

34. $I = \dfrac{Q}{t}$

Q = (number of electrons) / (number of electrons/coulomb)

$Q = \dfrac{574 \times 10^{15}\text{ e}}{6.25 \times 10^{18}\text{ e/C}} = 9.184 \times 10^{-2}\text{ C}$

$I = \dfrac{Q}{t} = \dfrac{9.184 \times 10^{-2}\text{ C}}{250 \times 10^{-3}\text{ s}} = \mathbf{0.367\text{ A}}$

35. Total wire length = 100 ft
Resistance per 1000 ft = (1000 ft)(6 Ω/100 ft) = 60 Ω
Smallest wire size is **AWG 27** which has 51.47 Ω/1000 ft

36. (a) 4R7J = **4.7 Ω ± 5%**

(b) 560KF = **560 kΩ ± 1%**

(c) 1M5G = **1.5 MΩ ± 2%**

37. The circuit in (b) can have both lamps on at the same time.

38. There is always current through R_5.

39. See Figure 2-5.

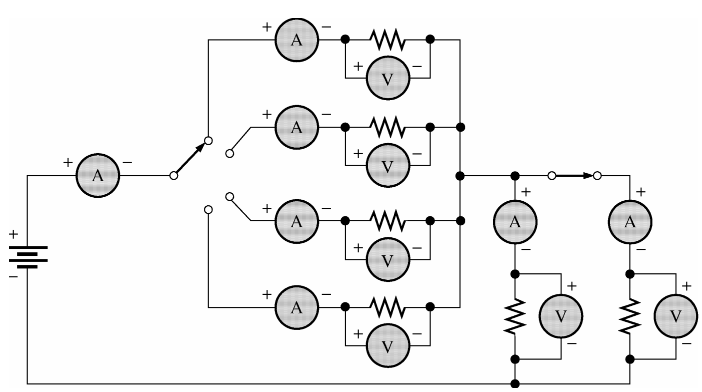

Figure 2-5

40. See Figure 2-5.

41. See Figure 2-6.

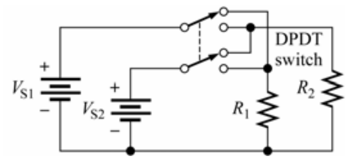

Figure 2-6

42. See Figure 2-7.

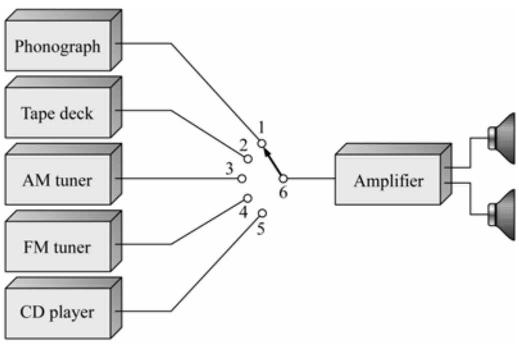

Figure 2-7

CHAPTER 3
OHM'S LAW, ENERGY, AND POWER

BASIC PROBLEMS

SECTION 3-1 Ohm's Law

1. I is directly proportional to V and will change the same percentage as V.
   (a) $I = 3(1\text{ A}) = \mathbf{3\text{ A}}$
   (b) $I = 1\text{ A} - (0.8)(1\text{ A}) = 1\text{ A} - 0.8\text{ A} = \mathbf{0.2\text{ A}}$
   (c) $I = 1\text{ A} + (0.5)(1\text{ A}) = 1\text{ A} + 0.5\text{ A} = \mathbf{1.5\text{ A}}$

2. (a) When the resistance doubles, the current is halved from 100 mA to **50 mA.**
   (b) When the resistance is reduced by 30%, the current increases from 100 mA to $I = V/0.7R = 1.429(V/R) = (1.429)(100\text{ mA}) \cong \mathbf{143\text{ mA}}$
   (c) When the resistance is quadrupled, the current decreases from 100 mA to **25 mA**.

3. Tripling the voltage triples the current from 10 mA to 30 mA, but doubling the resistance halves the current to **15 mA.**

SECTION 3-2 Application of Ohm's Law

4. (a) $I = \dfrac{V}{R} = \dfrac{5\text{ V}}{1\ \Omega} = \mathbf{5\text{ A}}$
   (b) $I = \dfrac{V}{R} = \dfrac{15\text{ V}}{10\ \Omega} = \mathbf{1.5\text{ A}}$
   (c) $I = \dfrac{V}{R} = \dfrac{50\text{ V}}{100\ \Omega} = \mathbf{0.5\text{ A}}$
   (d) $I = \dfrac{V}{R} = \dfrac{30\text{ V}}{15\text{ k}\Omega} = 2\ \mathbf{mA}$
   (e) $I = \dfrac{V}{R} = \dfrac{250\text{ V}}{4.7\text{ M}\Omega} = \mathbf{53.2\ \mu A}$

5. (a) $I = \dfrac{V}{R} = \dfrac{9\text{ V}}{2.7\text{ k}\Omega} = \mathbf{3.33\text{ mA}}$
   (b) $I = \dfrac{V}{R} = \dfrac{5.5\text{ V}}{10\text{ k}\Omega} = \mathbf{550\ \mu A}$
   (c) $I = \dfrac{V}{R} = \dfrac{40\text{ V}}{68\text{ k}\Omega} = \mathbf{588\ \mu A}$
   (d) $I = \dfrac{V}{R} = \dfrac{1\text{ kV}}{2\text{ k}\Omega} = \mathbf{500\text{ mA}}$
   (e) $I = \dfrac{V}{R} = \dfrac{66\text{ kV}}{10\text{ M}\Omega} = \mathbf{6.60\text{ mA}}$

6. $I = \frac{V}{R} = \frac{12\text{ V}}{10\ \Omega} = \mathbf{1.2\ A}$

7. (a) $I = \frac{V}{R} = \frac{25\text{ V}}{10\text{ k}\Omega} = \mathbf{2.50\ mA}$ (b) $I = \frac{V}{R} = \frac{5\text{ V}}{2.2\text{ M}\Omega} = \mathbf{2.27\ \mu A}$

(c) $I = \frac{V}{R} = \frac{15\text{ V}}{1.8\text{ k}\Omega} = \mathbf{8.33\ mA}$

8. Orange, violet, yellow, gold, brown ≡ 37.4 Ω ± 1%

$I = \frac{V_S}{R} = \frac{12\text{ V}}{37.4\ \Omega} = \mathbf{0.321\ A}$

9. $I = \frac{24\text{ V}}{37.4\ \Omega} = 0.642\text{ A}$

0.642 A is greater than 0.5 A, so **the fuse will blow.**

10. (a) $V = IR = (2\text{ A})(18\ \Omega) = \mathbf{36\ V}$ (b) $V = IR = (5\text{ A})(47\ \Omega) = \mathbf{235\ V}$
(c) $V = IR = (2.5\text{ A})(620\ \Omega) = \mathbf{1550\ V}$ (d) $V = IR = (0.6\text{ A})(47\ \Omega) = \mathbf{28.2\ V}$
(e) $V = IR = (0.1\text{ A})(470\ \Omega) = \mathbf{47\ V}$

11. (a) $V = IR = (1\text{ mA})(10\ \Omega) = \mathbf{10\ mV}$ (b) $V = IR = (50\text{ mA})(33\ \Omega) = \mathbf{1.65\ V}$
(c) $V = IR = (3\text{ A})(4.7\text{ k}\Omega) = \mathbf{14.1\ kV}$ (d) $V = IR = (1.6\text{ mA})(2.2\text{ k}\Omega) = \mathbf{3.52\ V}$
(e) $V = IR = (250\ \mu\text{A})(1\text{ k}\Omega) = \mathbf{250\ mV}$ (f) $V = IR = (500\text{ mA})(1.5\text{ M}\Omega) = \mathbf{750\ kV}$
(g) $V = IR = (850\ \mu\text{A})(10\text{ M}\Omega) = \mathbf{8.5\ kV}$ (h) $V = IR = (75\ \mu\text{A})(47\ \Omega) = \mathbf{3.53\ mV}$

12. $V_S = IR = (3\text{ A})(27\ \Omega) = \mathbf{81\ V}$

13. (a) $V = IR = (3\text{ mA})(27\text{ k}\Omega) = \mathbf{81\ V}$ (b) $V = IR = (5\ \mu\text{A})(100\text{ M}\Omega) = \mathbf{500\ V}$
(c) $V = IR = (2.5\text{ A})(47\ \Omega) = \mathbf{117.5\ V}$

14. (a) $R = \frac{V}{I} = \frac{10\text{ V}}{2\text{ A}} = \mathbf{5\ \Omega}$ (b) $R = \frac{V}{I} = \frac{90\text{ V}}{45\text{ A}} = \mathbf{2\ \Omega}$

