Chapter 1

1. –

2. –

3. –

4. $10 \text{ min} \left[\frac{1 \text{ h}}{60 \text{ min}}\right] = \mathbf{0.167 \text{ h}}$

$$v = \frac{d}{t} = \frac{30.5 \text{ mi}}{1.167 \text{ h}} = \mathbf{26.14 \text{ mph}}$$

5. a. mph = (0.6)(160 km/h) = **96 mph**
b. km/h = (1.7)(70 mph) = **119 km/h**

6. $100 \text{ yds} \left[\frac{3 \text{ ft}}{1 \text{ yd}}\right] \left[\frac{1 \text{ mi}}{5{,}280 \text{ ft}}\right] = 0.0568 \text{ mi}$

$$\frac{60 \text{ mi}}{\text{h}} \left[\frac{1 \text{ h}}{60 \text{ min}}\right] \left[\frac{1 \text{ min}}{60 \text{ s}}\right] = 0.0167 \text{ mi/s}$$

$$t = \frac{d}{v} = \frac{0.0568 \text{ mi}}{0.0167 \text{ mi/s}} = \mathbf{3.40 \text{ s}}$$

7. a. $\frac{95 \text{ mi}}{\text{h}} \left[\frac{5{,}280 \text{ ft}}{\text{mi}}\right] \left[\frac{1 \text{ h}}{60 \text{ min}}\right] \left[\frac{1 \text{ min}}{60 \text{ s}}\right] = \mathbf{139.33 \text{ ft/s}}$

b. $t = \frac{d}{v} = \frac{60 \text{ ft}}{139.33 \text{ ft/s}} = \mathbf{0.43 \text{ s}}$

c. $v = \frac{d}{t} = \frac{60 \text{ ft}}{1 \text{ s}} \left[\frac{60 \text{ s}}{1 \text{ min}}\right] \left[\frac{60 \text{ min}}{1 \text{ h}}\right] \left[\frac{1 \text{ mi}}{5{,}280 \text{ ft}}\right] = \mathbf{40.91 \text{ mph}}$

8. –

9. –

10. –

11. MKS, CGS, $°C = \frac{5}{9}(°F - 32) = \frac{5}{9}(68 - 32) = \frac{5}{9}(36) = \mathbf{20°}$
SI: K = 273.15 + °C = 273.15 + 20 = **293.15**

12. $1000 \text{ J} \left[\frac{0.7378 \text{ ft - lb}}{1 \text{ J}}\right] = \mathbf{737.8 \text{ ft-lbs}}$

13. a. $70.8 \cancel{kg}\left[\frac{2.2 \text{ lbs}}{\cancel{kg}}\right] =$ **155.76 lbs**

b. $145 \cancel{lbs}\left[\frac{1 \text{ kg}}{2.2 \cancel{lbs}}\right] =$ **65.91 kg**

c. $6 \cancel{ft}\left[\frac{12 \cancel{in.}}{\cancel{ft}}\right]\left[\frac{2.54 \text{ cm}}{1 \cancel{in.}}\right] =$ **182.88 cm**

d. $179.9 \cancel{cm}\left[\frac{1 \cancel{in.}}{2.54 \cancel{cm}}\right]\left[\frac{1 \text{ ft}}{12 \cancel{in.}}\right] =$ **5.9 ft = 5 ft 10.8 in.**

14. a. °F = 2(°C) + 30° = 40° + 30° = **70°**

b. $°F = \frac{9}{5}(°C) + 32° = \frac{9}{5}(20°) + 32° =$ **68°**

c. very close

d. 30°C → **90°F vs. 86°F**
5°C → **40°F vs 41°F**

15. a. **14.6** b. **56.0**
c. **1,046.1** d. $\frac{1}{16} = 0.0625 =$ **0.1**
e. 3.14159 = **3.1**

16. a. **14.60** b. **56.04**
c. **1,046.06** d. $\frac{1}{16} = 0.0625 =$ **0.06**
e. 3.14159 = **3.14**

17. a. **14.603** b. **56.042**
c. 1,046.060 d. $\frac{1}{16} = 0.0625 =$ **0.063**
e. 3.14159 = **3.142**

18. a. $\mathbf{10^4}$ b. $\mathbf{10^6}$ c. $\mathbf{10^3}$ d. $\mathbf{10^{-3}}$
e. $\mathbf{10^0}$ f. $\mathbf{10^{-1}}$

19. a. $\mathbf{15 \times 10^3}$ b. $\mathbf{5 \times 10^{-3}}$ c. $\mathbf{2.4 \times 10^6}$ d. $\mathbf{60 \times 10^3}$
e. $\mathbf{4.02 \times 10^{-4}}$ f. $\mathbf{2 \times 10^{-10}}$

