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Chapter

1

Introduction

1.3 Converting Units

1\. a. $27\ \cancel{\text{min}} \times (60\ \text{s}/\cancel{\text{min}}) = 1620\ \text{s}$

b. $0.8\ \cancel{\text{h}} \times (3600\ \text{s}/\cancel{\text{h}}) = 2880\ \text{s}$

c. $\left(2\cancel{\text{h}} \times \frac{3600\ \text{s}}{\cancel{\text{h}}}\right) + \left(3\ \cancel{\text{min}} \times \frac{60\ \text{s}}{\cancel{\text{min}}}\right) + 47\ \text{s} = 7427\ \text{s}$

d. $35\ \cancel{\text{hp}} \times (746\ \text{W}/\cancel{\text{hp}}) = 26\,110\ \text{W}$

e. $1827\ \cancel{\text{W}} \times \frac{1\ \text{hp}}{746\ \cancel{\text{W}}} = 2.45\ \text{hp}$

f. $23\ \cancel{\text{rev}}. \times 360^\circ/\cancel{\text{rev}} = 8280^\circ$

3\. a. $1.2\ \text{m} \times 70\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}} = 0.84\ \text{m}^2$

b. $\frac{1}{2}\left(25\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right)(0.5\ \text{m}) = 0.0625\ \text{m}^2$

c. $\left(10\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right)\left(25\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right)$
$\left(80\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right) = 0.02\ \text{m}^3$

d. $\frac{4\pi}{3}\left(10\ \cancel{\text{in}} \times \frac{2.54\ \cancel{\text{cm}}}{\cancel{\text{in}}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right)^3 = 0.0686\ \text{m}^3$

5\. $\frac{15\ \text{parts}}{12\ \cancel{\text{s}}} \times \frac{3600\ \cancel{\text{s}}}{\text{h}} = 4500\ \text{parts/h}$

7\. $\frac{27\ \cancel{\text{mi}}}{\cancel{\text{gal}}} \times \frac{1.609\ \text{km}}{\cancel{\text{mi}}} \times \frac{1\ \cancel{\text{gal}}}{3.785\ \text{liters}} = 11.5\ \text{km/liter}$

9\. $\frac{18\cancel{^\circ}}{0.02\ \cancel{\text{s}}} \times \frac{1\ \text{rev}}{360\cancel{^\circ}} \times \frac{60\ \cancel{\text{s}}}{1\ \text{min}} = 150\ \text{rpm}$

11\. $\frac{60\ \text{mi}}{\cancel{\text{h}}} \times 500\ \cancel{\text{s}} \times \frac{1\ \cancel{\text{h}}}{3600\ \cancel{\text{s}}} = 8.33\ \text{mi}$

13\. $\frac{2000\ \cancel{\text{yd}}}{\cancel{\text{h}}} \times \frac{0.914\ \text{m}}{\cancel{\text{yd}}} \times \frac{1\ \cancel{\text{h}}}{3600\ \text{s}} = 0.508\ \text{m/s}$

15\. $\frac{3\ \text{km}}{\text{h}} \times \frac{8}{60}\ \text{h} + \frac{5\ \text{km}}{\text{h}} \times 1.25\ \text{h} + \frac{4\ \text{km}}{\text{h}} \times \frac{12}{60}\ \text{h} = 7.45\ \text{km}$

17\. $\frac{2\ \text{km}}{\text{h}} \times \frac{15}{60}\ \text{h} + \frac{5\ \text{km}}{\text{h}} + \frac{18\ \text{h}}{60}\ \text{h} + \frac{2.5\ \text{km}}{\text{h}} \times t_3 = 2.85\text{km}$

Thus, $t_3 = 0.34\text{h} = 20.4$ minutes.

19\. Machine 1: $\frac{\$0.43}{\text{min}} \times \frac{60\ \text{min}}{\text{h}} = \$25.80/\text{h}$

Machine 2: $\frac{\$200}{8\ \text{h}} = \$25.00/\text{h}$ (This one is cheaper to operate. Buy it.)

