This print-out should have 11 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

**Resistance and Resistivity**  
001 10.0 points

A wire is made of a material with a resistivity of $1.6148 \times 10^{-8} \, \Omega \cdot \text{m}$. It has length $3.96051 \, \text{m}$ and diameter $0.30576 \, \text{mm}$.

What is the resistance of the wire?

Correct answer: $0.871001 \, \Omega$.

Explanation:

Let:

\[
\rho = 1.6148 \times 10^{-8} \, \Omega \cdot \text{m}, \\
\ell = 3.96051 \, \text{m}, \quad \text{and} \\
r = 0.15288 \, \text{mm} = 0.00015288 \, \text{m}.
\]

\[
R = \rho \frac{\ell}{A} = \frac{\rho \ell}{\pi r^2} = \frac{(1.6148 \times 10^{-8} \, \Omega \cdot \text{m})(3.96051 \, \text{m})}{\pi (0.00015288 \, \text{m})^2} = 0.871001 \, \Omega.
\]

**Electron Flow**  
002 (part 1 of 2) 10.0 points

The potential difference in a simple circuit is $11 \, \text{V}$ and the resistance is $6 \, \Omega$.

What current flows in the circuit?

Correct answer: $1.83333 \, \text{A}$.

Explanation:

Let:

\[
V = 11 \, \text{V} \quad \text{and} \\
R = 6 \, \Omega.
\]

The current is

\[
I = \frac{V}{R} = \frac{11 \, \text{V}}{6 \, \Omega} = 1.83333 \, \text{A}.
\]

**003 (part 2 of 2) 10.0 points**

How many electrons pass a given point in the circuit in $6 \, \text{min}$? The fundamental charge is $1.602 \times 10^{-19} \, \text{C}$.

Correct answer: $4.11985 \times 10^{21}$.

Explanation:

Let:

\[
I = 1.83333 \, \text{A}, \\
t = 6 \, \text{min} = 360 \, \text{s}, \quad \text{and} \\
e = 1.602 \times 10^{-19} \, \text{C}.
\]

\[
I = \frac{q}{t} \quad \text{and the total charge for } n \, \text{electrons is}
\]

\[
q = ne = \frac{It}{e} = \frac{(1.83333 \, \text{A})(360 \, \text{s})}{1.602 \times 10^{-19} \, \text{C}} = 4.11985 \times 10^{21}.
\]

**Serway CP 17 30**  
004 10.0 points

A platinum resistance thermometer has a resistance of $200 \, \Omega$ when placed in an ice $0^\circ \text{C}$ bath and $88.4 \, \Omega$ when immersed in a crucible containing a melting substance.

What is the melting point of the substance? The temperature coefficient of the platinum is $0.00392 \, (\circ \text{C})^{-1}$. The resistor was calibrated at a temperature of $20^\circ \text{C}$.

Correct answer: $-131.187^\circ \text{C}$.

Explanation:

Let:

\[
T_0 = 20^\circ \text{C}, \\
R_1 = 200 \, \Omega, \\
T_1 = 0^\circ \text{C}, \\
R = 88.4 \, \Omega, \quad \text{and} \\
\alpha = 0.00392 \, (\circ \text{C})^{-1}.
\]

The resistance at $20^\circ \text{C}$ is

\[
R_0 = \frac{R_1}{1 + \alpha(T_1 - T_0)} = \frac{200 \, \Omega}{1 + [0.00392(\circ \text{C})^{-1}] (0^\circ \text{C} - 20^\circ \text{C})} = 217.014 \, \Omega,
\]
and

\[
R = R_0 \left[ 1 + \alpha (T - T_0) \right] \\
= R_0 + R_0 \alpha (T - T_0) \\
T - T_0 = \frac{R - R_0}{\alpha R_0} \\
T = T_0 + \frac{R - R_0}{\alpha R_0} \\
T = 20^\circ C \\
\quad + \frac{88.4 \Omega - 217.014 \Omega}{[0.00392(\circ C)^{-1}] (217.014 \Omega)} \\
= -131.187^\circ C.
\]

006 (part 2 of 2) 10.0 points

What must be the diameter of the wire?

Correct answer: 0.822362 mm.

Explanation:

The cross-sectional area of the wire is

\[
A = \pi \left( \frac{d}{2} \right)^2 = \frac{V}{L},
\]

so the diameter is

\[
d = \sqrt{\frac{4V}{\pi L}} \\
= \sqrt{\frac{4(7.25446 \times 10^{-6} \text{ m}^3)}{\pi (13.6581 \text{ m})}} \frac{1 \text{ mm}}{1 \text{ m}} \\
= 0.822362 \text{ mm}.
\]

Adding a Resistor

007 10.0 points

A loop circuit has a resistance of \( R_1 \) and a current of 2.1 A. The current is reduced to 1.4 A when an additional 1.5 \( \Omega \) resistor is added in series with \( R_1 \).