20. a. $4.2 \times 10^3 + 48.0 \times 10^3 = 52.2 \times 10^3 =$ $\mathbf{5.22 \times 10^4}$
b. $90 \times 10^3 + 360 \times 10^3 = 450 \times 10^3 =$ $\mathbf{4.50 \times 10^5}$
c. $50 \times 10^{-5} - 6 \times 10^{-5} = 44 \times 10^{-5} =$ $\mathbf{4.40 \times 10^{-4}}$
d. $1.2 \times 10^3 + 0.05 \times 10^3 - 0.4 \times 10^3 = 0.85 \times 10^3 =$ **850**

21. a. $(10^2)(10^3) = 10^5 = \mathbf{100 \times 10^3}$
b. $(10^{-2})(10^3) = 10^1 = \mathbf{10}$
c. $(10^3)(10^6) = \mathbf{1 \times 10^9}$
d. $(10^2)(10^{-5}) = \mathbf{1 \times 10^{-3}}$
e. $(10^{-6})(10 \times 10^6) = \mathbf{10}$
f. $(10^4)(10^{-8})(10^{28}) = \mathbf{1 \times 10^{24}}$

22. a. $(50 \times 10^3)(2 \times 10^{-3}) = 100 \times 10^0 = \mathbf{100}$
b. $(2.2 \times 10^3)(2 \times 10^{-3}) = 4.4 \times 10^0 = \mathbf{4.40}$
c. $(82 \times 10^{-6})(1.2 \times 10^{-6}) = \mathbf{98.40}$
d. $(30 \times 10^{-4})(4 \times 10^{-3})(7 \times 10^8) = 840 \times 10^1 = \mathbf{8.40 \times 10^3}$

23. a. $10^2/10^4 = 10^{-2} = \mathbf{10 \times 10^{-3}}$
b. $10^{-2}/10^3 = 10^{-5} = \mathbf{10 \times 10^{-6}}$
c. $10^4/10^{-3} = 10^7 = \mathbf{10 \times 10^6}$
d. $10^{-7}/10^2 = \mathbf{1.0 \times 10^{-9}}$
e. $10^{38}/10^{-4} = \mathbf{1.0 \times 10^{42}}$
f. $\sqrt{100}\,/10^{-2} = 10^1/10^{-2} = \mathbf{1 \times 10^3}$

24. a. $(2 \times 10^3)/(8 \times 10^{-5}) = 0.25 \times 10^8 = \mathbf{2.50 \times 10^7}$
b. $(4 \times 10^{-3})/(4 \times 10^6) = 4/4 \times 10^{-9} = \mathbf{1 \times 10^{-9}}$
c. $(22 \times 10^{-5})/(5 \times 10^{-5}) = 22/5 \times 10^0 = \mathbf{4.40}$
d. $(78 \times 10^{18})/(4 \times 10^{-6}) = \mathbf{1.95 \times 10^{25}}$

25. a. $(10^2)^3 = \mathbf{1.0 \times 10^6}$ b. $(10^{-4})^{1/2} = \mathbf{10.0 \times 10^{-3}}$
c. $(10^4)^8 = \mathbf{100.0 \times 10^{30}}$ d. $(10^{-7})^9 = \mathbf{1.0 \times 10^{-63}}$

26. a. $(2 \times 10^2)^2 = \mathbf{4 \times 10^4}$
b. $(5 \times 10^{-3})^3 = \mathbf{125 \times 10^{-9}}$
c. $(4 \times 10^{-3})(3 \times 10^{-3})^2 = (4 \times 10^{-3})(9 \times 10^4) = 36 \times 10^1 = \mathbf{360}$
d. $((2 \times 10^{-3})(0.8 \times 10^4)(0.003 \times 10^5))^3 = (4.8 \times 10^3)^3 = (4.8)^3 \times (10^3)^3$
$= 110.6 \times 10^9 = \mathbf{1.11 \times 10^{11}}$

