(44 Points) HW #8 Solutions
Physics 23, Fall 06

(6 points)

E31-8 $(5.0\,\mathrm{A})R_1 = \Delta V$. $(4.0\,\mathrm{A})(R_1 + 2.0\,\Omega) = \Delta V$. Combining, $5R_1 = 4R_1 + 8.0\,\Omega$, or $R_1 = 8.0\,\Omega$.

E31-22 Combining n identical resistors in series results in an equivalent resistance of $r_{\mathrm{eq}} = nR$. Combining n identical resistors in parallel results in an equivalent resistance of $r_{\mathrm{eq}} = R/n$. If the resistors are arranged in a square array consisting of n parallel branches of n series resistors, then the effective resistance is R. Each will dissipate a power P, together they will dissipate n^2P.

So we want nine resistors, since four would be too small.

E31-38 $r = \rho L/A = (3.5\times10^{-5}\Omega\cdot\mathrm{m})(1.96\times10^{-2}\mathrm{m})/\pi(5.12\times10^{-3}\mathrm{m})^2 = 8.33\times10^{-3}\Omega$.

(a) $i = \sqrt{P/r} = \sqrt{(1.55\,\mathrm{W})/(8.33\times10^{-3}\Omega)} = 13.6\,\mathrm{A}$, so (4 points)

$$j = i/A = (13.6\,\mathrm{A})/\pi(5.12\times10^{-3}\mathrm{m})^2 = 1.66\times10^{5}\mathrm{A/m^2}.$$

(b) $\Delta V = \sqrt{Pr} = \sqrt{(1.55\,\mathrm{W})(8.33\times10^{-3}\Omega)} = 0.114\,\mathrm{V}$. (2 points)

E31-44 (a) $\Delta V = \mathcal{E}(1 - e^{-t/\tau_C})$, so (2 points)

$$\tau_C = -(1.28\times10^{-6}\mathrm{s})/\ln(1 - 5.00\,\mathrm{V}/13.0\,\mathrm{V}) = 2.64\times10^{-6}\mathrm{s}$$

(b) $C = \tau_C/R = (2.64\times10^{-6}\mathrm{s})/(15.2\times10^{3}\Omega) = 1.73\times10^{-10}\mathrm{F}$ (2 points)

E31-45 (a) $\Delta V = \mathcal{E}e^{-t/\tau_C}$, so

$$\tau_C = -(10.0\,\mathrm{s})/\ln(1.06\,\mathrm{V}/100\,\mathrm{V}) = 2.20\,\mathrm{s}$$

(b) $\Delta V = (100\,\mathrm{V})e^{-17\,\mathrm{s}/2.20\,\mathrm{s}} = 4.4\times10^{-2}\mathrm{V}$.

E31-46 $\Delta V = \mathcal{E}e^{-t/\tau_C}$ and $\tau_C = RC$, so (6 points)

$$R = -\frac{t}{C\ln(\Delta V/\Delta V_0)} = -\frac{t}{(220\times10^{-9}\mathrm{F})\ln(0.8\,\mathrm{V}/5\,\mathrm{V})} = \frac{t}{4.03\times10^{-7}\mathrm{F}}.$$

If t is between $10.0\,\mu\mathrm{s}$ and $6.0\,\mathrm{ms}$, then R is between

$$R = (10\times10^{-6}\mathrm{s})/(4.03\times10^{-7}\mathrm{F}) = 24.8\Omega,$$

and

$$R = (6\times10^{-3}\mathrm{s})/(4.03\times10^{-7}\mathrm{F}) = 14.9\times10^{3}\Omega.$$

P31-2 Traversing the circuit we have (6 points)

$$\mathcal{E} - ir_1 + \mathcal{E} - ir_2 - iR = 0,$$

so $i = 2\mathcal{E}/(r_1 + r_2 + R)$. The potential difference across the first battery is then

$$\Delta V_1 = \mathcal{E} - ir_1 = \mathcal{E}\left(1 - \frac{2r_1}{r_1 + r_2 + R}\right) = \mathcal{E}\frac{r_2 - r_1 + R}{r_1 + r_2 + R}$$

This quantity will only vanish if $r_2 - r_1 + R = 0$, or $r_1 = R + r_2$. Since $r_1 > r_2$ this is actually possible; $R = r_1 - r_2$.

P31-10 We can assume that R "contains" all of the resistance of the resistor, the battery and the ammeter, then

$$R = (1.50\,\text{V})/(1.0\,\text{m/A}) = 1500\,\Omega.$$

For each of the following parts we apply $R + r = \Delta V/i$, so

(8 points)

(a) $r = (1.5\,\text{V})/(0.1\,\text{mA}) - (1500\,\Omega) = 1.35 \times 10^4\Omega$,
(b) $r = (1.5\,\text{V})/(0.5\,\text{mA}) - (1500\,\Omega) = 1.5 \times 10^3\Omega$,
(c) $r = (1.5\,\text{V})/(0.9\,\text{mA}) - (1500\,\Omega) = 167\Omega$.
(d) $R = (1500\,\Omega) - (18.5\,\Omega) = 1482\,\Omega$

ddle and the right is

P31-12 $\Delta V_1 + \Delta V_2 = \Delta V_S + \Delta V_X$; if $V_a = V_b$, then $\Delta V_1 = \Delta V_S$. Using the first expression,

$$i_a(R_1 + R_2) = i_b(R_S + R_X),$$

(8 points)

using the second,

$$i_a R_1 = i_b R_2.$$

Dividing the first by the second,

$$1 + R_2/R_1 = 1 + R_X/R_S,$$

or $R_X = R_S(R_2/R_1)$.