(c) $R = \frac{V}{I} = \frac{50\text{ V}}{5\text{ A}} = \mathbf{10\ \Omega}$ (d) $R = \frac{V}{I} = \frac{5.5\text{ V}}{10\text{ A}} = \mathbf{0.55\ \Omega}$

(e) $R = \frac{V}{I} = \frac{150\text{ V}}{0.5\text{ A}} = \mathbf{300\ \Omega}$

15. (a) $R = \frac{V}{I} = \frac{10\text{ kV}}{5\text{ A}} = \mathbf{2\ k\Omega}$ (b) $R = \frac{V}{I} = \frac{7\text{ V}}{2\text{ mA}} = \mathbf{3.5\ k\Omega}$

(c) $R = \frac{V}{I} = \frac{500\text{ V}}{250\text{ mA}} = \mathbf{2\ k\Omega}$ (d) $R = \frac{V}{I} = \frac{50\text{ V}}{500\ \mu\text{A}} = \mathbf{100\ k\Omega}$

(e) $R = \frac{V}{I} = \frac{1\,\text{kV}}{1\,\text{mA}} = 1\ \mathbf{M\Omega}$

16. $R = \frac{V}{I} = \frac{6\text{ V}}{2\text{ mA}} = \mathbf{3\ k\Omega}$

17. (a) $R = \frac{V}{I} = \frac{8\text{ V}}{2\text{ A}} = \mathbf{4\ \Omega}$ (b) $R = \frac{V}{I} = \frac{12\text{ V}}{4\text{ mA}} = \mathbf{3\ k\Omega}$

(c) $R = \frac{V}{I} = \frac{30\text{ V}}{150\,\mu\text{A}} = 0.2\text{ M}\Omega = \mathbf{200\ k\Omega}$

SECTION 3-3 Energy and Power

18. Since 1 watt = 1 joule, P = 350 J/s = **350 W**

19. $P = \frac{W}{t} = \frac{7500\text{ J}}{5\text{ h}}$

$$\left(\frac{7500\text{ J}}{5\text{ h}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right) = \frac{7500\text{ J}}{18{,}000\text{ s}} = 0.417\text{ J/s} = \mathbf{417\ mW}$$

20. (a) 1000 W = 1 × 10^3 W = **1 kW** (b) 3750 W = 3.750 × 10^3 W = **3.75 kW**
(c) 160 W = 0.160 × 10^3 W = **0.160 kW** (d) 50,000 W = 50 × 10^3 W = **50 kW**

21. (a) 1,000,000 W = 1 × 10^6 W = **1 MW** (b) 3 × 10^6 W = **3 MW**
(c) 15 × 10^7 W = 150 × 10^6 W = **150 MW** (d) 8700 kW = 8.7 × 10^6 W = **8.7 MW**

22. (a) 1 W = 1000 × 10^{-3} W = **1000 mW** (b) 0.4 W = 400 × 10^{-3} W = **400 mW**
(c) 0.002 W = 2 × 10^{-3} W = **2 mW** (d) 0.0125 W = 12.5 × 10^{-3} W = **12.5 mW**

23. (a) 2 W = **2,000,000 μW** (b) 0.0005 W = **500 μW**
(c) 0.25 mW = **250 μW** (d) 0.00667 mW = **6.67 μW**

24. (a) 1.5 kW = 1.5 × 10^3 W = **1500 W** (b) 0.5 MW = 0.5 × 10^6 W = **500,000 W**
(c) 350 mW = 350 × 10^{-3} W = **0.350 W** (d) 9000 μW = 9000 × 10^{-6} W = **0.009 W**

25. $P = \dfrac{W}{t}$ in watts

$V = \dfrac{W}{Q}$

$I = \dfrac{Q}{t}$

$P = VI = \dfrac{W}{t}$

So, (1 V)(1 A) = 1 W

26. $P = \dfrac{W}{t} = \dfrac{1\text{ J}}{1\text{ s}} = 1\text{ W}$

$1\text{ kW} = 1000\text{ W} = \dfrac{1000\text{ J}}{1\text{ s}}$

1 kW-second = 1000 J

1 kWh = 3600 × 1000 J

1 kWh = 3.6 × 10^6 J

SECTION 3-4 Power in an Electric Circuit

27. $P = VI = (5.5\text{ V})(3\text{ mA}) = \mathbf{16.5\text{ mW}}$

28. $P = VI = (115\text{ V})(3\text{ A}) = \mathbf{345\text{ W}}$

29. $P = I^2R = (500\text{ mA})^2(4.7\text{ k}\Omega) = \mathbf{1.18\text{ kW}}$

30. $P = I^2R = (100 \times 10^{-6}\text{ A})^2(10 \times 10^3\ \Omega) = 1 \times 10^{-4}\text{ W} = \mathbf{100\ \mu W}$

31. $P = \dfrac{V^2}{R} = \dfrac{(60\text{ V})^2}{620\ \Omega} = \mathbf{5.81\text{ W}}$

32. $P = \dfrac{V^2}{R} = \dfrac{(1.5\text{ V})^2}{56\ \Omega} = 0.0402\text{ W} = \mathbf{40.2\text{ mW}}$

33. $P = I^2R$

$R = \dfrac{P}{I^2} = \dfrac{100\text{ W}}{(2\text{ A})^2} = \mathbf{25\ \Omega}$

34. 5×10^6 watts for 1 minute = 5×10^3 kWmin

$$\frac{5 \times 10^3 \text{ kWmin}}{60 \text{ min/1 hr}} = \mathbf{83.3\ kWh}$$

35. $$\frac{6700 \text{ W/s}}{(1000 \text{ W/kW})(3600 \text{ s/h})} = \mathbf{0.00186\ kWh}$$

36. (50 W)(12 h) = **600 Wh**
50 W = 0.05 kW
(0.05 kW)(12 h) = **0.6 kWh**

37. $$I = \frac{V}{R_L} = \frac{1.25 \text{ V}}{10\ \Omega} = 0.125 \text{ A}$$

$P = VI = (1.25 \text{ V})(0.125 \text{ A}) = 0.156 \text{ W} =$ **156 mW**

38. $$P = \frac{W}{t}$$

$$156 \text{ mW} = \frac{156 \text{ mJ}}{1 \text{ s}}$$

$W_{\text{tot}} = (156 \text{ mJ/s})(90 \text{ h})(3600 \text{ s/h}) =$ **50,544 J**

SECTION 3-5 The Power Rating of Resistors

39. $P = I^2R = (10 \text{ mA})^2(6.8 \text{ k}\Omega) = 0.68 \text{ W}$
Use the next highest standard power rating of **1 W**.

40. If the 8 W resistor is used, it will be operating in a marginal condition.
To allow for a **safety margin of 20%**, use a **12 W** resistor.

SECTION 3-6 Energy Conversion and Voltage Drop in a Resistance

41. (a) + at top, – at bottom of resistor (b) + at bottom, – at top of resistor

(c) + on right, – on left of resistor

SECTION 3-7 Power Supplies

42. $V_{\text{OUT}} = \sqrt{P_L R_L} = \sqrt{(1 \text{ W})(50\ \Omega)} =$ **7.07 V**

43. Ampere-hour rating = (1.5 A)(24 h) = **36 Ah**

44. $I = \dfrac{80\text{ Ah}}{10\text{ h}} = \mathbf{8\ A}$

45. $I = \dfrac{650\text{ mAh}}{48\text{ h}} = \mathbf{13.5\ mA}$

46. $P_{LOST} = P_{IN} - P_{OUT} = 500\text{ mW} - 400\text{ mW} = \mathbf{100\ mW}$

$\%\text{ efficiency} = \left(\dfrac{P_{OUT}}{P_{IN}}\right)100\% = \left(\dfrac{400\text{ mW}}{500\text{ mW}}\right)100\% = \mathbf{80\%}$

47. $P_{OUT} = (\text{efficiency})P_{IN} = (0.85)(5\text{ W}) = \mathbf{4.25\ W}$

SECTION 3-8 Introduction to Troubleshooting

48. The 4th bulb from the left is open.

49. If should take **five** (maximum) resistance measurements.

ADVANCED PROBLEMS

50. Assume that the total consumption of the power supply is the input power plus the power lost.

$P_{OUT} = 2\text{ W}$

$\%\text{ efficiency} = \left(\dfrac{P_{OUT}}{P_{IN}}\right)100\%$

$P_{IN} = \left(\dfrac{P_{OUT}}{\%\text{ efficiency}}\right)100\% = \left(\dfrac{2\text{ W}}{60\%}\right)100\% = 3.33\text{ W}$

The power supply itself uses

$P_{IN} - P_{OUT} = 3.33\text{ W} - 2\text{ W} = 1.33\text{ W}$

Energy $= W = Pt = (1.33\text{ W})(24\text{ h}) = 31.9\text{ Wh} \cong \mathbf{0.032\ kWh}$

51. $R_f = \dfrac{V}{I} = \dfrac{120\text{ V}}{0.8\text{ A}} = \mathbf{150\ \Omega}$

52. Measure the current with an ammeter connected as shown in Figure 3-1. Then calculate the unknown resistance with the formula, $\boldsymbol{R = 12\ \text{V}/I}$.