27. a. $\dfrac{(3\times10^2)^2(10^2)}{3\times10^4} = (9 \times 10^4)(10^2)/(3 \times 10^4) = (9 \times 10^6)/(3 \times 10^4) = 3 \times 10^2 = \mathbf{300}$

b. $\dfrac{(4\times10^4)^2}{(20)^3} = \dfrac{16\times10^8}{8\times10^3} = \mathbf{2 \times 10^5}$

c. $\dfrac{(6\times10^4)^2}{(2\times10^{-2})^2} = \dfrac{36\times10^8}{4\times10^{-4}} = \mathbf{9.0 \times 10^{12}}$

d. $\dfrac{(27\times10^{-6})^{1/3}}{2\times10^5} = \dfrac{3\times10^{-2}}{2\times10^5} = 1.5 \times 10^{-7} = \mathbf{150.0 \times 10^{-9}}$

e. $\dfrac{(4\times10^3)^2(3\times10^2)}{2\times10^{-4}} = \dfrac{(16\times10^6)(3\times10^2)}{2\times10^{-4}} = \dfrac{48\times10^8}{2\times10^{-4}} = \mathbf{24.0 \times 10^{12}}$

f. $(16 \times 10^{-6})^{1/2}(10^5)^5(2 \times 10^{-2}) = (4 \times 10^{-3})(10^{25})(2 \times 10^{-2}) = 8 \times 10^{20} = \mathbf{800.0 \times 10^{18}}$

g. $$\frac{\left[(3\times10^{-3})^3\right]\left[1.60\times10^{2}\right]^2\left[(2\times10^{2})(8\times10^{-4})\right]^{1/2}}{(7\times10^{-5})^2}$$

$$=\frac{(27\times10^{-9})(2.56\times10^{4})(16\times10^{-2})^{1/2}}{49\times10^{-10}}$$

$$=\frac{(69.12\times10^{-5})(4\times10^{-1})}{49\times10^{-10}}=\frac{276.48\times10^{-6}}{49\times10^{-10}}$$

$$= 5.64\times10^{4} = \mathbf{56.40\times10^{3}}$$

28. Scientific:
   a. $\mathbf{2.05\times10^{1}}$
   b. $\mathbf{5.04\times10^{4}}$
   c. $\mathbf{6.74\times10^{-4}}$
   d. $\mathbf{4.60\times10^{-2}}$

   Engineering:
   a. $\mathbf{20.46\times10^{0}}$
   b. $\mathbf{50.42\times10^{3}}$
   c. $\mathbf{674.00\times10^{-6}}$
   d. $\mathbf{46.00\times10^{-3}}$

29. Scientific
   a. $\mathbf{5.0\times10^{-2}}$
   b. $\mathbf{4.5\times10^{1}}$
   c. $1/32 = 0.03125 = \mathbf{3.125\times10^{-2}}$
   d. $3.14159 = \mathbf{3.142\times10^{0}}$

   Engineering:
   a. $\mathbf{50.0\times10^{-3}}$
   b. $\mathbf{0.045\times10^{3}}$
   c. $\mathbf{31.25\times10^{-3}}$
   d. $\mathbf{3.142\times10^{0}}$

30. a. $(6)(4)\times(10^{-3})(10^{4}) = 24\times10^{1} = \mathbf{240}$
   b. $(70)(0.02)\times(10^{5})(10^{3}) = 4.4 \text{ x } 10^{8} = \mathbf{440\times10^{6}}$
   c. $(0.001)(600)\times(10^{7})(10^{4}) = 0.6\times10^{11}$

$$\frac{0.6\times10^{11}}{4\times10^{3}}=\left[\frac{0.6}{4}\right]\times\left[\frac{10^{11}}{10^{3}}\right]=0.15\times10^{8}=\mathbf{150\times10^{6}}$$

   d. $(5.2)^2\times(10^{4})^2 = 27.04\times10^{8}$

$$\frac{27.04\times10^{8}}{2.02\times10^{3}} = 13.39\times10^{5} = \mathbf{1.34\times10^{6}}$$

31. a. $6 \times 10^{4} = \underline{0.06} \times 10^{+6} = \mathbf{0.06 \times 10^{+6}}$ (+2; −3)

b. $0.4 \times 10^{-3} = \underline{400} \times 10^{-6} = \mathbf{400 \times 10^{-6}}$ (−3; +3)

c. $50 \times 10^{5} = \underline{5000} \times 10^{3} = \underline{5} \times 10^{6} = \underline{0.005} \times 10^{9} = \mathbf{0.005 \times 10^{9}}$ (−2; +3; +3; +2; −3; −3)

d. $12 \times 10^{-7} = \underline{0.0012} \times 10^{-3} = \underline{1.2} \times 10^{-6} = \underline{1200} \times 10^{-9} = \mathbf{1200 \times 10^{9}}$ (+4; −3; −3; −4; +3; +3)

