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Department of Physics and Astronomy

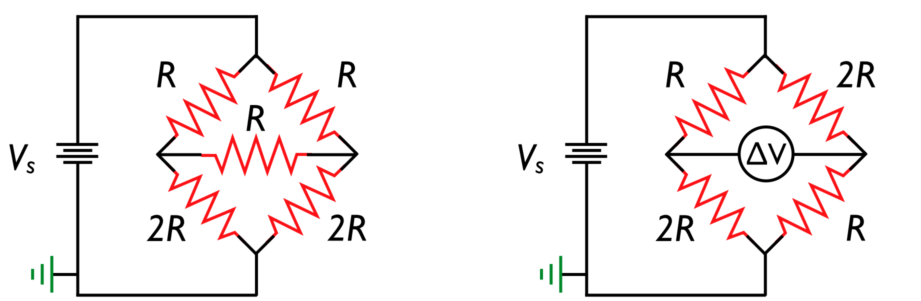
PH 102 Spring 2015

Exam 2

Instructions

1. Solve three of the four problems below.
2. All problems have equal weight. Do your work on separate sheets.
3. You are allowed 1 sheet of standard 8.5×11 in paper and a calculator.

□ **1. Symbolic solution (a)** Consider the "bridge" arrangement of resistors in Fig. 1a. This is an example of an arrangement which cannot be reduced to a single equivalent using only our rules for series and parallel resistance. In this circuit, what is the current through the central (horizontal) resistor? **(b)** In Fig. 1b, two resistors have been swapped, and the central resistor removed. What voltage does the voltmeter read in this case, in terms of the source voltage V_s? (You do not need to know R; think about proportions.) **(c)** For the circuit in Fig. 1b, what is the total current leaving the battery?



(a) *Find I for the central resistor.* **(b)** *What does the voltmeter read?*

Figure 1: *Problem 1*

□ **2.** A heater coil uses a 3 m length of wire which is 1 mm diameter (approximately 18 gauge). The wire is made of copper with a resistivity of $\rho = 1.6 \times 10^{-8}\,\Omega \cdot \text{m}$. **(a)** What is the resistance of the wire? The area of a circle is $\pi r^2 = \pi d^2/4$. **(b)** What is the current through the heater coil if it is connected to a 120 V voltage source? **(c)** What is the power dissipated in the heater? **(d)** If the density of electrons in copper is $n = 8.47 \times 10^{28}\,/\text{m}^3$, how long does it take a single electron to make the 3 m journey through the heater?

□ **3.** What is the current through the center 9 V battery in the circuit below?

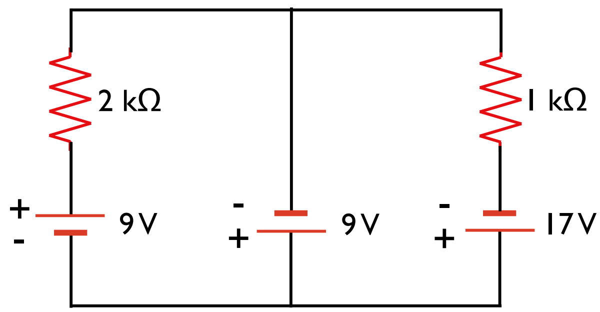
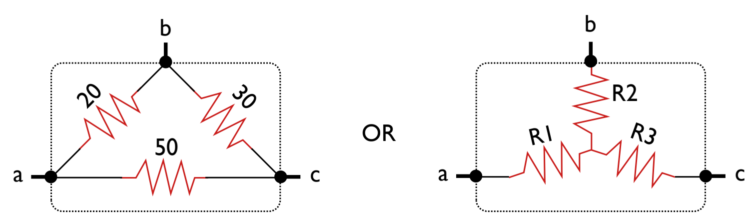


Figure 2: *Problem 2*

□ **4.** Referring to the figure at left below, a black box with three terminals, a, b, and c, contains nothing but three resistors and connecting wire. You measure the resistance between pairs of terminals, R_{ab}, R_{ac}, and R_{bc}.

What resistances $R1$, $R2$, and $R3$ for the box at right below would give the same measurements, R_{ab}, R_{ac}, and R_{bc}.?



Constants:

$$k_e \equiv 1/4\pi\epsilon_o = 8.98755 \times 10^9\,\mathrm{N\cdot m^2\cdot C^{-2}}$$
$$\epsilon_o = 8.85 \times 10^{-12}\,\mathrm{C^2/N\cdot m^2}$$
$$e = 1.60218 \times 10^{-19}\,\mathrm{C}$$

Power	Prefix	Abbreviation
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T

Current/resistors/circuits:

$$\begin{aligned}
I &= \frac{\Delta Q}{\Delta t} = nqAv_d \\
J &= \frac{I}{A} = nqv_d \\
v_d &= -\frac{e\tau}{m}E \qquad \tau = \text{scattering time} \\
\varrho &= \frac{m}{ne^2\tau} \\
\Delta V &= \frac{\varrho l}{A} I = RI \\
R &= \frac{\Delta V}{I} = \frac{\varrho l}{A} \\
\mathscr{P} &= I\Delta V = I^2 R = \frac{[\Delta V]^2}{R} \quad \text{power} \\
R_{\text{eq, series}} &= R_1 + R_2 \\
\frac{1}{R_{\text{eq, par}}} &= \frac{1}{R_1} + \frac{1}{R_2}
\end{aligned}$$

Unit	Symbol	equivalent to
newton	N	$\mathrm{kg\cdot m/s^2}$
joule	J	$\mathrm{kg\cdot m^2/s^2} = \mathrm{N\cdot m}$
watt	W	$\mathrm{J/s = m^2\cdot kg/s^3}$
coulomb	C	$\mathrm{A\cdot s}$
amp	A	$\mathrm{C/s}$
volt	V	$\mathrm{W/A = m^2\cdot kg/\cdot s^3\cdot A}$
farad	F	$\mathrm{C/V = A^2\cdot s^4/m^2\cdot kg}$
ohm	Ω	$\mathrm{V/A = m^2\cdot kg/s^3\cdot A^2}$
tesla	T	$\mathrm{Wb/m^2} = \mathrm{kg/s^2\cdot A}$
electron volt	eV	$1.6 \times 10^{-19}\,\mathrm{J}$
-	$1\,\mathrm{T\cdot m/A}$	$1\,\mathrm{N/A^2}$
-	$1\,\mathrm{T\cdot m^2}$	$1\,\mathrm{V\cdot s}$
-	$1\,\mathrm{N/C}$	$1\,\mathrm{V/m}$