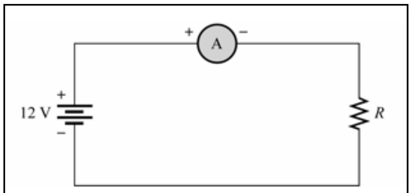

Figure 3-1

53. Calculate I for each value of V:

$$I_1 = \frac{0\ \text{V}}{100\ \Omega} = \mathbf{0\ A} \qquad I_2 = \frac{10\ \text{V}}{100\ \Omega} = \mathbf{100\ mA}$$

$$I_3 = \frac{20\ \text{V}}{100\ \Omega} = \mathbf{200\ mA} \qquad I_4 = \frac{30\ \text{V}}{100\ \Omega} = \mathbf{300\ mA}$$

$$I_5 = \frac{40\ \text{V}}{100\ \Omega} = \mathbf{400\ mA} \qquad I_6 = \frac{50\ \text{V}}{100\ \Omega} = \mathbf{500\ mA}$$

$$I_7 = \frac{60\ \text{V}}{100\ \Omega} = \mathbf{600\ mA} \qquad I_8 = \frac{70\ \text{V}}{100\ \Omega} = \mathbf{700\ mA}$$

$$I_9 = \frac{80\ \text{V}}{100\ \Omega} = \mathbf{800\ mA} \qquad I_{10} = \frac{90\ \text{V}}{100\ \Omega} = \mathbf{900\ mA}$$

$$I_{11} = \frac{100\ \text{V}}{100\ \Omega} = \mathbf{1\ A}$$

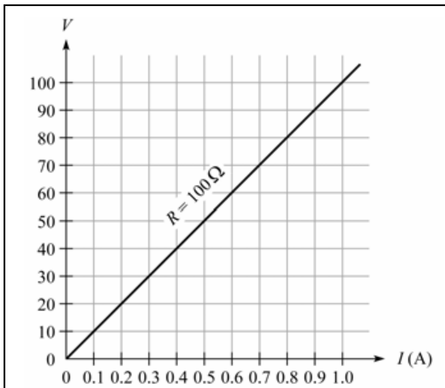

Figure 3-2

The graph is a straight line as shown in Figure 3-2. This indicates a *linear* relationship between I and V.

54. $R = \dfrac{V_S}{I} = \dfrac{1\text{ V}}{5\text{ mA}} = \mathbf{200\ \Omega}$

(a) $I = \dfrac{V_S}{R} = \dfrac{1.5\text{ V}}{200\ \Omega} = \mathbf{7.5\ mA}$

(b) $I = \dfrac{V_S}{R} = \dfrac{2\text{ V}}{200\ \Omega} = \mathbf{10\ mA}$

(c) $I = \dfrac{V_S}{R} = \dfrac{3\text{ V}}{200\ \Omega} = \mathbf{15\ mA}$

(d) $I = \dfrac{V_S}{R} = \dfrac{4\text{ V}}{200\ \Omega} = \mathbf{20\ mA}$

(e) $I = \dfrac{V_S}{R} = \dfrac{10\text{ V}}{200\ \Omega} = \mathbf{50\ mA}$

55. $R_1 = \dfrac{V}{I} = \dfrac{1\text{ V}}{2\text{ A}} = \mathbf{0.5\ \Omega}$ $R_2 = \dfrac{V}{I} = \dfrac{1\text{ V}}{1\text{ A}} = \mathbf{1\ \Omega}$ $R_3 = \dfrac{V}{I} = \dfrac{1\text{ V}}{0.5\text{ A}} = \mathbf{2\ \Omega}$

56. $\dfrac{V_2}{30\text{ mA}} = \dfrac{10\text{ V}}{50\text{ mA}}$

$V_2 = \dfrac{(10\text{ V})(30\text{ mA})}{50\text{ mA}} = 6\text{ V}$ **new value**

The voltage decreased by 4 V, from 10 V to 6 V.

57. The current increase is 50%, so the voltage increase must be the same; that is, the voltage must be increased by (0.5)(20 V) = **10 V**.

The new value of voltage is V_2 = 20 V + (0.5)(20 V) = 20 V + 10 V = **30 V**

58. $R = \dfrac{100\text{ V}}{750\text{ mA}}$ $0.133\text{ k}\Omega = \mathbf{133\ \Omega}$; $R = \dfrac{100\text{ V}}{1\text{ A}} = \mathbf{100\ \Omega}$

If $R = 0\ \Omega$, the voltage source will be shorted causing possible damage.

59. Resistance value = 3300 Ω ± 5%
$R_{max} = 3300\ \Omega + (0.05)(3300\ \Omega) = 3465\ \Omega$
$R_{min} = 3300\ \Omega - (0.05)(3300\ \Omega) = 3135\ \Omega$
$I_{max} = \dfrac{V_S}{R_{min}} = \dfrac{12\text{ V}}{3135\ \Omega} = \mathbf{3.83\ mA}$
$I_{min} = \dfrac{V_S}{R_{max}} = \dfrac{12\text{ V}}{3465\ \Omega} = \mathbf{3.46\ mA}$

60. Wire resistance: $R_W = \dfrac{(10.4\,\text{CM}\cdot\Omega/\text{ft})(24\,\text{ft})}{1624.3\,\text{CM}} = 0.154\ \Omega$

(a) $I = \dfrac{V}{R + R_W} = \dfrac{6\text{ V}}{100.154\ \Omega} = \mathbf{59.9\ mA}$

(b) $V_R = (59.9\text{ mA})(100\ \Omega) = \mathbf{5.99\ V}$

(c) $V_{R_W} = 6\text{ V} - 5.99\text{ V} = 0.01\text{ V}$

For one length of wire, $V = \dfrac{0.01\text{ V}}{2} = \mathbf{0.005\ V}$

61. 300 W = 0.3 kW
30 days = (30 days)(24 h/day) = 720 h
Energy = (0.3 kW)(720 h) = **216 kWh**

62. $\dfrac{1500\text{ kWh}}{31\text{ days}} = 48.39\text{ kWh/day}$

$P = \dfrac{48.39\text{ kWh/day}}{24\text{ h/day}} = \mathbf{2.02\ kW}$

63. The minimum power rating you should use is **12 W** so that the power dissipation does not exceed the rating.

64. (a) $P = \dfrac{V^2}{R} = \dfrac{(12\text{ V})^2}{10\ \Omega} = \mathbf{14.4\ W}$

(b) $W = Pt = (14.4\text{ W})(2\text{ min})(1/60\text{ h/min}) = \mathbf{0.48\ Wh}$

(c) Neither, the power is the same because it is not time dependent.

65. $V_{R(\text{max})} = 120\text{ V} - 100\text{ V} = 20\text{ V}$

$I_{\text{max}} = \dfrac{V_{R(\text{max})}}{R_{\text{min}}} = \dfrac{20\text{ V}}{8\ \Omega} = 2.5\text{ A}$

A fuse with a rating of less than 2.5 A must be used. **A 2 A fuse is recommended.**

Multisim Troubleshooting Problems

66. R is open.

67. No fault

68. R_1 is shorted.

69. Lamp 4 is shorted.

70. Lamp 6 is open.

CHAPTER 4
SERIES CIRCUITS

BASIC PROBLEMS

SECTION 4-1 Resistors in Series

1. See Figure 4-1.

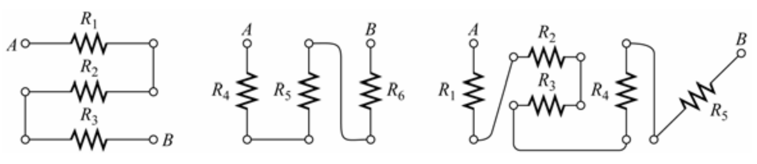

Figure 4-1

2. The groups of series resistors are

R_1, R_2, R_3, R_9 R_4; R_{13}, R_7, R_{14}, R_{16}; R_6, R_8, R_{12}; R_{10}, R_{11}, R_{15}, R_5

See Figure 4-2.