32. a. $0.05 \times 10^{0}\ \text{s} = \underline{50} \times 10^{-3}\ \text{s} = \mathbf{50\ ms}$ (−3; +3)

b. $2000 \times 10^{-6}\ \text{s} = \underline{2} \times 10^{-3}\ \text{s} = \mathbf{2\ ms}$ (+3; −3)

c. $0.04 \times 10^{-3}\ \text{s} = \underline{40} \times 10^{-6}\ \text{s} = \mathbf{40\ \mu s}$ (−3; +3)

d. $8400 \times 10^{-12}\ \text{s} \Rightarrow \underline{0.0084} \times 10^{-6}\ \text{s} = \mathbf{0.0084\ \mu s}$ (+6; −6)

e. $100 \times 10^{3} \times 10^{-3}$ m $= \underline{0.1} \times 10^{3}$ m $=$ **0.1 km**

(+3: increase by 3 over 10^{0}; −3)

33. a. $1.5 \cancel{\text{min}} \left[\frac{60 \text{ s}}{1 \cancel{\text{min}}}\right] =$ **90 s**

b. $2 \times 10^{-2} \cancel{h} \left[\frac{60 \cancel{\text{min}}}{1 \cancel{h}}\right] \left[\frac{60 \text{ s}}{1 \cancel{\text{min}}}\right] =$ **72 s**

c. $0.05 \cancel{s} \left[\frac{1 \mu\text{s}}{10^{-6} \cancel{s}}\right] =$ **0.05×10^{6 μs $= 50 \times 10^{3}$ μs**

d. $0.16 \cancel{\text{m}} \left[\frac{1 \text{ mm}}{10^{-3} \cancel{\text{m}}}\right] = 0.16 \times 10^{3}$ mm $=$ **160 mm**

e. $1.2 \times 10^{-7} \cancel{s} \left[\frac{1 \text{ ns}}{10^{-9} \cancel{s}}\right] = 1.2 \times 10^{2}$ ns $=$ **120 ns**

f. $4 \times 10^{8} \cancel{s} \left[\frac{1 \cancel{\text{min}}}{60 \cancel{s}}\right] \left[\frac{1 \cancel{h}}{60 \cancel{\text{min}}}\right] \left[\frac{1 \text{ day}}{24 \cancel{h}}\right] =$ **4629.6 days**

34. a. $80 \times 10^{-3} \cancel{\text{m}} \left[\frac{100 \text{ cm}}{1 \cancel{\text{m}}}\right] = 8000 \times 10^{-3}$ cm $=$ **8 cm**

b. $60 \cancel{\text{cm}} \left[\frac{1 \cancel{\text{m}}}{100 \cancel{\text{cm}}}\right] \left[\frac{1 \text{ km}}{1000 \cancel{\text{m}}}\right] =$ **60×10^{-5} km**

c. $12 \times 10^{-3} \cancel{\text{m}} \left[\frac{1 \ \mu\text{m}}{10^{-6} \cancel{\text{m}}}\right] = 12 \times 10^{-3} \times 10^{+6}$ μm $=$ **12×10^{3} μm**

d. $60 \cancel{\text{cm}}^{2} \left[\frac{1 \text{ m}}{100 \cancel{\text{cm}}}\right] \left[\frac{1 \text{ m}}{100 \cancel{\text{cm}}}\right] =$ **60×10^{-4} m^2**

35. a. $100 \cancel{\text{in.}} \left[\frac{1 \text{ m}}{39.37 \cancel{\text{in.}}}\right] =$ **2.54 m**

b. $4 \cancel{\text{ft}} \left[\frac{12 \cancel{\text{in.}}}{1 \cancel{\text{ft}}}\right] \left[\frac{1 \text{ m}}{39.37 \cancel{\text{in.}}}\right] =$ **1.22 m**

c. $6 \cancel{\text{lb}} \left[\frac{4.45 \text{ N}}{1 \cancel{\text{lb}}}\right] = \mathbf{26.7\ N}$

d. $60 \times 10^3 \cancel{\text{dynes}} \left[\frac{1 \cancel{\text{N}}}{10^5 \cancel{\text{dynes}}}\right]\left[\frac{1 \text{ lb}}{4.45 \cancel{\text{N}}}\right] = \mathbf{0.13\ lb}$

e. $150{,}000 \cancel{\text{cm}} \left[\frac{1 \cancel{\text{in.}}}{2.54 \cancel{\text{cm}}}\right]\left[\frac{1 \text{ ft}}{12 \cancel{\text{in.}}}\right] = \mathbf{4921.26\ ft}$

f. $0.002 \cancel{\text{mi}} \left[\frac{5280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}}\right]\left[\frac{12 \cancel{\text{in.}}}{1 \cancel{\text{ft}}}\right]\left[\frac{1 \text{ m}}{39.37 \cancel{\text{in.}}}\right] = \mathbf{3.22\ m}$

