Workshop week 6

39. $\boxed{\text{SSM}}$ ***REASONING*** Using Ohm's law (Equation 20.2) we can write an expression for the voltage across the original circuit as $V = I_0 R_0$. When the additional resistor R is inserted in series, assuming that the battery remains the same, the voltage across the new combination is given by $V = I(R + R_0)$. Since V is the same in both cases, we can write $I_0 R_0 = I(R + R_0)$. This expression can be solved for R_0.

SOLUTION Solving for R_0, we have

$$I_0 R_0 - IR_0 = IR \quad \text{or} \quad R_0(I_0 - I) = IR$$

Therefore, we find that

$$R_0 = \frac{IR}{I_0 - I} = \frac{(12.0\text{ A})(8.00\ \Omega)}{15.0\text{ A} - 12.0\text{ A}} = \boxed{32\ \Omega}$$

41. ***REASONING AND SOLUTION*** The equivalent resistance of the circuit is

$$R_s = R_1 + R_2 = 36.0\ \Omega + 18.0\ \Omega = 54.0\ \Omega$$

Ohm's law for the circuit gives $I = V/R_s = (15.0\text{ V})/(54.0\ \Omega) = 0.278\text{ A}$

a. Ohm's law for R_1 gives $V_1 = (0.278\text{ A})(36.0\ \Omega) = \boxed{10.0\text{ V}}$

b. Ohm's law for R_2 gives $V_2 = (0.278\text{ A})(18.0\ \Omega) = \boxed{5.00\text{ V}}$

42. ***REASONING*** Since the two resistors are connected in series, they are equivalent to a single equivalent resistance that is the sum of the two resistances, according to Equation 20.16. Ohm's law (Equation 20.2) can be applied with this equivalent resistance to give the battery voltage.

SOLUTION According to Ohm's law, we find

$$V = IR_s = I\left(R_1 + R_2\right) = \left(0.12\text{ A}\right)\left(47\,\Omega + 28\,\Omega\right) = \boxed{9.0\text{ V}}$$

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43. SSM ***REASONING*** The equivalent series resistance R_s is the sum of the resistances of the three resistors. The potential difference V can be determined from Ohm's law as $V = IR_s$.

SOLUTION
a. The equivalent resistance is

$$R_s = 25\ \Omega + 45\ \Omega + 75\ \Omega = \boxed{145\ \Omega}$$

b. The potential difference across the three resistors is

$$V = IR_s = (0.51\text{ A})(145\ \Omega) = \boxed{74\text{ V}}$$

45. SSM ***REASONING*** The resistance of one of the wires in the extension cord is given by

Equation 20.3: $R = \rho L / A$, where the resistivity of copper is $\rho = 1.72 \times 10^{-8}\ \Omega\cdot\text{m}$, according to Table 20.1. Since the two wires in the cord are in series with each other, their total resistance is $R_{\text{cord}} = R_{\text{wire 1}} + R_{\text{wire 2}} = 2\rho L / A$. Once we find the equivalent resistance of the entire circuit (extension cord + trimmer), Ohm's law can be used to find the voltage applied to the trimmer.

SOLUTION
a. The resistance of the extension cord is

$$R_{\text{cord}} = \frac{2\rho L}{A} = \frac{2(1.72\times10^{-8}\ \Omega\cdot\text{m})(46\text{ m})}{1.3\times10^{-6}\text{ m}^2} = \boxed{1.2\ \Omega}$$

b. The total resistance of the circuit (cord + trimmer) is, since the two are in series,

$$R_s = 1.2\ \Omega + 15.0\ \Omega = 16.2\ \Omega$$

Therefore from Ohm's law (Equation 20.2: $V = IR$), the current in the circuit is

$$I = \frac{V}{R_s} = \frac{120\text{ V}}{16.2\ \Omega} = 7.4\text{ A}$$

Finally, the voltage applied to the trimmer alone is (again using Ohm's law),

$$V_{\text{trimmer}} = (7.4\text{ A})(15.0\ \Omega) = \boxed{110\text{ V}}$$

48. ***REASONING AND SOLUTION*** The rule for combining parallel resistors is

$$\frac{1}{R_P}=\frac{1}{R_1}+\frac{1}{R_2}$$

which gives

$$\frac{1}{R_2}=\frac{1}{R_P}-\frac{1}{R_1}=\frac{1}{115\,\Omega}-\frac{1}{155\,\Omega} \qquad \text{or} \qquad \boxed{R_2=446\,\Omega}$$

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49. SSM ***REASONING AND SOLUTION*** Since the circuit elements are in parallel, the equivalent resistance can be obtained directly from Equation 20.17:

$$\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{16\,\Omega}+\frac{1}{8.0\,\Omega} \qquad \text{or} \qquad \boxed{R_p=5.3\,\Omega}$$

52. ***REASONING*** When the switch is open, no current goes to the resistor R_2. Current exists only in R_1, so it is the equivalent resistance. When the switch is closed, current is sent to both resistors. Since they are wired in parallel, we can use Equation 20.17 to find the equivalent resistance. Whether the switch is open or closed, the power P delivered to the circuit can be found from the relation $P=V^2/R$ (Equation 20.6c), where V is the battery voltage and R is the equivalent resistance.

SOLUTION

a. When the switch is open, there is current only in resistor R_1. Thus, the equivalent resistance is $R_1=\boxed{65.0\,\Omega}$.

b. When the switch is closed, there is current in both resistors and, furthermore, they are wired in parallel. The equivalent resistance is

$$\frac{1}{R_P}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{65.0\,\Omega}+\frac{1}{96.0\,\Omega} \qquad \text{or} \qquad R_P=\boxed{38.8\,\Omega} \qquad (20.17)$$

c. When the switch is open, the power delivered to the circuit by the battery is given by $P=V^2/R_1$, since the only resistance in the circuit is R_1. Thus, the power is

$$P=\frac{V^2}{R_1}=\frac{(9.00\text{ V})^2}{65.0\,\Omega}=\boxed{1.25\text{ W}} \qquad (20.6)$$

d. When the switch is closed, the power delivered to the circuit is $P=V^2/R_P$, where R_P is the equivalent resistance of the two resistors wired in parallel:

$$P=\frac{V^2}{R_P}=\frac{(9.00\text{ V})^2}{38.8\,\Omega}=\boxed{2.09\text{ W}} \qquad (20.6)$$