Chapter 4

1. $V = IR$ = (5.6 mA)(220 Ω) = **1.23 V**

2. $I = \dfrac{V}{R} = \dfrac{24\text{ V}}{2.2\text{ k}\Omega}$ = **10.91 mA**

3. $R = \dfrac{V}{I} = \dfrac{24\text{ V}}{1.5\text{ mA}}$ = **16 kΩ**

4. $I = \dfrac{V}{R} = \dfrac{12\text{ V}}{40\times10^{-3}\ \Omega}$ = **300 A**

5. $V = IR$ = (3.6 μA)(100 kΩ) = 0.36 V = **360 mV**

6. $I = \dfrac{V}{R} = \dfrac{120\text{ V}}{50\text{ k}\Omega}$ = **2.4 mA**

7. $R = \dfrac{V}{I} = \dfrac{120\text{ V}}{2.2\text{ A}}$ = **54.55 Ω**

8. $I = \dfrac{V}{R} = \dfrac{120\text{ V}}{8\text{ k}\Omega}$ = **15 mA**

9. $R = \dfrac{V}{I} = \dfrac{120\text{ V}}{4.2\text{ A}}$ = **28.57 Ω**

10. $R = \dfrac{V}{I} = \dfrac{4.5\text{ V}}{80\text{ mA}}$ = **56.25 Ω**

11. $R = \dfrac{V}{I} = \dfrac{24\text{ mV}}{20\,\mu\text{A}}$ = **1.2 kΩ**

12. $V = IR$ = (12 A)(0.5 Ω) = **6 V**

13. a. $R = \dfrac{V}{I} = \dfrac{120\text{ V}}{9.5\text{ A}}$ = **12.63 Ω**

b. $t = 2\text{ h}\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right]$ = 7200 s

$W = Pt = VIt$
= (120 V)(9.5 A)(7200 s)
= $\mathbf{8.21\times10^{6}\ J}$

14. $V = IR$ = (5.6 mA)(3.3 MΩ) = **18.48 V**

15. –

16. –

17. –

18. –

19. –

20. $P = \dfrac{W}{t} = \dfrac{540\text{ J}}{3.6\text{ min}\left[\dfrac{60\text{ s}}{1\text{ min}}\right]} = \dfrac{540\text{ J}}{216\text{ s}} = \mathbf{2.5\text{ W}}$

21. $t = \dfrac{W}{P} = \dfrac{640\text{ J}}{40\text{ J/s}} = \mathbf{16\text{ s}}$

22. a. $8\text{ h}\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right] = 28{,}800\text{ s}$

$W = Pt = (8\text{ W})(28{,}000\text{ s}) = \mathbf{224\text{ kJ}}$

b. $\text{kWh} = \dfrac{(8\text{ W})(8\text{ h})}{1000} = \mathbf{64 \times 10^{-3}\text{ kWh}}$

23. $P = VI = (3\text{ V})(1.4\text{ A}) = 4.20\text{ W}$

$t = \dfrac{W}{P} = \dfrac{12\text{ J}}{4.2\text{ W}} = \mathbf{2.86\text{ s}}$

24. $P = EI = (12\text{ V})(40\text{ A}) = \mathbf{480\text{ W}}$

25. $P = I^2R = (7.2\text{ mA})^2\ 4\text{ k}\Omega = \mathbf{207.36\text{ mW}}$

26. $P = I^2R \Rightarrow I = \sqrt{\dfrac{P}{R}} = \sqrt{\dfrac{240\text{ mW}}{2.2\text{ k}\Omega}} = \mathbf{10.44\text{ mA}}$

27. $I = \sqrt{\dfrac{P}{R}} = \sqrt{\dfrac{2\text{ W}}{82\ \Omega}} = \mathbf{156.17\text{ mA}}$

$V = IR = (156.17\text{ mA})(82\ \Omega) = \mathbf{12.81\text{ V}}$

28. $I = \dfrac{E}{R} = \dfrac{22\text{ V}}{16.8\text{ k}\Omega} = \mathbf{1.31\text{ mA}}$