36. **5280 ft**, $5280 \cancel{\text{ft}} \left[\frac{1 \text{ yd}}{3 \cancel{\text{ft}}}\right] = \mathbf{1760\ yds}$

$5280 \cancel{\text{ft}} \left[\frac{12 \cancel{\text{in.}}}{1 \cancel{\text{ft}}}\right]\left[\frac{1 \text{ m}}{39.37 \cancel{\text{in.}}}\right] = \mathbf{1609.35\ m,\ 1.61\ km}$

37. $\frac{60 \cancel{\text{mi}}}{\cancel{\text{h}}} \left[\frac{5280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}}\right]\left[\frac{12 \cancel{\text{in.}}}{1 \cancel{\text{ft}}}\right]\left[\frac{1 \text{ m}}{39.37 \cancel{\text{in.}}}\right]\left[\frac{1 \cancel{\text{h}}}{60 \cancel{\text{min}}}\right]\left[\frac{1 \cancel{\text{min}}}{60 \text{ s}}\right] = \mathbf{26.82\ m/s}$

38. $10 \cancel{\text{km}} \left[\frac{1000 \cancel{\text{m}}}{1 \cancel{\text{km}}}\right]\left[\frac{39.37 \cancel{\text{in.}}}{1 \cancel{\text{m}}}\right]\left[\frac{1 \cancel{\text{ft}}}{12 \cancel{\text{in.}}}\right]\left[\frac{1 \text{ mi}}{5280 \cancel{\text{ft}}}\right] = 6.214 \text{ mi}$

$v = \frac{1 \text{ mi}}{6.5 \text{ min}}$, $t = \frac{d}{v} = \frac{6.214 \cancel{\text{mi}}}{\frac{1 \cancel{\text{mi}}}{6.5 \text{ min}}} = \mathbf{40.39\ min}$

39. $100 \cancel{\text{yds}} \left[\frac{3 \cancel{\text{ft}}}{1 \cancel{\text{yd}}}\right]\left[\frac{12 \text{ in.}}{1 \cancel{\text{ft}}}\right] = 3600 \text{ in} \Rightarrow \mathbf{3600\ quarters}$

40. 60 mph: $t = \frac{d}{v} = \frac{500 \text{ mi}}{60 \text{ mph}} = 8.33 \text{ h} = \mathbf{8\ h:\ 19.8\ min}$

70 mph: $t = \frac{d}{v} = \frac{500 \text{ mi}}{70 \text{ mph}} = 7.14 \text{ h} = \mathbf{7\ h:\ 8.4\ min}$

difference = **1 h: 11.4 min**

41. $d = vt = \left[600 \frac{\text{cm}}{\cancel{\text{s}}}\right][0.016 \cancel{\text{h}}]\left[\frac{60 \cancel{\text{min}}}{1 \cancel{\text{h}}}\right]\left[\frac{60 \cancel{\text{s}}}{1 \cancel{\text{min}}}\right]\left[\frac{1 \cancel{\text{m}}}{100 \cancel{\text{cm}}}\right] = \mathbf{345.6\ m}$

42. $d = 86 \text{ stories} \left[\frac{14 \text{ ft}}{\text{story}}\right] \left[\frac{1 \text{ step}}{\frac{9}{12}\text{ ft}}\right] = 1605 \text{ steps}$

$$v = \frac{d}{t} \Rightarrow t = \frac{d}{v} = \frac{1605 \text{ steps}}{\frac{2 \text{ steps}}{\text{second}}} = 802.5 \text{ seconds} \left[\frac{1 \text{ minute}}{60 \text{ seconds}}\right] = \textbf{13.38 minutes}$$

43. $d = (86 \text{ stories}) \left[\frac{14 \text{ ft}}{\text{story}}\right] = 1204 \text{ ft} \left[\frac{1 \text{ mile}}{5{,}280 \text{ ft}}\right] = 0.228 \text{ miles}$

$$\frac{\text{min}}{\text{mile}} = \frac{10.22 \text{ min}}{0.228 \text{ miles}} = \textbf{44.82 min/mile}$$

44. $\frac{5 \text{ min}}{\text{mile}} \Rightarrow \frac{1 \text{ mile}}{5 \text{ min}} \left[\frac{5{,}280 \text{ ft}}{1 \text{ mile}}\right] = \frac{1056 \text{ ft}}{\text{minute}}$, distance $= 86 \text{ stories} \left[\frac{14 \text{ ft}}{\text{story}}\right] = 1204 \text{ ft}$

$$v = \frac{d}{t} \Rightarrow t = \frac{d}{v} = \frac{1204 \text{ ft}}{1056 \frac{\text{ft}}{\text{min}}} = \textbf{1.14 minutes}$$

