Chapter 19

19. (*a*) Note that adding resistors in series always results in a larger resistance, and adding resistors in parallel always results in a smaller resistance. Closing the switch adds another resistor in parallel with R_3 and R_4, which lowers the net resistance of the parallel portion of the circuit, and thus lowers the equivalent resistance of the circuit. That means that more current will be delivered by the battery. Since R_1 is in series with the battery, its voltage will increase. Because of that increase, the voltage across R_3 and R_4 must decrease so that the total voltage drops around the loop are equal to the battery voltage. Since there was no voltage across R_2 until the switch was closed, its voltage will increase. To summarize:

$$\boxed{V_1 \text{ and } V_2 \text{ increase ; } V_3 \text{ and } V_4 \text{ decrease}}$$

(*b*) By Ohm's law, the current is proportional to the voltage for a fixed resistance. Thus

$$\boxed{I_1 \text{ and } I_2 \text{ increase ; } I_3 \text{ and } I_4 \text{ decrease}}$$

(*c*) Since the battery voltage does not change and the current delivered by the battery increases, the power delivered by the battery, found by multiplying the voltage of the battery by the current delivered, $\boxed{\text{increases}}$.

(*d*) Before the switch is closed, the equivalent resistance is R_3 and R_4 in parallel, combined with R_1 in series.

$$R_{\text{eq}} = R_1 + \left(\frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = 125\,\Omega + \left(\frac{2}{125\,\Omega}\right)^{-1} = 187.5\,\Omega$$

The current delivered by the battery is the same as the current through R_1.

$$I_{\text{total}} = \frac{V_{\text{battery}}}{R_{\text{eq}}} = \frac{22.0\,\text{V}}{187.5\,\Omega} = 0.1173\,\text{A} = I_1$$

The voltage across R_1 is found by Ohm's law.

$$V_1 = IR_1 = (0.1173\,\text{A})(125\,\Omega) = 14.66\,\text{V}$$

The voltage across the parallel resistors is the battery voltage less the voltage across R_1.

$$V_{\text{p}} = V_{\text{battery}} - V_1 = 22.0\,\text{V} - 14.66\,\text{V} = 7.34\,\text{V}$$

The current through each of the parallel resistors is found from Ohm's law.

$$I_3 = \frac{V_{\text{p}}}{R_2} = \frac{7.34\,\text{V}}{125\,\Omega} = 0.0587\,\text{A} = I_4$$

Notice that the current through each of the parallel resistors is half of the total current, within the limits of significant figures. The currents before closing the switch are as follows.

$$\boxed{I_1 = 0.117\,\text{A} \quad I_3 = I_4 = 0.059\,\text{A}}$$

After the switch is closed, the equivalent resistance is R_2, R_3, and R_4 in parallel, combined with R_1 in series. Do a similar analysis.

$$R_{eq} = R_1 + \left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right)^{-1} = 125\,\Omega + \left(\frac{3}{125\,\Omega}\right)^{-1} = 166.7\,\Omega$$

$$I_{total} = \frac{V_{battery}}{R_{eq}} = \frac{22.0\,\text{V}}{166.7\,\Omega} = 0.1320\,\text{A} = I_1 \qquad V_1 = IR_1 = (0.1320\,\text{A})(125\,\Omega) = 16.5\,\text{V}$$

$$V_p = V_{battery} - V_1 = 22.0\,\text{V} - 16.5\,\text{V} = 5.5\,\text{V} \qquad I_2 = \frac{V_p}{R_2} = \frac{5.5\,\text{V}}{125\,\Omega} = 0.044\,\text{A} = I_3 = I_4$$

Notice that the current through each of the parallel resistors is one third of the total current, within the limits of significant figures. The currents after closing the switch are as follows.

$$\boxed{I_1 = 0.132\,\text{A} \quad I_2 = I_3 = I_4 = 0.044\,\text{A}}$$

Yes, the predictions made in part (*b*) are all confirmed.

25. From Example 19-8, we have $I_1 = -0.87\,\text{A}$, $I_2 = 2.6\,\text{A}$, $I_3 = 1.7\,\text{A}$. If another significant figure had been kept, the values would be $I_1 = -0.858\,\text{A}$, $I_2 = 2.58\,\text{A}$, $I_3 = 1.73\,\text{A}$. We use those results.

(*a*) To find the potential difference between points a and d, start at point a and add each individual potential difference until reaching point d. The simplest way to do this is along the top branch.

$$V_{ad} = V_d - V_a = -I_1(30\,\Omega) = -(0.858\,\text{A})(30\,\Omega) = \boxed{-25.7\,\text{V}}$$

Slight differences will be obtained in the final answer depending on the branch used, due to rounding. For example, using the bottom branch, we get the following.

$$V_{ad} = V_d - V_a = \mathcal{E}_1 - I_2(21\,\Omega) = 80\,\text{V} - (2.58\,\text{A})(21\,\Omega) = -25.8\,\text{V}$$

(*b*) For the 80-V battery, the terminal voltage is the potential difference from point g to point e. For the 45-V battery, the terminal voltage is the potential difference from point d to point b.

80 V battery: $V_{terminal} = \mathcal{E}_1 - I_2 r = 80\,\text{V} - (2.58\,\text{A})(1.0\,\Omega) = \boxed{77.4\,\text{V}}$

45 V battery: $V_{terminal} = E_2 - I_3 r = 45\,\text{V} - (1.73\,\text{A})(1.0\,\Omega) = \boxed{43.3\,\text{V}}$

Chapter 20

1. (*a*) Use Eq. 20-1 to calculate the force with an angle of 90° and a length of 1 meter.

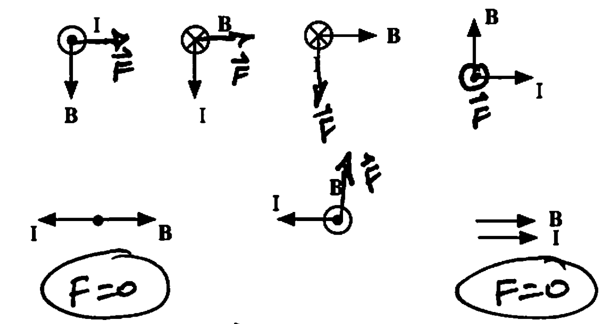
$$F = IlB\sin\theta \;\rightarrow\; \frac{F}{l} = IB\sin\theta = (8.40\,\text{A})(0.90\,\text{T})\sin 90^\circ = \boxed{7.6\,\text{N/m}}$$

(*b*) $\frac{F}{l} = IB\sin\theta = (8.40\,\text{A})(0.90\,\text{T})\sin 45.0^\circ = \boxed{5.3\,\text{N/m}}$

2. Use Eq. 20-1 to calculate the force.

$$F = IlB\sin\theta = (150\,\text{A})(160\,\text{m})(5.0\times10^{-5}\,\text{T})\sin 65^\circ = \boxed{1.1\,\text{N}}$$

Find the direction and magnitude of the magnetic force for the following configurations (I =2A, ℓ = 1m, and B =2T):



($I\ell B \sin 180 = 0$)

Except for the two cases where F=0,

$$F = I\ell B \sin 90° = (2)(1)(2) = \boxed{4N}$$