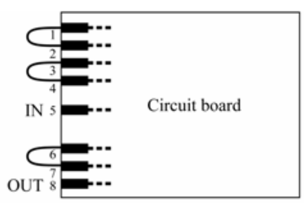

Figure 4-2

3. $R_{1-8} = R_{13} + R_7 + R_{14} + R_{16}$

$= 68\ \text{k}\Omega + 33\ \text{k}\Omega + 47\ \text{k}\Omega + 22\ \text{k}\Omega$

$= \mathbf{170\ k\Omega}$

4. $R_{2-3} = R_{12} + R_8 + R_6 = 10\ \Omega + 18\ \Omega + 22\ \Omega = \mathbf{50\ \Omega}$

SECTION 4-2 Total Series Resistance

5. $R_T = 82\ \Omega + 56\ \Omega = \mathbf{138\ \Omega}$

6. (a) $R_T = 560\ \Omega + 1.0\ \text{k}\Omega = \mathbf{1560\ \Omega}$
   (b) $R_T = 47\ \Omega + 33\ \Omega = \mathbf{80\ \Omega}$
   (c) $R_T = 1.5\ \text{k}\Omega + 2.2\ \text{k}\Omega + 10\ \text{k}\Omega = \mathbf{13.7\ k\Omega}$
   (d) $R_T = 1.0\ \text{k}\Omega + 1.8\ \text{k}\Omega + 100\ \text{k}\Omega + 1.0\ \text{M}\Omega = \mathbf{1{,}102{,}800\ \Omega}$

7. (a) $R_T = 1.0\ \text{k}\Omega + 4.7\ \text{k}\Omega + 2.2\ \text{k}\Omega = \mathbf{7.9\ k\Omega}$
   (b) $R_T = 10\ \Omega + 10\ \Omega + 12\ \Omega + 1.0\ \Omega = \mathbf{33\ \Omega}$
   (c) $R_T = 1.0\ \text{M}\Omega + 560\ \text{k}\Omega + 1.0\ \text{M}\Omega + 680\ \text{k}\Omega + 10\ \text{M}\Omega = \mathbf{13.24\ M\Omega}$

   See Figure 4-3.

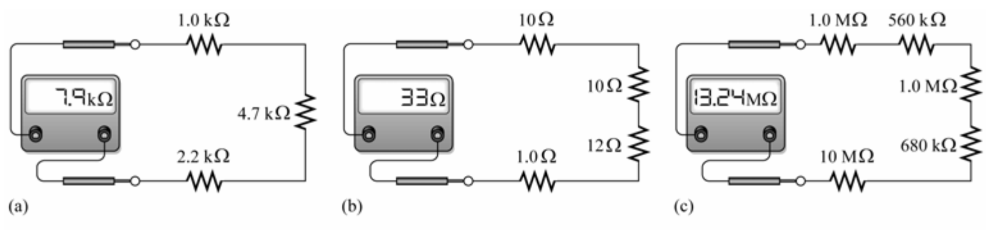

Figure 4-3

8. $R_T = 12(5.6\ \text{k}\Omega) = \mathbf{67.2\ k\Omega}$

9. $R_T = 6(47\ \Omega) + 8(100\ \Omega) + 2(22\ \Omega) = 282\ \Omega + 800\ \Omega + 44\ \Omega = \mathbf{1126\ \Omega}$

10. $R_T = R_1 + R_2 + R_3 + R_4 + R_5$
    $R_5 = R_T - (R_1 + R_2 + R_3 + R_4)$
    $= 20\ \text{k}\Omega - (4.7\ \text{k}\Omega + 1.0\ \text{k}\Omega + 2.2\ \text{k}\Omega + 3.9\ \text{k}\Omega)$
    $= 20\ \text{k}\Omega - 11.8\ \text{k}\Omega$
    $= \mathbf{8.2\ k\Omega}$

11. (a) $R_{1\text{–}8} = R_{13} + R_7 + R_{14} + R_{16}$
    $= 68\ \text{k}\Omega + 33\ \text{k}\Omega + 47\ \text{k}\Omega + 22\ \text{k}\Omega = \mathbf{170\ k\Omega}$

    (b) $R_{2\text{–}3} = R_{12} + R_8 + R_6$
    $= 10\ \Omega + 18\ \Omega + 22\ \Omega = \mathbf{50\ \Omega}$

    (c) $R_{4\text{–}7} = R_{10} + R_{11} + R_{15} + R_5$
    $= 2.2\ \text{k}\Omega + 8.2\ \text{k}\Omega + 1.0\ \text{k}\Omega + 1.0\ \text{k}\Omega = \mathbf{12.4\ k\Omega}$

    (d) $R_{5\text{–}6} = R_1 + R_2 + R_3 + R_9 + R_4$
    $= 220\ \Omega + 330\ \Omega + 390\ \Omega + 470\ \Omega + 560\ \Omega = \mathbf{1.97\ k\Omega}$

12. $R_T = R_{1-8} + R_{2-3} + R_{4-7} + R_{5-6}$
$= 170\ k\Omega + 50\ \Omega + 12.4\ k\Omega + 1.97\ k\Omega = \mathbf{184.42\ k\Omega}$

SECTION 4-3 Current in a Series Circuit

13. $I = \frac{V_S}{R_T} = \frac{12\text{ V}}{120\ \Omega} = \mathbf{0.1\ A}$

14. $I = \mathbf{5\ mA}$ at all points in the circuit.

SECTION 4-4 Application of Ohm's Law

15. (a) $R_T = 2.2\ k\Omega + 5.6\ k\Omega + 1.0\ k\Omega = 8.8\ k\Omega$

$$I = \frac{V}{R_T} = \frac{5.5\text{ V}}{8.8\ k\Omega} = \mathbf{625\ \mu A}$$

(b) $R_T = 1.0\ M\Omega + 2.2\ M\Omega + 560\ k\Omega = 3.76\ M\Omega$

$$I = \frac{16\text{ V}}{3.76\ M\Omega} = \mathbf{4.26\ \mu A}$$

The ammeters are connected in series. See Figure 4-4.

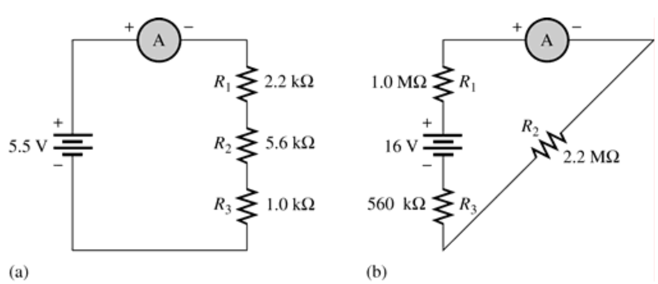

Figure 4-4

16. (a) $V_1 = \left(\frac{R_1}{R_T}\right)V_S = \left(\frac{2.2\ k\Omega}{8.8\ k\Omega}\right)5.5\text{ V} = \mathbf{1.375\ V}$

$$V_2 = \left(\frac{R_2}{R_T}\right)V_S = \left(\frac{5.6\ k\Omega}{8.8\ k\Omega}\right)5.5\text{ V} = \mathbf{3.5\ V}$$

$$V_3 = \left(\frac{R_3}{R_T}\right)V_S = \left(\frac{1.0\ k\Omega}{8.8\ k\Omega}\right)5.5\text{ V} = \mathbf{625\ mV}$$

(b) $V_1 = \left(\frac{R_1}{R_T}\right)V_S = \left(\frac{1.0\ \text{M}\Omega}{3.76\ \text{M}\Omega}\right)16\ \text{V} = \mathbf{4.26\ V}$

$V_2 = \left(\frac{R_2}{R_T}\right)V_S = \left(\frac{2.2\ \text{M}\Omega}{3.76\ \text{M}\Omega}\right)16\ \text{V} = \mathbf{9.36\ V}$

$V_3 = \left(\frac{R_3}{R_T}\right)V_S = \left(\frac{560\ \text{k}\Omega}{3.76\ \text{M}\Omega}\right)16\ \text{V} = \mathbf{2.38\ V}$

17. (a) $R_T = 3(470\ \Omega) = 1410\ \Omega$

$I = \frac{48\ \text{V}}{1410\ \Omega} = \mathbf{34.0\ mA}$

(b) $V_R = IR = (34.0\ \text{mA})(470\ \Omega) = \mathbf{16\ V}$

(c) $P_{min} = I^2R = (34.0\ \text{mA})^2 470\ \Omega = \mathbf{0.543\ W}$

18. $R_T = \frac{V_S}{I_T} = \frac{5\ \text{V}}{1\ \text{mA}} = 5\ \text{k}\Omega$