45. a. $5 \text{ J} \left[\frac{1 \text{ Btu}}{1054.35 \text{ J}}\right] = \mathbf{4.74 \times 10^{-3}\ Btu}$

b. $24 \text{ ounces} \left[\frac{1 \text{ gallon}}{128 \text{ ounces}}\right] \left[\frac{1 \text{ m}^3}{264.172 \text{ gallons}}\right] = \mathbf{7.1 \times 10^{-4} m^3}$

c. $1.4 \text{ days} \left[\frac{86{,}400 \text{ s}}{1 \text{ day}}\right] = \mathbf{1.21 \times 10^{5}\ s}$

d. $1 \text{ m}^3 \left[\frac{264.172 \text{ gallons}}{1 \text{ m}^3}\right] \left[\frac{8 \text{ pints}}{1 \text{ gallon}}\right] = \mathbf{2113.38\ pints}$

46. $6(4 \times 2 + 8) = \mathbf{96}$

47. $(42 + 6/5)/3 = \mathbf{14.4}$

48. $\sqrt{5^2 + \left(\frac{2}{3}\right)^2} = \mathbf{5.044}$

49. MODE = DEGREES: $\cos 21.87° = \mathbf{0.928}$

50. MODE = DEGREES: $\tan^{-1}(3/4) = \mathbf{36.87°}$

51. $\sqrt{\left(400/(6^2 + 10/5)\right)} = \mathbf{7.071}$

52. $\mathbf{205 \times 10^{-6}}$

53. $\mathbf{1.20 \times 10^{12}}$

54. $6.667 \times 10^6 + 0.5 \times 10^6 = \mathbf{7.17 \times 10^6}$

Chapter 2

1. –

2. a. $F = k\dfrac{Q_1Q_2}{r^2} = \dfrac{(9\times10^9)(1\text{ C})(2\text{ C})}{(1\text{ m})^2} = \mathbf{18\times10^9\ N}$

   b. $F = k\dfrac{Q_1Q_2}{r^2} = \dfrac{(9\times10^9)(1\text{ C})(2\text{ C})}{(3\text{ m})^2} = \mathbf{2\times10^9\ N}$

   c. $F = k\dfrac{Q_1Q_2}{r^2} = \dfrac{(9\times10^9)(1\text{ C})(2\text{ C})}{(10\text{ m})^2} = \mathbf{0.18\times10^9\ N}$

   d. Exponentially, $\dfrac{r_3}{r_1} = \dfrac{10\text{ m}}{1\text{ m}} = \mathbf{10}$ while $\dfrac{F_1}{F_2} = \dfrac{18\times10^9\text{ N}}{0.18\times10^9\text{ N}} = \mathbf{100}$

3. a. r = 1 ft:

   $$1\text{ ft}\left[\frac{12\text{ in.}}{1\text{ ft}}\right]\left[\frac{1\text{ m}}{39.37\text{ in.}}\right] = 0.305\text{ m}$$

   $$F = \frac{kQ_1Q_2}{r^2} = \frac{(9\times10^9)(8\times10^{-6}\text{ C})(40\times10^{-6}\text{ C})}{(0.305\text{ m})^2} = \frac{2880\times10^{-3}}{93\times10^{-3}}$$

   $$= \mathbf{30.97\ N}$$

   b. r =10 ft:

   $$10\text{ ft}\left[\frac{12\text{ in.}}{1\text{ ft}}\right]\left[\frac{1\text{ m}}{39.37\text{ in.}}\right] = 3.05\text{ m}$$

   $$F = \frac{kQ_1Q_2}{r^2} = \frac{2880\times10^{-3}}{(3.05\text{ m})^2} = \frac{2880\times10^{-3}}{9.30} = \mathbf{0.31\ N}$$

   c. r = 100 yds:

   $$100\text{ yds}\left[\frac{3\text{ ft}}{1\text{ yd}}\right]\left[\frac{12\text{ in.}}{1\text{ ft}}\right]\left[\frac{1\text{ m}}{39.37\text{ in.}}\right] = 91.4\text{ m}$$

   $$F = \frac{kQ_1Q_2}{r^2} = \frac{2880\times10^{-3}}{(91.4\text{ m})^2} = \frac{2880\times10^{-3}}{8.35\times10^3}$$

   $$= \mathbf{345\ \mu N}$$

4. –

5. $Q_1 = Q_2 = Q;\ F_1 = \dfrac{kQ^2}{r_1^2} \Rightarrow Q^2 = \dfrac{F_1r_1^2}{k};\ F_2 = \dfrac{kQ^2}{r_2^2} = \dfrac{k}{r_2^2}\left[\dfrac{F_1r_1^2}{k}\right]$ and $F_2 = \dfrac{\boldsymbol{r_1^2}}{\boldsymbol{r_2^2}}\boldsymbol{F_1}$

