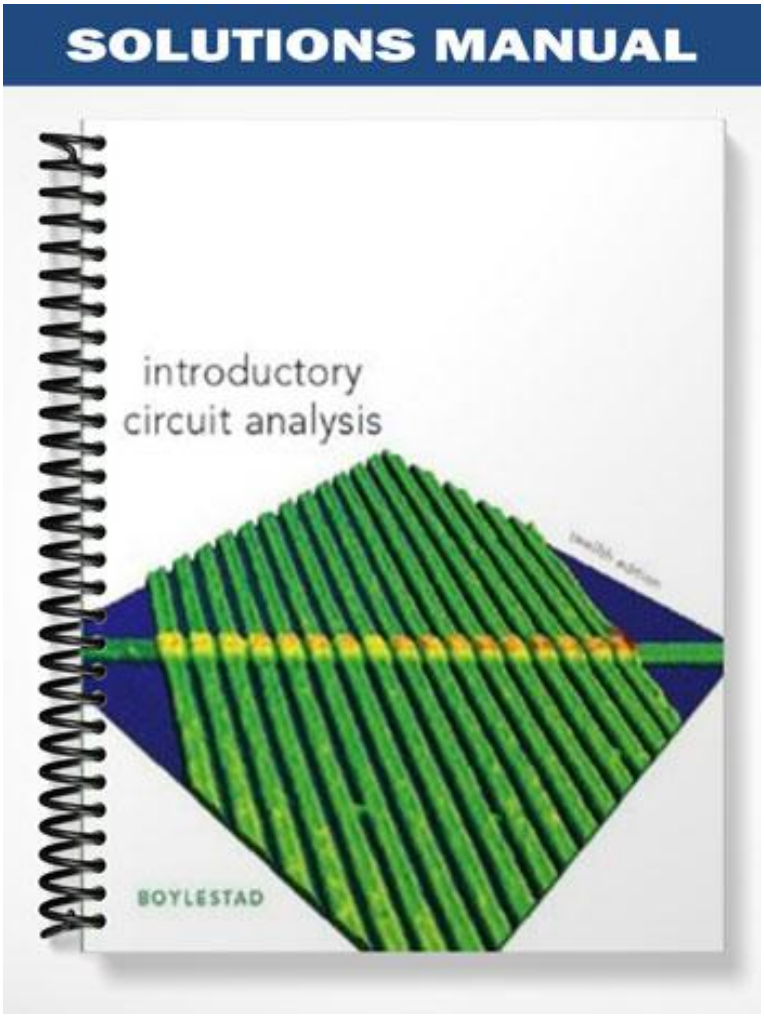
SOLUTIONS MANUAL



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

3. a. r = 1 mi:

   $$1\text{ mi}\left[\frac{5280\text{ ft}}{1\text{ mi}}\right]\left[\frac{12\text{ in.}}{1\text{ ft}}\right]\left[\frac{1\text{ m}}{39.37\text{ in.}}\right] = 1609.35\text{ m}$$

   $$F = \frac{kQ_1Q_2}{r^2} = \frac{(9\times10^9)(8\times10^{-6}\text{ C})(40\times10^{-6}\text{ C})}{(1609.35\text{ m})^2} = \frac{2880\times10^{-3}}{2.59\times10^6}$$

   $= \mathbf{1.11\ \mu N}$

   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. $$\frac{1\text{ in.}}{16}\left[\frac{1\text{ m}}{39.37\text{ in.}}\right] = 1.59\text{ mm}$$

   $$F = \frac{kQ_1Q_2}{r^2} = \frac{2880\times10^{-3}}{(1.59\times10^{-3}\text{ m})^2} = \frac{2880\times10^{-3}}{2.53\times10^{-6}} = 1138.34\times10^3\text{ N}$$

   $= \mathbf{1138.34\ kN}$

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

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. $V = \dfrac{W}{Q} = \dfrac{1.2\text{ J}}{20\ \mu\text{C}} =$ **60 kV**

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

10. $Q = \dfrac{W}{V} = \dfrac{120\ \mu\text{J}}{20\text{ mV}} = 6\text{ mC}\left[\dfrac{6.242\times10^{18}\text{electrons}}{1\text{ C}}\right] =$ **37.45×10^{15} electrons**