$P = I^2R = (1.31\text{ mA})^2\ 16.8\text{ k}\Omega = \mathbf{28.83\text{ mW}}$

$W = Pt = (28.83\text{ mW})\left(1\text{ h}\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right]\right) = \mathbf{103.79\text{ J}}$

29. $E = \dfrac{P}{I} = \dfrac{10\text{ kW}}{48\text{ A}} = \mathbf{208.33\text{ V}}$

30. $I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1\text{ W}}{4.7\text{ M}\Omega}}$ = **461.27 μA**

no

31. $V = \sqrt{PR} = \sqrt{(42\text{ mW})(2.2\text{ k}\Omega)} = \sqrt{92.40}$ = **9.61 V**

32. $P = VI$, $I = \frac{P}{V} = \frac{100\text{ W}}{120\text{ V}}$ = 0.833 A

$R = \frac{V}{I} = \frac{120\text{ V}}{0.833\text{ A}}$ = **144.06 Ω**

33. $V = \frac{P}{I} = \frac{450\text{ W}}{3.75\text{ A}}$ = **120 V**

$R = \frac{V}{I} = \frac{120\text{ V}}{3.75\text{ A}}$ = **32 Ω**

34. a. $P = EI$ and $I = \frac{P}{E} = \frac{0.4\times10^{-3}\text{ W}}{3\text{ V}}$ = **0.13 mA**

b. Ah rating = (0.13 mA)(500 h) = **66.5 mAh**

35. $I = \sqrt{\frac{P}{R}} = \sqrt{\frac{100\text{ W}}{20\text{ k}\Omega}} = \sqrt{5\times10^{-3}}$ = **70.71 mA**

$V = \sqrt{PR} = \sqrt{(100\text{ W})(20\text{ k}\Omega)}$ = **1.42 kV**

36. $P = EI$ = (240 V)(30 A) = 7.2 kW

$P_{HP} = \frac{7.2\text{ kW}}{746\text{ W/HP}}$ = **9.65 hP**

37. a. $W = Pt = \left(\frac{V^2}{R}\right)t = \left(\frac{12\text{ V}}{10\ \Omega}\right)^2 60\text{ s}$ = **86.4 J**

b. Energy doubles, power the same

38. $W = Pt \Rightarrow t = \frac{W}{P} = \frac{12\times10^3\ \cancel{\text{W}}\text{h}}{1500\ \cancel{\text{W}}}$ = **8 h**

39. $\frac{12\text{ h}}{\cancel{\text{week}}}\left[\frac{4\frac{1}{3}\cancel{\text{weeks}}}{1\ \cancel{\text{month}}}\right][5\text{ months}]$ = 260 h

$\text{kWh} = \frac{(230\text{ W})(260\text{ h})}{1000}$ = **59.80 kWh**

40. a. $W = Pt = (60\text{ W})(10\cancel{\text{ h}})\left(\frac{60\cancel{\text{ min}}}{1\cancel{\text{ h}}}\right)\left(\frac{60\text{ s}}{1\cancel{\text{ min}}}\right) = \mathbf{2.16 \times 10^6\ Ws}$

b. $1\text{ Ws} = 1\text{ J} \therefore \mathbf{2.16 \times 10^6\ J}$

c. $W = Pt = (60\text{ W})(10\text{ h}) = \mathbf{600\ Wh}$

d. $\frac{600\text{ Wh}}{1000\text{ W/1 kWh}} = \mathbf{0.6\ kWh}$

e. $\text{Cost} = (0.6\text{ kWh})(12\text{ ¢/kWh}) = \mathbf{7.2\ ¢}$

41. a. $\text{kWh} = \frac{Pt}{1000} \Rightarrow P = \frac{(1000)(\text{kWh})}{P} = \frac{(1000)(1200\text{ kWh})}{10\text{ h}} = \mathbf{120\ kW}$

b. $I = \frac{P}{E} = \frac{120 \times 10^3\text{ Wh}}{240\text{ V}} = \mathbf{500\ A}$

c. $P_{\text{lost}} = P_i - P_o = P_i - \eta P_i = P_i(1 - \eta) = 120\text{ kW}(1 - 0.76) = 28.8\text{ kW}$

$\text{kWh}_{\text{lost}} = \frac{Pt}{1000} = \frac{(28.8\text{ kW})(10\text{ h})}{1000} = \mathbf{288\ kWh}$