1.4 Power of Ten Notation

21\. a. 8.675×10^3

b. 8.72×10^{-3}

c. 1.24×10^3

d. 3.72×10^{-1}

e. 3.48×10^2

f. 2.15×10^{-7}

g. 1.47×10^1

23\. a. $\frac{1.25 \times 10^2}{1 \times 10^3} = 1.25 \times 10^{-1}$

b. $\frac{8 \times 10^4}{1 \times 10^{-3}} = 8 \times 10^7$

c. $\frac{3 \times 10^4}{1.5 \times 10^6} = 2 \times 10^4 \times 10^{-6} = 2 \times 10^{-2}$

d. $\frac{(16)(21.8) \times 10^{-7} \times 10^6}{(14.2)(12) \times 10^{-5}} = 2.05 \times 10^4$

25\. a. $(4 \times 10^3)(5 \times 10^{-2})^2 = (4 \times 10^3)(25 \times 10^{-4})$
$= 100 \times 10^{-1} = 10$

b. $(4 \times 10^3)(-5 \times 10^{-2})^2 = (4 \times 10^3)(25 \times 10^{-4}) = 10$

c. $\frac{(6 \times 10)^2}{(10 \times 10^{-1})} = \frac{36 \times 10^2}{1} = 3.6 \times 10^3$

d. $\frac{(50)^{-2}(2.5 \times 10^6)(6 \times 10^3)}{(1 \times 10^3)(2 \times 10^{-1})^2} = \frac{(2.5)(6) \times 10^6 \times 10^3}{(5 \times 10)^2(1 \times 10^3)(4 \times 10^{-2})}$

$= \frac{15 \times 10^9}{25 \times 10^2 \times 10^3 \times 4 \times 10^{-2}} = \frac{15 \times 10^9}{100 \times 10^3}$
$= 0.15 \times 10^6 = 15 \times 10^4$

e. $\frac{(-0.027)^{1/3}(-0.2)^2}{(24)^\circ \times 10^{-3}} = \frac{(-0.3)(-2 \times 10^{-1})^2}{1 \times 10^{-3}}$
$= \frac{(-0.3)(4 \times 10^{-2})}{1 \times 10^{-3}} = -12$

27\. i. $(8.42 \times 10^2)(1.4 \times 10^{-3}) = 11.79 \times 10^{-1} = 1.179$

ii. $\dfrac{3.52 \times 10^{-2}}{7.91 \times 10^{-3}} = 0.445 \times 10^1 = 4.45$

Direct computation for these examples is less work.

29\. 6.24×10^{18}

31\. $\dfrac{6.24 \times 10^{18} \text{ electrons}}{1 \text{ s}} \times 10.03 \times 10^3 \text{ s}$

$= 62.6 \times 10^{21}$ electrons

33\. $t = \dfrac{3.47 \times 10^5 \text{ km}}{299\ 792.458 \text{ km/s}} = 1.16 \text{ s}$

35\. $\dfrac{3.73 \times 10^4 \text{ m}^3}{1 \text{ s}} \times \dfrac{3600 \text{ s}}{1 \text{ h}} \times \dfrac{1 \text{ liter}}{1 \times 10^{-3} \text{ m}^3}$

$= 13.4 \times 10^{10}$ liters/h

1.5 Prefixes

37\. a. kilo, k

b. mega, M

c. giga, G

d. micro, μ

e. milli, m

f. pico, p

39\. a. 1.5 ms

b. 27 μs

c. 350 ns

41\. a. 150×10^3 V; 0.15×10^6 V

b. 0.33×10^{-3} W; 33×10^{-5} W

43\. a. 330 V + 150 V + 200 V = 680 V

b. 60 W + 100 W + 2.7 W = 162.7 W

45\. $1500 \text{ W} = 1.5 \times 10^3 \text{ W} = 1.5 \text{ kW}$

47\. $I_3 = I_1 + I_2 + I_4 = 12 \text{ A} + 150 \text{ A} + 25 \text{ A} = 187 \text{ A}$

49\. $39 \text{ mmfd} = 39\mu\mu\text{F} = 39 \times 10^{-6} \times 10^{-6} = 39 \times 10^{-12}\text{F}$

$= 39$ pF

51\. Radio signal: $t = \dfrac{5000 \text{ km}}{299\ 792.458 \text{ km/s}} = 16.68 \text{ ms}$

Telephone signal: $t = \dfrac{5000 \times 10^3 \text{ m}}{150 \text{ m}/\mu\text{s}} = 33.33 \text{ ms}$

$\therefore$ Radio signal arrives first by 16.65 ms.