11. $Q = \dfrac{W}{V} = \dfrac{72\text{ J}}{9\text{ V}} =$ **8 C**

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

b. $40 \times 10^{12}\ \text{eV}\left[\dfrac{1\text{ C}}{6.242\times10^{18}\ \text{electrons}}\right] =$ **6.41 μJ**

13. $I = \dfrac{Q}{t} = \dfrac{12\text{ mC}}{2.8\text{ s}} =$ **4.29 mA**

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

15. $Q = It = (40\text{ mA})(0.8)(60\text{ s}) =$ **1.92 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. $21.847 \times 10^{18}\ \text{electrons}\left[\dfrac{1\text{C}}{6.242\times10^{18}\ \text{electrons}}\right] = 3.5\text{ C}$

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

19. $Q = It = (4\text{ mA})(90\text{ s}) = 360\text{ mC}$

$$360\text{ m}\cancel{\text{C}}\left[\frac{6.242\times10^{18}\text{ electrons}}{1\cancel{\text{C}}}\right] = \mathbf{2.25\times10^{18}\ electrons}$$

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

21. $$0.84\times10^{16}\ \cancel{\text{electrons}}\left[\frac{1\text{ C}}{6.242\times10^{18}\ \cancel{\text{electrons}}}\right] = 1.346\text{ mC}$$

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

22. a. $Q = It = (2\text{ mA})(0.01\ \mu\text{s}) = 2\times10^{-11}\text{ C}$

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

$$= 1.25\times10^{8}\ ¢ = \$1.25\times10^{6} = \mathbf{1.25\ million}$$

b. $Q = It = (100\ \mu\text{A})(1.5\text{ ns}) = 1.5\times10^{-13}\text{ C}$

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

(a) > (b)

23. $Q = It = (200\times10^{-3}\text{ A})(30\text{ s}) = 6\text{ C}$

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

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

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

25. $$Q = \frac{W}{V} = \frac{0.4\text{ J}}{24\text{ V}} = 0.0167\text{ C}$$

$$I = \frac{Q}{t} = \frac{0.0167\text{ C}}{5\times10^{-3}\text{ s}} = \mathbf{3.34\ A}$$

26. $$I = \frac{\text{Ah rating}}{t(\text{hours})} = \frac{200\text{ Ah}}{40\text{ h}} = \mathbf{5\ A}$$

27. $\text{Ah} = (0.8\text{ A})(75\text{ h}) = \mathbf{60.0\ Ah}$

28. $$t(\text{hours}) = \frac{\text{Ah rating}}{I} = \frac{32\text{ Ah}}{1.28\text{ A}} = \mathbf{25\ h}$$

29. 40 Ah(for 1 h): $W_1 = VQ = V \cdot I \cdot t = (12\text{ V})(40\text{ A})(1\text{ h})\left[\frac{60\text{ min}}{1\text{ h}}\right]\left[\frac{60\text{ s}}{1\text{ min}}\right] = 1.728 \times 10^6\text{ J}$

60 Ah(for 1 h): $W_2 = (12\text{ V})(60\text{ A})(1\text{ h})\left[\frac{60\text{ min}}{1\text{ h}}\right]\left[\frac{60\text{ s}}{1\text{ min}}\right] = 2.592 \times 10^6\text{ J}$

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

For 60 s discharge: $40\text{ Ah} = It = I[60\text{ s}]\left[\frac{1\text{ min}}{60\text{ s}}\right]\left[\frac{1\text{ h}}{60\text{ min}}\right] = I(16.67 \times 10^{-3}\text{ h})$

$$\text{and } I = \frac{40\text{ Ah}}{16.67 \times 10^{-3}\text{ h}} = \mathbf{2400\text{ A}}$$

$60\text{ Ah} = It = I[60\text{ s}]\left[\frac{1\text{ min}}{60\text{ s}}\right]\left[\frac{1\text{ h}}{60\text{ min}}\right] = I(16.67 \times 10^{-3}\text{ h})$

$$\text{and } I = \frac{60\text{ Ah}}{16.67 \times 10^{-3}\text{ h}} = \mathbf{3600\text{ A}}$$

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

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

31. $(18\text{ Ah} - 15.5\text{ Ah})/18\text{ Ah} \times 100\% =$ **13.89%**

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

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

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

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

34. –

35. –

36. –

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

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

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

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

38. –

39. –

40. –

41. –