What is the value of \( R_1 \)? Assume the internal resistance of the source of \( \text{emf} \) is zero.

Correct answer: 3 \( \Omega \).

Explanation:

Let : \( I_1 = 2.1 \text{ A}, \)
\( I_2 = 1.4 \text{ A}, \) and
\( R_2 = 1.5 \text{ \( \Omega \).} \)

Let the current with \( R_1 \) be \( I_1 \) and the current with additional resistance \( R_2 \) be \( I_2 \). Then
since the *emf* is a constant and the internal resistance of the battery is zero, we have

\[
I_1 R_1 = I_2 (R_1 + R_2)
\]

\[
I_1 R_1 = I_2 R_1 + I_2 R_2
\]

\[
R_1 = \frac{I_2}{I_1 - I_2} R_2
\]

\[
= \frac{1.4 \text{ A}}{2.1 \text{ A} - 1.4 \text{ A}} (1.5 \Omega)
\]

\[
= 3 \Omega.
\]

Serway CP 18 06
008 10.0 points

Consider the circuit

![Circuit Diagram]

Find the equivalent resistance.

Correct answer: 22.6975 Ω.

**Explanation:**

Let : $R_1 = 19 \Omega$, $R_2 = 8 \Omega$, $R_3 = 13.8 \Omega$, and $R_4 = 13.7 \Omega$.

$R_2$, $R_3$ and $R_4$ are in parallel, so

\[
\frac{1}{R_{234}} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}
\]

Since

\[
R_3 + R_4 + R_2 R_3
\]

\[
= (13.8 \Omega) (13.7 \Omega) + (8 \Omega) (13.7 \Omega)
\]

\[
+ (8 \Omega) (13.8 \Omega) = 409.06 \Omega,
\]

then

\[
R_{234} = \frac{(8 \Omega) (13.8 \Omega) (13.7 \Omega)}{409.06} = 3.69745 \Omega.
\]

$R_1$ and $R_{234}$ are in series, so

\[
R_{eq} = R_1 + R_{234} = 19 \Omega + 3.69745 \Omega
\]

\[
= 22.6975 \Omega.
\]

Triple the Current
009 10.0 points

The current in a circuit is tripled by connecting a 564 Ω resistor parallel with the resistance of the circuit.

Determine the resistance of the circuit in the absence of the 564 Ω resistor.

Correct answer: 1128 Ω.

**Explanation:**

Let : $R_1 = 564 \Omega$.

If the initial resistance is $R$ and the added resistance is $R_1$ we have

\[
\frac{3}{R} = \frac{1}{R} + \frac{1}{R_1}
\]

\[
\frac{2}{R} = \frac{1}{R_1}
\]

\[
R = 2R_1 = 2(564 \Omega) = 1128 \Omega
\]

Currents in a Circuit
010 (part 1 of 2) 10.0 points
The currents are flowing in the direction indicated by the arrows. A negative current denotes flow opposite to the direction of the arrow. Assume the batteries have zero internal resistance.

Find the current through the 17.7 Ω resistor and the 5 V battery at the top of the circuit.

Correct answer: 0.881356 A.

Explanation:

Let: \( R_1 = 17.7 \, \Omega \), \( R_2 = 20 \, \Omega \), \( \mathcal{E}_1 = 5 \, V \), and \( \mathcal{E}_2 = 10.6 \, V \).

Then, for the upper circuit

\[
\mathcal{E}_1 - I_2 R_2 - I_1 R_1 = 0 \\
\mathcal{E}_1 + \mathcal{E}_2 - I_1 R_1 = 0
\]

\[
I_1 = \frac{\mathcal{E}_1 + \mathcal{E}_2}{R_1} = \frac{5 \, V + 10.6 \, V}{17.7 \, \Omega} = 0.881356 \, A.
\]

Alternate Solution: Using the outside loop

\[
-\mathcal{E}_1 - \mathcal{E}_2 + I_1 R_1 = 0
\]

\[
I_1 = \frac{\mathcal{E}_1 + \mathcal{E}_2}{R_1}.
\]

Find the current through the 20 Ω resistor in the center of the circuit.

Correct answer: -0.53 A.

Explanation:

From Eq. (2)

\[
I_2 = -\frac{\mathcal{E}_2}{R_2} = -\frac{-10.6 \, V}{20 \, \Omega} = -0.53 \, A.
\]