Questions and Problems from Serway

- Question 28.6

  Solution

  Electrical power transmission takes place at high voltage, on the order of 100 kV, at rms currents on the order of 100 A. Assuming a pure copper wire of cross sectional area 0.002 m and resistivity $\rho = 1.7 \times 10^{-8}$ Ω·m, the potential difference between two points A and B on the wire separated by distance d is

$$\begin{aligned}\Delta V = V_{\mathsf{B}} - V_{\mathsf{B}} &= IR \\ &= I\rho\frac{d}{A} \\ &= \frac{(100)(1.7 \times 10^{-8})}{0.002}d \\ &= 0.001d\end{aligned}$$

  If the bird's feet are 0.02 m apart, this is a potential difference of only 2×10^{-5} V. Even at the 100 A current in the wire itself, the power is a mere $\mathscr{P} = IV = (100)(2 \times 10^{-5}) = 0.002$ W. The current through the bird can be assumed to be much smaller than that through copper wire.

- Question 28.14

  Solution

  The bulb will glow with decreasing intensity until the capacitor is fully charged, at which point it will extinguish.

- Question 28.16

  Solution

  There is a better safety factor with lower voltage, but the higher voltage requires thinner conductors. Higher voltage also has the advantage of a smaller step-down from transmission voltage levels.

- Problem 28.1

  Solution

The resistance R of the load resistor is given by

$$\begin{aligned} R &= \frac{\Delta V}{I} \\ &= \frac{\Delta V \cdot \Delta V}{\mathscr{P}} \\ &= \frac{(11.6)^2}{20.0} \\ &= \boxed{6.73\ \Omega}. \end{aligned}$$

Since the emf must equal the sum of all voltage drops, then the internal resistance

$$\begin{aligned} r &= \frac{\mathcal{E} - IR}{I} \\ &= \frac{(\mathcal{E} - \Delta V)R}{\Delta V} \\ &= \frac{(15.0 - 11.6)(6.73)}{11.6} \\ &= \boxed{1.97\ \Omega}. \end{aligned}$$

- Problem 28.7

  Solution

  After redrawing the circuit, the equivalent resistance is found to be 12.94 Ω. Working backwards, we can find individual currents and voltage drops in each resistor. The current through the 25.0-Ω line is $\boxed{0.227\ \text{A}}$. The potential difference between points A and B is $\boxed{5.68\ \text{V}}$.

- Problem 28.15

  Solution

  Once again, this is a problem of equivalent resistance. It is not necessary to use all the steps for applying Kirchhoff's Rules, although they will certainly work. The equivalent resistance is found to be 6.75 Ω, and then working backwards we can find the powers:

$$\begin{aligned} \mathscr{P}_{1.00\,\Omega} &= \boxed{4.00\ \text{W}}; \\ \mathscr{P}_{2.00\,\Omega} &= \boxed{14.2\ \text{W}}; \\ \mathscr{P}_{3.00\,\Omega} &= \boxed{1.33\ \text{W}}; \\ \mathscr{P}_{4.00\,\Omega} &= \boxed{28.4\ \text{W}}. \end{aligned}$$

- Problem 28.17

  Solution

  This is a problem for Kirchhoff's Rules. The currents are

$$\begin{aligned} I_{\text{left}} &= \boxed{0.846\ \text{A}}; \\ I_{\text{center}} &= \boxed{0.462\ \text{A}}; \\ I_{\text{right}} &= \boxed{1.31\ \text{A}}. \end{aligned}$$

- Problem 28.25

  Solution

  Once again, use Kirchhoff's Rules. The current in the 2.00-Ω resistor is $\boxed{0.909\ \text{A}}$ and $V_{\text{a}} - V_{\text{b}} = \boxed{1.82\ \text{V}}$.

- Problem 28.27

  Solution

  The time constant is simply $\tau = RC = (1.00 \times 10^6)(5.00 \times 10^{-6}) = \boxed{5\text{s}}$. The charge on the fully charged capacitor is at 30 V is $Q = C\Delta V = (5.00 \times 10^{-6})(30) = \boxed{150\ \mu\text{C}}$. Ten seconds after the switch is thrown, the current is

$$\begin{aligned} I &= \frac{\mathcal{E}}{R} e^{-t/\tau} \\ &= \left(\frac{30}{1.00 \times 10^6} \right) e^{-10/5} \\ &= \boxed{4.06\ \mu\text{A}}. \end{aligned}$$

- Problem 28.31

  Solution

  Since the circuit has been connected for a long time, the capacitor is fully charged and constitutes a break in the circuit. Neglecting that branch, this becomes simply a problem of equivalent resistance, found to be 3.33 Ω. Working backwards, we may then find the voltage on either side of the capacitor, and calculate the potential difference across it: $\boxed{6.00\ \text{V}}$.

  When the battery is removed, to return to the negative plate, the positive charge on the positive plate of the capacitor must navigate through a network where the resistors

previously in parallel are now in series, and those previously in series are now in parallel. In this configuration, the equivalent resistance is 3.60 Ω. Solving for t in

$$q = Qe^{-t/RC}$$

we have

$$\begin{aligned} t &= -RC \ln \frac{q}{Q} \\ &= -(3.60)(1.00 \times 10^{-6}) \ln \frac{1}{10} \\ &= \boxed{9.29\ \mu\text{s}}. \end{aligned}$$

- Problem 28.61

  Solution

  When the capacitor is fully charged, current only flows through the left-hand loop of the circuit. When the switch is disconnected, the capacitor discharges through only the right hand loop. The currents are thus

$$\begin{aligned} I_{12.0\,\text{k}\Omega} &= \boxed{0.333\ \text{mA}}; \\ I_{15.0\,\text{k}\Omega} &= \boxed{0.333\ \text{mA}}; \\ I_{3.0\,\text{k}\Omega} &= \boxed{0\ \text{A}}. \end{aligned}$$

  The charge on the capacitor may be found by inserting the voltage drop across the 15.0-kΩ resistor into

$$\begin{aligned} Q &= C\Delta V \\ &= CIR \\ &= (1 \times 10^{-5})(0.333)(1.5 \times 10^{4}) \\ &= \boxed{50\ \mu\text{C}}. \end{aligned}$$