42. $\#\text{kWh} = \frac{\$1.00}{12¢} = 8.33$

$\text{kWh} = \frac{Pt}{1000} \Rightarrow t = \frac{(\text{kWh})(1000)}{P} = \frac{(8.33)(1000)}{250\text{ W}} = \mathbf{33.32\ h}$

43. a. $\frac{\$120}{30\text{ days}} = \mathbf{\$4/day}$

b. $\frac{\$4\text{ / day}}{15\text{ h/day}} = \mathbf{26.7¢/h}$

c. $\frac{26.7¢/\text{h}}{12¢/\text{kWh}} = \mathbf{2.23\ kW}$

d. $\frac{2.23\text{ kW}}{60\text{ W}} = 37.17 \cong \mathbf{37\ bulbs}$

e. no

44. $\frac{\$1.00}{12¢/\text{kWh}} = 8.33\text{ kWh}$

$\frac{8.33\text{ kWh}}{187\text{ W}} = \mathbf{44.55\ h}$

45. t = 5 h/day(365 days) = 1825 h

$$\text{kWh} = \frac{P \cdot t}{1000} = \frac{(339\text{ W})(1825\text{ h})}{1000} = 618.68\text{ kWh}$$

Cost = (618.68 kWh)(12¢/kWh) = \$74.24

$$\text{kWh} = \frac{P \cdot t}{1000} = \frac{(213\text{ W})(1825\text{ h})}{1000} = 388.73\text{ kWh}$$

Cost = (388.73 kWh)(12¢/kWh) = \$46.65

Cost Savings = \$74.24 − \$46.65 = **\$27.59**

46. $$\text{kWh} = \frac{P \cdot t}{1000} = \frac{(78\text{ W})(4\text{ h/day})(31\text{ days})}{1000} = 9.67\text{ kWh}$$

Cost = (12¢/kWh)(9.67 kWh) = **\$1.16**

47. a. $P = EI$ = (120 V)(100 A) = **12 kW**

b. P_T = 2(250 W) + 3000 W + (10)(60W) + 2400 W + 2 kW + 1000 W = 9.5 kW

Yes, 12 kW > 9.5 kW

c. $W = Pt$ = (9.5 kW)(2 h) = **19 kWh**

48. $$\text{kWh} = \frac{(1600\text{ W})(8\text{ h}) + (1200\text{ W})(1/3\text{ h}) + (4800\text{ W})(1\text{ h}) + (900\text{ W})(1/4\text{ h}) + (200\text{ W})(1.2\text{ h}) + (50\text{ W})(3.5\text{ h})}{1000}$$

$$= \frac{12{,}800\text{ Wh} + 400\text{ Wh} + 4800\text{ Wh} + 225\text{ Wh} + 240\text{ Wh} + 175\text{ Wh}}{1000} = 18.64\text{ kWh}$$

(18.64 kWh)(12¢/kWh) = \$**2.24**

49. $$\text{kWh} = \frac{(200\text{W})(4\text{ h}) + (6)(60\text{ W})(6\text{ h}) + (1200\text{ W})(0.5\text{ h}) + (175\text{ W})(3.5\text{ h}) + (250\text{ W})\left(4\frac{1}{3}\text{ h}\right) + (30\text{ W})(8\text{ h})}{1000}$$

$$= \frac{800\text{ Wh} + 2160\text{ Wh} + 600\text{ Wh} + 612.5\text{ Wh} + 1083.32\text{ Wh} + 240\text{ Wh}}{1000} = \mathbf{5.496\text{ kWh}}$$

(5.496 kWh)(12¢/kWh) = **65.95¢**

50. $$\eta = \frac{P_o}{P_i} \times 100\% = \frac{(0.5\ \cancel{\text{hp}})\left[\frac{746\text{ W}}{\cancel{\text{hp}}}\right]}{410\text{ W}} \times 100\% = \frac{373}{410} \times 100\% = 90.98\%$$