53\. a. $R = \dfrac{V}{I} = \dfrac{50 \text{ V}}{24 \text{ mA}} = 2.083 \text{ k}\Omega$. (Since V and I are specified as exact, you can use as many digits as you like.)

b. $R_{\text{max}} = \dfrac{V_{\text{max}}}{I_{\text{min}}} = \dfrac{50.1 \text{ V}}{23.9 \text{ mA}} = 2.096 \text{ k}\Omega = 2.10 \text{ k}\Omega$

when rounded to 3 digits

$R_{\text{min}} = \dfrac{V_{\text{min}}}{I_{\text{max}}} = \dfrac{49.9 \text{ V}}{24.1 \text{ mA}} = 2.071 \text{ k}\Omega = 2.07 \text{ k}\Omega$

when rounded to 3 digits.

The actual value of R lies somewhere between 2.07 kΩ and 2.10 kΩ.

55\. See CD in the back of the book.

1.6 Circuit Diagrams

57\. Same as Figure 1–7(a) of the text.

Chapter

2

Voltage and Current

2.1 Atomic Theory

1. There are of the order of 10^{23} free electrons per cm^3 at room temperature in copper.

   a. $1\ m^3 = (100\ cm)^3 = 10^6\ cm^3$. Thus, the number of electrons is

   $$N = \frac{10^{23}\ \text{electrons}}{\cancel{cm}^3} \times 10^6\ \cancel{cm}^3 = 10^{29}\ \text{electrons}$$

   b. Volume =

   $$\frac{\pi d^2}{4} \times l = \frac{\pi}{4}(0.163\ cm)^2(500\ cm) = 10.4\ cm^3$$

   $$N = \frac{10^{23}\ \text{electrons}}{\cancel{cm}^3} \times 10.4\ \cancel{cm}^3$$

   $= 10.4 \times 10^{23}$ electrons

3. Original: $F_1 = k\dfrac{Q_1Q_2}{r_1^2}$

   New: $F_2 = \dfrac{k(2Q_1)(3Q_2)}{\left(\dfrac{r_1}{2}\right)^2} = \dfrac{(2)(3)}{\left(\dfrac{1}{2}\right)^2}\left[k\dfrac{Q_1Q_2}{r_1^2}\right] = 24\ F_1$

   $\therefore$ Force increases by a factor of 24.

5. a. It has a lot of free electrons. This results from having few (e.g., 1) electrons in its valence shell

   b. Inexpensive and easily formed into wires.

   c. Has a full valence shell. Therefore, no free electrons.

   d. The electrical force is so great that electrons are torn from their parent atoms. This movement of electrons constitutes a current. We see the effect as a lightning discharge.

2.2 The Unit of Electrical Charge: The Coulomb

7. a. $F = \dfrac{9 \times 10^9(1 \times 10^{-6}\ C)(7 \times 10^{-6}\ C)}{(10 \times 10^{-3})^2}$

   = 630 N (repulsive)

   b. $F = \dfrac{9 \times 10^9(8 \times 10^{-6})(4 \times 10^{-6})}{(0.12)^2}$

   = 20 N (attractive)

   c. $F = \dfrac{9 \times 10^9(1.602 \times 10^{-19})^2}{(12 \times 10^{-8})^2}$

   $= 1.60 \times 10^{-14}$ N (replusive)

   d. $F = \dfrac{9 \times 10^9(1.602 \times 10^{-19})^2}{(5.3 \times 10^{-11})^2}$

   $= 8.22 \times 10^{-8}$ N (attractive)

   e. Neutron is uncharged $\therefore F = 0$

9. $180\ N = \dfrac{9 \times 10^9(4 \times 10^{-6})Q_2}{(2 \times 10^{-2})^2}$ $\therefore Q_2 = 2\mu C$ (Attractive)