$R_{each} = \frac{5\ \text{k}\Omega}{4} = \mathbf{1.25\ k\Omega}$

SECTION 4-5 Voltage Sources in Series

19. $V_T = 5\ \text{V} + 9\ \text{V} = \mathbf{14\ V}$

20. (a) $V_{S(tot)} = 10\ \text{V} + 5\ \text{V} + 8\ \text{V} = \mathbf{23\ V}$ (b) $V_{S(tot)} = 10\ \text{V} + 50\ \text{V} - 25\ \text{V} = \mathbf{35\ V}$
(c) $V_{S(tot)} = 8\ \text{V} - 8\ \text{V} = \mathbf{0\ V}$

SECTION 4-6 Kirchhoff's Voltage Law

21. $V_S = 5.5\ \text{V} + 8.2\ \text{V} + 12.3\ \text{V} = \mathbf{26\ V}$

22. $V_S = V_1 + V_2 + V_3 + V_4 + V_5$
$V_5 = V_S - (V_1 + V_2 + V_3 + V_4) = 20\ \text{V} - (1.5\ \text{V} + 5.5\ \text{V} + 3\ \text{V} + 6\ \text{V}) = 20\ \text{V} - 16\ \text{V} = \mathbf{4\ V}$

23. (a) By Kirchhoff's voltage law:

$15\ \text{V} = 2\ \text{V} + V_2 + 3.2\ \text{V} + 1\ \text{V} + 1.5\ \text{V} + 0.5\ \text{V}$
$V_2 = 15\ \text{V} - (2\ \text{V} + 3.2\ \text{V} + 1\ \text{V} + 1.5\ \text{V} + 0.5\ \text{V}) = 15\ \text{V} - 8.2\ \text{V} = \mathbf{6.8\ V}$

See Figure 4-5(a).

(b) $V_R = \mathbf{8\ V}$; $V_{2R} = \mathbf{16\ V;}$ $V_{3R} = \mathbf{24\ V}$; $V_{4R} = \mathbf{32\ V}$

See Figure 4-5(b).

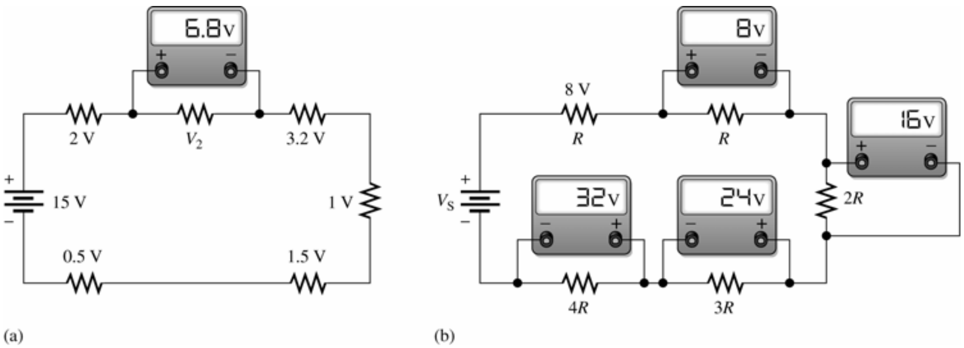

Figure 4-5

SECTION 4-7 Voltage Dividers

24. $\left(\dfrac{22\ \Omega}{500\ \Omega}\right)100 = \mathbf{4.4\%}$

25. (a) $V_{AB} = \left(\dfrac{47\ \Omega}{147\ \Omega}\right)12\ \text{V} = \mathbf{3.84\ V}$

(b) $V_{AB} = \left(\dfrac{2.2\ \text{k}\Omega + 3.3\ \text{k}\Omega}{1.0\ \text{k}\Omega + 2.2\ \text{k}\Omega + 3.3\ \text{k}\Omega}\right)8\ \text{V} = \left(\dfrac{5.5\ \text{k}\Omega}{6.5\ \text{k}\Omega}\right)8\ \text{V} = \mathbf{6.77\ V}$

26. $V_A = V_S = \mathbf{15\ V}$

$$V_B = \left(\frac{R_2 + R_3}{R_1 + R_2 + R_3}\right)V_S = \left(\frac{13.3\ \text{k}\Omega}{18.9\ \text{k}\Omega}\right)15\ \text{V} = \mathbf{10.6\ V}$$

$$V_C = \left(\frac{R_3}{R_1 + R_2 + R_3}\right)V_S = \left(\frac{3.3\ \text{k}\Omega}{18.9\ \text{k}\Omega}\right)15\ \text{V} = \mathbf{2.62\ V}$$

27. $V_{\min} = \left(\dfrac{R_3}{R_1 + R_2 + R_3}\right)V_S = \left(\dfrac{680\ \Omega}{2150\ \Omega}\right)12\ \text{V} = \mathbf{3.80\ V}$

$$V_{\max} = \left(\frac{R_2 + R_3}{R_1 + R_2 + R_3}\right)V_S = \left(\frac{1680\ \Omega}{2150\ \Omega}\right)12\ \text{V} = \mathbf{9.38\ V}$$

28. $R_T = R + 2R + 3R + 4R + 5R = 15R$

$V_R = \left(\frac{R}{15R}\right)9\text{ V} = \mathbf{0.6\ V}$ $\quad V_R = \left(\frac{2R}{15R}\right)9\text{ V} = \mathbf{1.2\ V}$ $\quad V_R = \left(\frac{3R}{15R}\right)9\text{ V} = \mathbf{1.8\ V}$

$V_R = \left(\frac{4R}{15R}\right)9\text{ V} = \mathbf{2.4\ V}$ $\quad V_R = \left(\frac{5R}{15R}\right)9\text{ V} = \mathbf{3.0\ V}$

29. $V_{5.6\text{k}} = \mathbf{10\ V}$ (by measurement); $\quad I = \frac{10\text{ V}}{5.6\text{ k}\Omega} = 1.79\text{ mA}$;

$V_{1\text{k}} = (1.79\text{ mA})(1\text{ k}\Omega) = \mathbf{1.79\ V}$; $\quad V_{560}\ (1.79\text{ mA})(560\ \Omega) = \mathbf{1\ V}$;

$V_{10\text{k}} = (1.79\text{ mA})(10\text{ k}\Omega) = \mathbf{17.9\ V}$

SECTION 4-8 Power in a Series Circuit

30. $P_T = 5(50\text{ mW}) = \mathbf{250\ mW}$

31. $R_T = 5.6\text{ k}\Omega + 1\text{ k}\Omega + 560\ \Omega + 10\text{ k}\Omega = 17.16\text{ k}\Omega$
$P = I^2R_T = (1.79\text{ mA})^2(17.16\text{ k}\Omega) = 0.055\text{ W} = \mathbf{55\ mW}$

SECTION 4-9 Voltage Measurement

32. Voltage from point A to ground (G): $V_{AG} = \mathbf{10\ V}$

Resistance between A and G: $R_{AG} = 5.6\text{ k}\Omega + 5.6\text{ k}\Omega + 1.0\text{ k}\Omega + 1.0\text{ k}\Omega = 13.2\text{ k}\Omega$

Resistance between B and G: $R_{BG} = 5.6\text{ k}\Omega + 1.0\text{ k}\Omega + 1.0\text{ k}\Omega = 7.6\text{ k}\Omega$

Resistance between C and G: $R_{CG} = 1.0\text{ k}\Omega + 1.0\text{ k}\Omega = 2\text{ k}\Omega$

$$V_{BG} = \left(\frac{R_{BG}}{R_{AG}}\right)10\text{ V} = \left(\frac{7.6\text{ k}\Omega}{13.2\text{ k}\Omega}\right)10\text{ V} = \mathbf{5.76\ V}$$

$$V_{CG} = \left(\frac{R_{CG}}{R_{AG}}\right)10\text{ V} = \left(\frac{2\text{ k}\Omega}{13.2\text{ k}\Omega}\right)10\text{ V} = \mathbf{1.52\ V}$$

$$V_{DG} = \left(\frac{R_{DG}}{R_{AG}}\right)10\text{ V} = \left(\frac{1.0\text{ k}\Omega}{13.2\text{ k}\Omega}\right)10\text{ V} = \mathbf{0.758\ V}$$

33. Measure the voltage at point A with respect to ground and the voltage at point B with respect to ground. The difference of these two voltages is V_{R2}.

$$\boldsymbol{V_{R2} = V_A - V_B}$$

34. $R_T = R_1 + R_2 + R_3 + R_4 + R_5$
$= 560\ \text{k}\Omega + 560\ \text{k}\Omega + 100\ \text{k}\Omega + 1.0\ \text{M}\Omega + 100\ \text{k}\Omega = 2.32\ \text{M}\Omega$

$V_T = 15\ \text{V}$

$$V_A = \left(\frac{R_{AG}}{R_T}\right)V_T = \left(\frac{1.76\ \text{M}\Omega}{2.32\ \text{M}\Omega}\right)15\ \text{V} = \mathbf{11.4\ V}$$

$$V_B = \left(\frac{R_{BG}}{R_T}\right)V_T = \left(\frac{1.2\ \text{M}\Omega}{2.32\ \text{M}\Omega}\right)15\ \text{V} = \mathbf{7.76\ V}$$

$$V_C = \left(\frac{R_{CG}}{R_T}\right)V_T = \left(\frac{1.1\ \text{M}\Omega}{2.32\ \text{M}\Omega}\right)15\ \text{V} = \mathbf{7.11\ V}$$

$$V_D = \left(\frac{R_{DG}}{R_T}\right)V_T = \left(\frac{100\ \text{k}\Omega}{2.32\ \text{M}\Omega}\right)15\ \text{V} = \mathbf{647\ mV}$$

SECTION 4-10 Troubleshooting

35. (a) Zero current indicates an open. ***R*₄ is open** since all the voltage is dropped across it.