51. $$\eta = \frac{P_o}{P_i},\ P_i = \frac{P_o}{\eta} = \frac{(1.8\ \cancel{\text{hp}})(746\text{ W}/\cancel{\text{hp}})}{0.72} = 1865\text{ W}$$

$$P_i = EI,\ I = \frac{P_i}{E} = \frac{1865\text{ W}}{120\text{ V}} = \mathbf{15.54\text{ A}}$$

52. $$\eta = \frac{P_o}{P_i} \times 100\% = \frac{(0.81\text{ hp})(746\text{ W/hp})}{(4\text{ A})(220\text{V})} \times 100\% = \frac{686.65}{880} \times 100\% = \mathbf{78.03\%}$$

53. a. $P_i = EI = (120\text{ V})(1.8\text{ A}) = 216\text{ W}$

$P_i = P_o + P_{\text{lost}},\ P_{\text{lost}} = P_i - P_o = 216\text{ W} - 50\text{ W} =$ **166 W**

b. $\eta\% = \dfrac{P_o}{P_i} \times 100\% = \dfrac{50\text{ W}}{216\text{ W}} \times 100\% =$ **23.15%**

54. $P_i = EI = \dfrac{P_o}{\eta} \Rightarrow I = \dfrac{P_o}{\eta E} = \dfrac{(3.6\,\cancel{\text{hp}})(746\text{ W}/\cancel{\text{hp}})}{(0.76)(240\text{ V})} =$ **14.72 A**

55. a. $P_i = \dfrac{P_o}{\eta} = \dfrac{(2\,\cancel{\text{hp}})(746\text{ W}/\cancel{\text{hp}})}{0.9} =$ **1657.78 W**

b. $P_i = EI = 1657.78\text{ W}$

$(110\text{ V})I = 1657.78\text{ W}$

$I = \dfrac{1657.78\text{ W}}{120\text{ V}} =$ **13.81 A**

c. $P_i = \dfrac{P_o}{\eta} = \dfrac{(2\,\cancel{\text{hp}})(746\text{ W}/\cancel{\text{hp}})}{0.7} = 2131.43\text{ W}$

$P_i = EI = 2131.43\text{ W}$

$(120\text{ V})I = 2131.43\text{ W}$

$I = \dfrac{2131.43\text{ W}}{120\text{ V}} =$ **17.76 A**

56. $P_i = \dfrac{P_o}{\eta} = \dfrac{(15\,\cancel{\text{hp}})(746\text{ W}/\cancel{\text{hp}})}{(0.84)} = 13{,}321\text{ W}$

$I = \dfrac{P_i}{E} = \dfrac{13{,}321\text{ W}}{240\text{ V}} =$ **55.5 A**

57. $\eta_T = \eta_1 \cdot \eta_2$

$0.75 = 0.85 \times \eta_2$

$\eta_2 = 0.88,\ \eta_2 =$ **88%**

58. $\eta_T = \eta_1 \cdot \eta_2 = (0.87)(0.75) = 0.6525 \Rightarrow$ **65.25%**

59. $\eta_T = \eta_1 \cdot \eta_2 = 0.78 = 0.9\eta_2$

$\eta_2 = \dfrac{0.78}{0.9} = 0.867 \Rightarrow$ **86.7%**

60. a. $\eta_T = \eta_1 \cdot \eta_2 \cdot \eta_3 = (0.93)(0.87)(0.21) = 0.170 \Rightarrow$ **17%**

b. $\eta_T = \eta_1 \cdot \eta_2 \cdot \eta_3 = (0.93)(0.87)(0.80) = 0.647 \Rightarrow$ **64.7%**

$$\frac{64.7\% - 17\%}{17\%} \times 100\% = \textbf{280.59\%}$$

61. $$\eta_T = \frac{P_o}{P_i} = \eta_1 \cdot \eta_2 = \eta_1 \cdot 2\eta_1 = 2\eta_1^2$$

$$\eta_1^2 = \frac{P_o}{2P_i} \Rightarrow \eta_1 = \sqrt{\frac{P_o}{2P_i}} = \sqrt{\frac{128\text{ W}}{2(400\text{ W})}} = 0.4$$

$\eta_2 = 2\eta_1 = 2(0.4) = 0.8$

$\therefore$ $\eta_2 =$ **40%**, $\eta_2 =$ **80%**