11. $0.02\ N = \dfrac{9 \times 10^9 Q_1(5\ Q_1)}{(0.5)^2}$

    $0.02 = 180 \times 10^9\ Q_1^2$

    $\therefore Q_1 = 0.333\ \mu C$ and $Q_2 = 1.67\ \mu C$, both (+) or both (–).

13. 19×10^{13} ~~electron~~ $\times 1.6 \times 10^{-19}$ coulomb/~~electron~~ $= 30.4\ \mu C$

15. $Q_1 = -(14.6 \times 10^{13} \times 1.60 \times 10^{-19}) = -23.4\ \mu C$

    $Q_2 = 1.3\ \mu C$

    $Q_{final} = Q_{initial} + Q_1 + Q_2$

    $5.6\ \mu C = Q_{initial} - 23.4\ \mu C + 1.3\ \mu C$

    $\therefore Q_{initial} = 27.7\ \mu C$ (positive)

2.3 Voltage

17. $V = \dfrac{W}{Q} = \dfrac{360\ J}{15\ C} = 24\ V$

19. $V = \dfrac{W}{Q} = \dfrac{1200\ J}{0.5\ C} = 2400\ V$

21. $W = QV = (0.5 \times 10^{-6}\ C)(8.5 \times 10^3\ V) = 4.25\ mJ$

23. $Q = \dfrac{W}{V} = \dfrac{57\ J}{12\ V} = 4.75\ C$

2.4 Current

25. $I = \frac{Q}{t} = \frac{250\ \mu C}{5\ ms} = 50\ mA$

27. $Q = It = (16.7\ mA)(20\ ms) = 334\ \mu C$

29. $Q = (93.6 \times 10^{12})(1.6 \times 10^{-19}) = 15\ \mu C$

$I = \frac{Q}{t} = \frac{15 \times 10^{-6}\ C}{5 \times 10^{-3}\ s} = 3\ mA$

31. At $t = 0$, $q_0 = 20$ C. At $t = 1$ s, $q_1 = 100$ C.

$I = \frac{\Delta q}{\Delta t} = \frac{100\ C - 20\ C}{1\ s} = \frac{80\ C}{1\ s} = 80\ C/s = 80\ A$

33. $Q = \frac{47 \times 10^{19}\ \text{electrons}}{6.24 \times 10^{18}\ \text{electrons/C}} = 75.3\ C$

$V = \frac{W}{Q} = \frac{1353.6\ J}{75.3} = 18.0\ V$

$I = \frac{Q}{t} = \frac{75.3\ C}{78\ s} = 0.966\ A$

.

2.5 Practical DC Sources

35. a. $E_T = 1.47 + 1.61 + 1.58 = 4.66$ V
    b. $E_T = 1.47 + 1.61 - 1.58 = 1.50$ V

37. $\text{Life} = \frac{\text{capacity}}{\text{drain}} = \frac{1400\ mAh}{28\ mA} = 50\ h$

39. From Figure 2-15, capacity at 5˚C is 90% of its value MAX at 25˚C. Therefore, capacity = 0.9 Max = 81 Ah. Thus, Max = 81/0.9 = 90 Ah. At –15˚C, capacity = 0.65 Max = 0.65 (90) = 58.5 Ah. Thus, life ≈ 58.5 Ah/5 A = 11.7 h.

2.6 Measuring Voltage and Current

41. Both

43. The voltmeter and ammeter are interchanged.

45. Meter 1: Reading is 7 A, Meter 2: Reading is –7 A

2.7 Switches, Fuses, and Circuit Breakers

47. When a fuse "blows," it becomes an open circuit with source voltage across it. The voltage rating tells you how much voltage you can use the fuse with so that it does not arc over when it blows.