(b) $$\frac{V_S}{R_1 + R_2 + R_3} = \frac{10\ \text{V}}{300\ \Omega} = 33.3\ \text{mA}$$
R_4 and R_5 have no effect on the current. There is a **short from *A* to *B*.**

36. $R_T = 10\ \text{k}\Omega + 8.2\ \text{k}\Omega + 12\ \text{k}\Omega + 2.2\ \text{k}\Omega + 5.6\ \text{k}\Omega = 38\ \text{k}\Omega$
The meter reads about 28 kΩ. It should read 38 kΩ. **The 10 kΩ resistor is shorted.**

ADVANCED PROBLEMS

37. $V_1 = IR_1 = (10\ \text{mA})(680\ \Omega) = 6.8\ \text{V}$
$V_2 = IR_2 = (10\ \text{mA})(1.0\ \text{k}\Omega) = 10\ \text{V}$
$V_4 = IR_4 = (10\ \text{mA})(270\ \Omega) = 2.7\ \text{V}$
$V_5 = IR_5 = (10\ \text{mA})(270\ \Omega) = 2.7\ \text{V}$
$V_3 = V_S - (V_1 + V_2 + V_4 + V_5)$
$V_3 = 30\ \text{V} - (6.8\ \text{V} + 10\ \text{V} + 2.7\ \text{V} + 2.7\ \text{V}) = 30\ \text{V} - 22.2\ \text{V} = 7.8\ \text{V}$
$$R_3 = \frac{V_3}{I} = \frac{7.8\ \text{V}}{10\ \text{mA}} = 0.78\ \text{k}\Omega = \mathbf{780\ \Omega}$$

38. $R_T = 3(5.6\ \text{k}\Omega) + 1.0\ \text{k}\Omega + 2(100\ \Omega) = 18\ \text{k}\Omega$
Three 5.6 kΩ resistors, one 1 kΩ resistor, and two 100 Ω resistors

39. $V_A = \mathbf{10\ V}$, $R_T = 22\ \text{k}\Omega + 10\ \text{k}\Omega + 47\ \text{k}\Omega + 12\ \text{k}\Omega + 5.6\ \text{k}\Omega = 96.6\ \text{k}\Omega$
$$V_B = V_A - V_{22k} = 10\ \text{V} - \left(\frac{22\ \text{k}\Omega}{96.6\ \text{k}\Omega}\right)10\ \text{V} = 10\ \text{V} - 2.28\ \text{V} = \mathbf{7.72\ V}$$

$$V_C = V_B - V_{10k} = 7.72\text{ V} - \left(\frac{10\text{ k}\Omega}{96.6\text{ k}\Omega}\right)10\text{ V} = 7.72\text{ V} - 1.04\text{ V} = \mathbf{6.68\text{ V}}$$

$$V_D = V_C - V_{47k} = 6.68\text{ V} - \left(\frac{47\text{ k}\Omega}{96.6\text{ k}\Omega}\right)10\text{ V} = 6.68\text{ V} - 4.87\text{ V} = \mathbf{1.81\text{ V}}$$

$$V_E = V_D - V_{12k} = 1.81\text{ V} - \left(\frac{12\text{ k}\Omega}{96.6\text{ k}\Omega}\right)10\text{ V} = 1.81\text{ V} - 1.24\text{ V} = \mathbf{0.57\text{ V}}$$

$V_F = \mathbf{0\text{ V}}$

40. $V_2 = IR_2 = (20\text{ mA})(100\ \Omega) = \mathbf{2\text{ V}}$

$$R_5 = \frac{V_S}{I} = \frac{6.6\text{ V}}{20\text{ mA}} = \mathbf{330\ \Omega}$$

$$R_6 = \frac{P_6}{I^2} = \frac{112\text{ mW}}{(20\text{ mA})^2} = \mathbf{280\ \Omega}$$

$V_6 = IR_6 = (20\text{ mA})(280\ \Omega) = \mathbf{5.6\text{ V}}$

$V_1 = V_S - (20\text{ V} + V_6) = 30\text{ V} - (20\text{ V} + 5.6\text{ V}) = \mathbf{4.4\text{ V}}$

$$R_1 = \frac{V_1}{I} = \frac{4.4\text{ V}}{20\text{ mA}} = \mathbf{220\ \Omega}$$

$V_3 + V_4 = 20\text{ V} - V_2 - V_5 = 20\text{ V} - 2\text{ V} - 6.6\text{ V} = 11.4\text{ V}$

$$V_3 = V_4 = \frac{11.4\text{ V}}{2} = \mathbf{5.7\text{ V}} \qquad R_3 = R_4 = \frac{V_3}{I} = \frac{5.7\text{ V}}{20\text{ mA}} = \mathbf{285\ \Omega}$$

41. $V_S = IR_T = (250\text{ mA})(1.5\text{ k}\Omega) = 375\text{ V}$

$I_{new} = 250\text{ mA} - 0.25(250\text{ mA}) = 250\text{ mA} - 62.5\text{ mA} = 188\text{ mA}$

$$R_{new} = \frac{V_S}{I_{new}} = \frac{375\text{ V}}{188\text{ mA}} \cong 2000\ \Omega$$

500 Ω must be added to the existing 1500 Ω to reduce *I* by 25%.

42. $P = I^2R$

$$I_{max} = \sqrt{\frac{P}{R}} = \sqrt{\frac{0.5\text{ W}}{120\ \Omega}} = 0.0645\text{ A} = 64.5\text{ mA}$$

Since all resistors in series have the same current, use the largest R to determine the maximum current allowable because the largest R has the greatest power.
Thus, the **120 Ω resistor burns out first.**

43. (a) $P_T = \frac{1}{8}\text{ W} + \frac{1}{4}\text{ W} + \frac{1}{2}\text{ W} = 0.125\text{ W} + 0.25\text{ W} + 0.5\text{ W} = 0.875\text{ W}$

$$I = \sqrt{\frac{P_T}{R_T}} = \sqrt{\frac{0.875\text{ W}}{2400\ \Omega}} = \mathbf{19.1\text{ mA}}$$

(b) $V_S = I_T R_T = (19.1\text{ mA})(2400\ \Omega) = \mathbf{45.8\text{ V}}$

(c) $R = \frac{P}{I^2}$

$$R_{1/8} = \frac{P}{I^2} = \frac{0.125\text{ W}}{(19.1\text{ mA})^2} = \mathbf{343\ \Omega}$$

$$R_{1/4} = \frac{0.25\text{ W}}{(19.1\text{ mA})^2} = \mathbf{686\ \Omega}$$

$$R_{1/2} = \frac{0.5\text{ W}}{(19.1\text{ mA})^2} = \mathbf{1371\ \Omega}$$

44. See Figure 4-6.

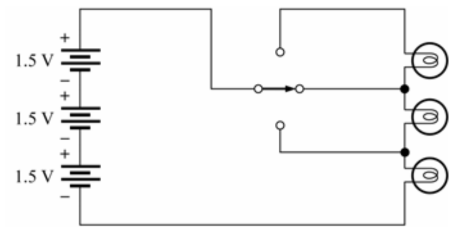

Figure 4-6

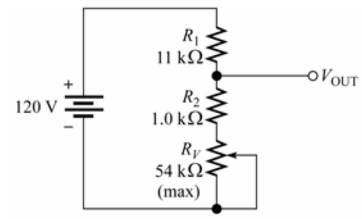

Figure 4-7

45. See Figure 4-7.

When the potentiometer is at minimum setting (0 Ω), V_{OUT} = 10 V:

$$R_1 + R_2 = \frac{120\text{ V}}{10\text{ mA}} = 12\text{ k}\Omega$$

$$\left(\frac{R_2}{R_1 + R_2}\right)120\text{ V} = 10\text{ V}$$

$$R_2 = \frac{10\text{ V}(12\text{ k}\Omega)}{120\text{ V}} = \mathbf{1.0\ k\Omega}$$