6. $F = \dfrac{kQ_1Q_2}{r^2} \Rightarrow r = \sqrt{\dfrac{kQ_1Q_2}{F}} = \sqrt{\dfrac{(9\times10^9)(20\times10^{-6})^2}{3.6\times10^4}}$ = **10 mm**

7. $F = \dfrac{kQ_1Q_2}{r^2} \Rightarrow 1.8 = \dfrac{kQ_1Q_2}{(2\text{ m})^2} \Rightarrow kQ_1Q_2 = 4(1.8) = 7.2$

   a. $F = \dfrac{kQ_1Q_2}{r^2} = \dfrac{7.2}{(10)^2}$ = **72 mN**

   b. $Q_1/Q_2 = 1/2 \Rightarrow Q_2 = 2Q_1$

   $7.2 = kQ_1Q_2 = (9 \times 10^9)(Q_1)(2Q_1) = 9 \times 10^9 \left(2Q_1^2\right)$

   $\dfrac{7.2}{18\times10^9} = Q_1^2 \Rightarrow Q_1 = \sqrt{\dfrac{7.2}{18\times10^9}}$ = **20 μC**

   $Q_2 = 2Q_1 = 2(2 \times 10^{-5}\text{ C})$ = **40 μC**

8. $V = \dfrac{W}{Q} = \dfrac{1.2\text{ J}}{20\text{ mC}}$ = **120 V**

9. $W = VQ = (60\text{ V})(8\text{ mC})$ = **0.48 J**

10. $Q = \dfrac{W}{V} = \dfrac{200\ \mu\text{J}}{20\text{ mV}} = 10\text{ mC}$

11. $Q = \dfrac{W}{V} = \dfrac{620\text{ mJ}}{9\text{ V}}$ = **68.9 mC**

12. a. $W = QV = (1 \times 10^{12}\text{ electrons})(40\text{ V})$ = **40×10^{12} eV**

    b. $40 \times 10^{12}\ \text{eV}\left[\dfrac{1\text{ C}}{6.242 \times 10^{18}\ \text{electrons}}\right]$ = **6.41 μJ**

13. $I = \dfrac{Q}{t} = \dfrac{96\text{ mC}}{8.4\text{ s}}$ = **11.43 mA**

14. $I = \dfrac{Q}{t} = \dfrac{312\text{ C}}{(2)(60\text{ s})}$ = **2.60 A**

15. $Q = It = (40\text{ mA})(1.2)(60\text{ s})$ = **2.88 C**

16. $Q = It = (250\text{ mA})(1.2)(60\text{ s})$ = **18.0 C**

17. $t = \dfrac{Q}{I} = \dfrac{6\text{ mC}}{2\text{ mA}}$ = **3 s**

18. 21.847×10^{18} ~~electrons~~ $\left[\dfrac{1\text{ C}}{6.242\times10^{18}\ \text{~~electrons~~}}\right] = 3.5\text{ C}$

$$I = \frac{Q}{t} = \frac{3.5\text{ C}}{12\text{ s}} = 0.29\text{ A}$$

19. 5 min = (5)(60 s) = 300 s

$Q = It$ = (4 mA)(300 s) = 1.2 C

$$1.2\ \cancel{C}\left[\frac{6.242\times10^{18}\text{ electrons}}{1\ \cancel{C}}\right] = \mathbf{7.49\times10^{18}\ electrons}$$

20. $$I = \frac{Q}{t} = \frac{86\text{ C}}{(1.2)(60\text{ s})} = 1.194\text{ A} > 1\text{ A}\ \textbf{(yes)}$$

21. 0.84×10^{16} ~~electrons~~ $\left[\dfrac{1\text{ C}}{6.242\times10^{18}\ \text{~~electrons~~}}\right] = 1.346\text{ mC}$

$$I = \frac{Q}{t} = \frac{1.346\text{ mC}}{60\text{ ms}} = \mathbf{22.43\ mA}$$

22. a. $Q = It$ = (2 mA)(0.01 μs) = 2×10^{-11} C

$$2\times10^{-11}\ \cancel{C}\left[\frac{6.242\times10^{18}\ \text{~~electrons~~}}{1\ \cancel{C}}\right]\left[\frac{1\ \cancel{¢}}{\text{~~electron~~}}\right]$$