R_1 = 12 kΩ – 1.0 kΩ = **11 kΩ**

When the potentiometer is at maximum setting, V_{OUT} = 100 V:

$$\left(\frac{R_2 + R_V}{R_1 + R_2 + R_V}\right)120\text{ V} = 100\text{ V}$$

$$\left(\frac{1.0\text{ k}\Omega + R_V}{12\text{ k}\Omega + R_V}\right)120\text{ V} = 100\text{ V}$$

$(1.0\text{ k}\Omega + R_V)120\text{ V} = (12\text{ k}\Omega + R_V)100\text{ V}$

$120\text{ k}\Omega + 120R_V = 1200\text{ k}\Omega + 100R_V$

$20R_V = 1080\text{ k}\Omega$

$R_V = \mathbf{54\ k\Omega}$

46. See Figure 4-8.

$$R_1 = \frac{(30\text{ V} - 24.6\text{ V})}{1\text{ mA}} = 5.4\text{ k}\Omega$$

$$R_2 = \frac{(24.6\text{ V} - 14.7\text{ V})}{1\text{ mA}} = 9.9\text{ k}\Omega$$

$$R_3 = \frac{(14.7\text{ V} - 8.18\text{ V})}{1\text{ mA}} = 6.52\text{ k}\Omega$$

$$R_4 = \frac{8.18\text{ V}}{1\text{ mA}} = 8.18\text{ k}\Omega$$

A series of standard value resistors must be used to approximately achieve each resistance as follows:

R_1 = **4700 Ω + 680 Ω + 22 Ω = 5.4 kΩ**
R_2 = **8200 Ω + 1500 Ω + 220 Ω = 9.92 kΩ**
R_3 = **5600 Ω + 820 Ω + 100 Ω = 6.52 kΩ**
R_4 = **6800 Ω + 1000 Ω + 180 Ω + 100 Ω + 100 Ω = 8.18 kΩ**

The highest power dissipation is in the 8200 Ω resistor.
$P = (1\text{ mA})^2 8200\ \Omega = 8.2\text{ mW}$

All resistors must be at least 1/8 W.

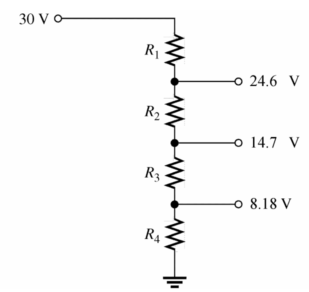

Figure 4-8

47. The groups are:

R_1, R_7, R_8, and R_{10}; R_2, R_4, R_6, and R_{11}; R_3, R_5, R_9, and R_{12}

See Figure 4-9.

$R_1 + R_7 + R_8 + R_{10}$ = 2.2 kΩ + 560 Ω + 470 Ω + 1.0 kΩ = **4.23 kΩ**
$R_2 + R_4 + R_6 + R_{11}$ = 4.7 kΩ + 5.6 kΩ + 3.3 kΩ + 10 kΩ = **23.6 kΩ**
$R_3 + R_5 + R_9 + R_{12}$ = 1.0 kΩ + 3.9 kΩ + 8.2 kΩ + 6.8 kΩ = **19.9 kΩ**

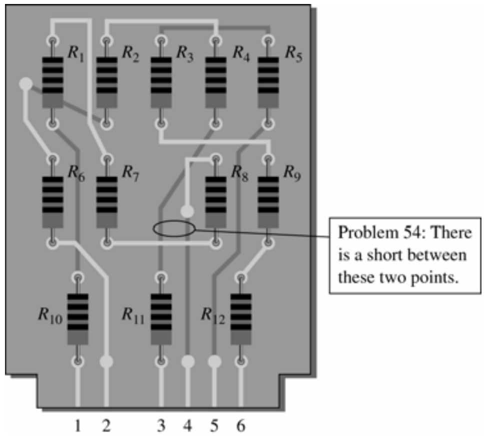

Figure 4-9

48. *Position 1:*
$R_T = R_1 + R_3 + R_5 = 510\ \Omega + 820\ \Omega + 680\ \Omega = \mathbf{2.01\ k\Omega}$

Position 2:
$R_T = R_1 + R_2 + R_3 + R_4 + R_5$
$= 510\ \Omega + 910\ \Omega + 820\ \Omega + 750\ \Omega + 680\ \Omega = \mathbf{3.67\ k\Omega}$

49. *Position A:*
$R_T = R_1 + R_2 + R_3 + R_4 = 220\ \Omega + 470\ \Omega + 510\ \Omega + 1.0\ k\Omega = 2.2\ k\Omega$

$$I = \frac{V}{R_T} = \frac{12\ V}{2.2\ k\Omega} = \mathbf{5.45\ mA}$$

Position B:
$R_T = R_2 + R_3 + R_4 = 470\ \Omega + 510\ \Omega + 1.0\ k\Omega = 1.98\ k\Omega$

$$I = \frac{V}{R_T} = \frac{12\ V}{1.98\ k\Omega} = \mathbf{6.06\ mA}$$

Position C:
$R_T = R_3 + R_4 = 510\ \Omega + 1.0\ k\Omega = 1.51\ k\Omega$

$$I = \frac{V}{R_T} = \frac{12\ V}{1.51\ k\Omega} = \mathbf{7.95\ mA}$$

Position D:
$R_T = R_4 = 1.0\ k\Omega$

$$I = \frac{V}{R_T} = \frac{12\ V}{1.0\ k\Omega} = \mathbf{12\ mA}$$

50. *Position A:*
$R_T = R_1 = 1.0\ k\Omega$

$$I = \frac{V}{R_T} = \frac{9\ V}{1.0\ k\Omega} = \mathbf{9\ mA}$$

Position B:
$R_T = R_1 + R_2 + R_5 = 1.0\text{ k}\Omega + 33\text{ k}\Omega + 22\text{ k}\Omega = 56\text{ k}\Omega$
$$I = \frac{V}{R_T} = \frac{9\text{ V}}{56\text{ k}\Omega} = \mathbf{161\ \mu A}$$

Position C:
$R_T = R_1 + R_2 + R_3 + R_4 + R_5 = 1.0\text{ k}\Omega + 33\text{ k}\Omega + 68\text{ k}\Omega + 27\text{ k}\Omega + 22\text{ k}\Omega = 151\text{ k}\Omega$
$$I = \frac{V}{R_T} = \frac{9\text{ V}}{151\text{ k}\Omega} = \mathbf{59.6\ \mu A}$$

51. First, find the value of R_5 with the switch in Position *D*.
$$6\text{ mA} = \frac{18\text{ V}}{R_5 + 1.8\text{ k}\Omega}$$
$$R_5 = \frac{18\text{ V}}{6\text{ mA}} - 1.8\text{ k}\Omega = 1.2\text{ k}\Omega$$

Position A:
$R_T = 5.38\text{ k}\Omega$ $\quad I = 18\text{ V}/5.38\text{ k}\Omega = 3.35\text{ mA}$
$V_1 = (3.35\text{ mA})(1.8\text{ k}\Omega) = \mathbf{6.03\ V}$
$V_2 = (3.35\text{ mA})(1.0\text{ k}\Omega) = \mathbf{3.35\ V}$
$V_3 = (3.35\text{ mA})(820\ \Omega) = \mathbf{2.75\ V}$
$V_4 = (3.35\text{ mA})(560\ \Omega) = \mathbf{1.88\ V}$
$V_5 = \mathbf{4\ V}$

Position B:
$R_T = 4.82\text{ k}\Omega$ $\quad I = 18\text{ V}/4.82\text{ k}\Omega = 3.73\text{ mA}$
$V_1 = (3.73\text{ mA})(1.8\text{ k}\Omega) = \mathbf{6.71\ V}$
$V_2 = (3.73\text{ mA})(1.0\text{ k}\Omega) = \mathbf{3.73\ V}$
$V_3 = (3.73\text{ mA})(820\ \Omega) = \mathbf{3.06\ V}$
$V_5 = \mathbf{4.5\ V}$

Position C:
$R_T = 4\text{ k}\Omega$ $\quad I = 18\text{ V}/4\text{ k}\Omega = 4.5\text{ mA}$
$V_1 = (4.5\text{ mA})(1.8\text{ k}\Omega) = \mathbf{8.1\ V}$
$V_2 = (4.5\text{ mA})(1.0\text{ k}\Omega) = \mathbf{4.5\ V}$
$V_5 = \mathbf{5.4\ V}$

Position D:
$R_T = 3\text{ k}\Omega$ $\quad I = 18\text{ V}/3\text{ k}\Omega = 6\text{ mA}$
$V_1 = (6\text{ mA})(1.8\text{ k}\Omega) = \mathbf{10.8\ V}$
$V_5 = \mathbf{7.2\ V}$

Note: The voltage approach can also be used.