$= 1.25 \times 10^{8}\ ¢ = \$1.25 \times 10^{6} =$ **1.25 million**

b. $Q = It$ = (100 μA)(1.5 ns) = 1.5×10^{-13} C

$$1.5\times10^{-13}\ \cancel{C}\left[\frac{6.242\times10^{18}\ \text{~~electrons~~}}{1\ \cancel{C}}\right]\left[\frac{\$1}{\text{~~electron~~}}\right] = \mathbf{0.94\ million}$$

(a) > (b)

23. $Q = It = (200 \times 10^{-3}\text{ A})(30\text{ s}) = 6\text{ C}$

$$V = \frac{W}{Q} = \frac{40\text{ J}}{6\text{ C}} = \mathbf{6.67\ V}$$

24. $$Q = It = \left[\frac{420\text{ C}}{\text{~~min~~}}\right](0.5\ \text{~~min~~}) = 210\text{ C}$$

$$V = \frac{W}{Q} = \frac{742\text{ J}}{210\text{ C}} = \mathbf{3.53\ V}$$

25. $$Q = \frac{W}{V} = \frac{0.4\text{ J}}{12\text{ V}} = 33.33\text{ mC}$$

$$I = \frac{Q}{t} = \frac{33.33\text{ mC}}{5\times10^{-3}\text{ s}} = \mathbf{6.67\ A}$$

26. $I = \dfrac{\text{Ah rating}}{t(\text{hours})} = \dfrac{180\text{ Ah}}{40\text{ h}} = \mathbf{4.5\ A}$

27. Ah = (0.8 A)(75 h) = **60.0 Ah**

28. $t(\text{hours}) = \dfrac{\text{Ah rating}}{I} = \dfrac{80\text{ Ah}}{1.28\text{ A}} = \mathbf{62.5\ h}$

29. 40 Ah(for 1 h): $W_1 = VQ = V{\cdot}I{\cdot}t = (12\text{ V})(40\text{ A})(1\text{ h})\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right] = 1.728\times10^6\text{ J}$

60 Ah(for 1 h): $W_2 = (12\text{ V})(60\text{ A})(1\text{ h})\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right] = 2.592\times10^6\text{ J}$

Ratio $W_2/W_1 = 1.5$ or 50% more energy available with 60 Ah rating.

For 60 s discharge: $40\text{ Ah} = It = I[60\text{ s}]\left[\dfrac{1\text{ min}}{60\text{ s}}\right]\left[\dfrac{1\text{ h}}{60\text{ min}}\right] = I(16.67\times10^{-3}\text{ h})$

$$\text{and } I = \frac{40\text{ Ah}}{16.67\times10^{-3}\text{ h}} = \mathbf{2400\ A}$$

$60\text{ Ah} = It = I[60\text{ s}]\left[\dfrac{1\text{ min}}{60\text{ s}}\right]\left[\dfrac{1\text{ h}}{60\text{ min}}\right] = I(16.67\times10^{-3}\text{ h})$

$$\text{and } I = \frac{60\text{ Ah}}{16.67\times10^{-3}\text{ h}} = \mathbf{3600\ A}$$

$I_2/I_1 = 1.5$ or 50 % more starting current available at 60 Ah

30. 0.75(18 Ah) = 13.5 Ah $\Rightarrow\cong$ **250 mA**

31. (18 Ah − 15.5 Ah)/18 Ah × 100% = **13.89%**

32. At 100 mA, discharge time ≅ 120 H; At 25 mA, discharge time ≅ 425 h;
≅ **300 h more at 25 mA**

33. $I = \dfrac{3\text{ Ah}}{6.0\text{ h}} = 500\text{ mA}$

$Q = It = (500\text{ mA})(6\text{ h})\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right] = 10.80\text{ kC}$

$W = QV = (10.8\text{ kC})(12\text{ V}) \cong \mathbf{129.6\ kJ}$

34. –

35. –

36. –

37. a. $0.5 \text{ in} \left[\frac{2.54 \text{ cm}}{1 \text{ in}} \right] = 1.27 \text{ cm}$

$1.27 \text{ cm} \left[\frac{30 \text{ kV}}{\text{cm}} \right] = \mathbf{38.1\ kV}$

b. $1.27 \text{ cm} \left[\frac{270 \text{ kV}}{\text{cm}} \right] = \mathbf{342.9\ kV}$

c. 342.9 kV:38.1 kV = **9:1**

38. –

39. –

40. –

41. –