52. See Figure 4-9. The results in the table are correct.

53. Yes, R_3 and R_5 are each shorted. Refer to Figure 4-9.

54. Yes, there is a short between the points indicated in Figure 4-9.

55. (a) R_{11} burned open due to excessive power because it had the largest value in ohms.
(b) Replace R_{11} (10 kΩ).
(c) $R_T = 47.7\ \text{k}\Omega$

$$I_{max} = \sqrt{\frac{P_{11}}{R_{11}}} = \sqrt{\frac{0.5\ \text{W}}{10\ \text{k}\Omega}} = 7.07\ \text{mA}$$

$$V_{TOTAL} = I_{max}R_T = (7.07\ \text{mA})(47.7\ \text{k}\Omega) = \mathbf{338\ V}$$

Multisim Troubleshooting Problems

56. R_1 is open.

57. R_6 is shorted.

58. R_2 is open.

59. Lamp 4 is open.

60. No fault

61. The 82 Ω resistor is shorted.

CHAPTER 5
PARALLEL CIRCUITS

BASIC PROBLEMS

SECTION 5-1 Resistors in Parallel

1. See Figure 5-1.

2. See Figure 5-2.

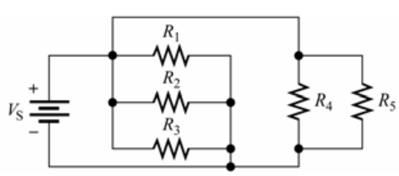

Figure 5-1

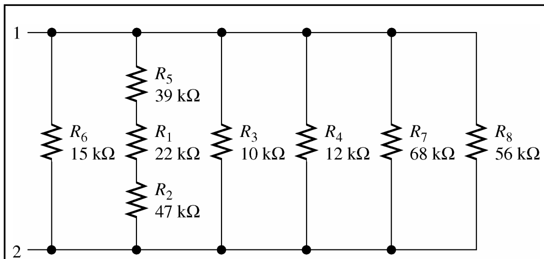

Figure 5-2

SECTION 5-2 Total Parallel Resistance

3. From Problem 2: $R_T = R_6 \parallel R_3 \parallel R_4 \parallel R_7 \parallel R_8 \parallel (R_1 + R_2 + R_5)$
$= 15\text{ k}\Omega \parallel 10\text{ k}\Omega \parallel 12\text{ k}\Omega \parallel 68\text{ k}\Omega \parallel 56\text{ k}\Omega \parallel 108\text{ k}\Omega = \mathbf{3.43\text{ k}\Omega}$

4. $$R_T = \frac{1}{\frac{1}{1.0\text{ M}\Omega}+\frac{1}{2.2\text{ M}\Omega}+\frac{1}{4.7\text{ M}\Omega}+\frac{1}{12\text{ M}\Omega}+\frac{1}{22\text{ M}\Omega}} = \mathbf{557\text{ k}\Omega}$$

5. (a) $R = 47\ \Omega \parallel 6\text{ k}\Omega =$ **25.6 Ω**
(b) $R = 560\ \Omega \parallel 1.0\text{ k}\Omega =$ **359 Ω**
(c) $R = 1.5\text{ k}\Omega \parallel 2.2\text{ k}\Omega \parallel 10\text{ k}\Omega =$ **819 Ω**
(d) $R = 1.0\text{ k}\Omega \parallel 2.2\text{ M}\Omega \parallel 1.0\text{ M}\Omega \parallel 470\text{ k}\Omega =$ **996 Ω**

6. (a) $R_T = \dfrac{R_1R_2}{R_1 + R_2} = \dfrac{(4.7\text{ k}\Omega)(2.2\text{ k}\Omega)}{4.7\text{ k}\Omega + 2.2\text{ k}\Omega} = \mathbf{1.5\ k\Omega}$

(b) $R_T = \dfrac{R_1R_2}{R_1 + R_2} = \dfrac{(27\ \Omega)(56\ \Omega)}{27\ \Omega + 56\ \Omega} = \mathbf{18.2\ \Omega}$

(c) $R_T = \dfrac{R_1R_2}{R_1 + R_2} = \dfrac{(1.5\text{ k}\Omega)(2.2\text{ k}\Omega)}{1.5\text{ k}\Omega + 2.2\text{ k}\Omega} = \mathbf{892\ \Omega}$

7. $R_T = \dfrac{22\text{ k}\Omega}{11} = \mathbf{2\ k\Omega}$

8. $R_{T1} = \dfrac{15\ \Omega}{5} = 3\ \Omega$

$R_{T2} = \dfrac{100\ \Omega}{10} = 10\ \Omega$

$R_{T3} = \dfrac{10\ \Omega}{2} = 5\ \Omega$

$R_T = \dfrac{1}{\dfrac{1}{3\ \Omega} + \dfrac{1}{10\ \Omega} + \dfrac{1}{5\ \Omega}} = \mathbf{1.58\ \Omega}$

SECTION 5-3 Voltage in a Parallel Circuit

9. $V_1 = V_2 = V_3 = V_4 = \mathbf{12\ V}$

$I_T = \dfrac{V_T}{R_T} = \dfrac{12\text{ V}}{600\ \Omega} = 20\text{ mA}$

The total current divides equally among the four equal resistors.

$I_1 = I_2 = I_3 = I_4 = \dfrac{20\text{ mA}}{4} = \mathbf{5\ mA}$

10. The resistors are all in parallel across the source. The voltmeters are each measuring the voltage across a resistor, so each meter indicates **100 V**.

SECTION 5-4 Application of Ohm’s Law

11. (a) $R_T = 33\text{ k}\Omega \parallel 33\text{ k}\Omega \parallel 33\text{ k}\Omega = 11\text{ k}\Omega$

$I_T = \dfrac{10\text{ V}}{11\text{ k}\Omega} = \mathbf{909\ \mu A}$

(b) $R_T = 1.0\ \text{k}\Omega \parallel 3.9\ \text{k}\Omega \parallel 560\ \Omega = 329\ \Omega$

$$I_T = \frac{25\ \text{V}}{329\ \Omega} = \mathbf{76\ mA}$$

12. $R_T = \dfrac{33\ \Omega}{3} = 11\ \Omega$

$$I_T = \frac{110\ \text{V}}{11\ \Omega} = \mathbf{10\ A}$$

13. (a) $R_T = 56\ \text{k}\Omega \parallel 22\ \text{k}\Omega = 15.\ 8\ \text{k}\Omega$

$$I_T = \frac{10\ \text{V}}{15.8\ \text{k}\Omega} = 633\ \mu\text{A}$$

(b) $R_T = 18\ \text{k}\Omega \parallel 100\ \text{k}\Omega = 15.3\ \text{k}\Omega$

$$I_T = \frac{8\ \text{V}}{15.3\ \text{k}\Omega} = 523\ \mu\text{A}$$

Circuit (a) has more current than circuit (b).

14. $R_T = \dfrac{V_S}{I_T} = \dfrac{5\ \text{V}}{2.5\ \text{mA}} = 2\ \text{k}\Omega$

$R_{each} = 4(2\ \text{k}\Omega) = \mathbf{8\ k\Omega}$

SECTION 5-5 Kirchhoff's Current Law

15. $I_T = 250\ \text{mA} + 300\ \text{mA} + 800\ \text{mA} = \mathbf{1350\ mA}$

16. $I_T = I_1 + I_2 + I_3 + I_4 + I_5$
$I_5 = I_T - (I_1 + I_2 + I_3 + I_4)$
$I_5 = 500\ \text{mA} - (50\ \text{mA} + 150\ \text{mA} + 25\ \text{mA} + 100\ \text{mA}) = 500\ \text{mA} - 325\ \text{mA} = \mathbf{175\ mA}$

17. $I_{2-3} = I_T - (I_1 + I_4) = 50\ \text{mA} - 35\ \text{mA} = 15\ \text{mA}$
$I_2 = I_3 = \mathbf{7.5\ mA}$
See Figure 5-3.

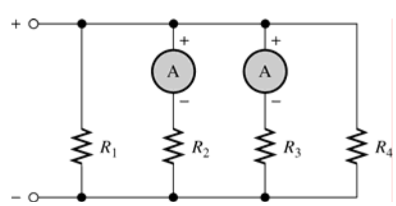

Figure 5-3