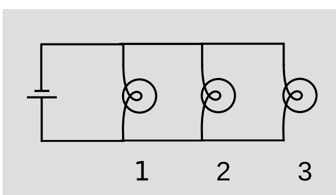
Practice Exam C for Physics 222 — covering Physics 221 and Fields and Circuits ch. 1-9

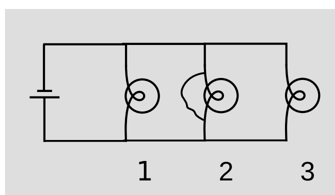
1 Measurements show that when a voltage difference of 38 mV is applied across a certain resistor, a current of 42 μA flows. Find the resistance.

2 Each of the following statements shows a basic misconception about physics. Explain what is wrong with each one. You do not have to have any specialized knowledge about any of the devices or situations described. You do not necessarily need to rewrite the statements to make them correct, but that would be one very good way to show you understand what was wrong with them.
(a) In a complete circuit, voltage is able to flow all the way around to where it started.
(b) The heating element of an electric stove is a resistor. It gets hot because it has a lot of resistance.
(c) The electric company supplies power to my house through the wires strung between telephone poles. The system isn't perfectly efficient, so some charge is dissipated in the wires.

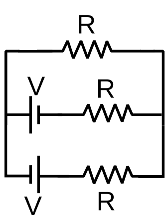
3 If you buy resistors from a store or a catalog, they are not actually available in every conceivable value. In the low kiloohm range, for example, the following values are ones that are most commonly manufactured: 1.0, 1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, 4.7, 5.6, 6.8, and 8.2 kΩ. When one needs some specific value of resistance that is not on the list, it becomes necessary to combine two or more resistors in some way so as to create the desired equivalent resistance. Suppose you have access to plenty of resistors in exactly the above values, but not in any other values. Find a way to make an equivalent resistance of about 1.3 kΩ. It doesn't have to be exact (the resistors have tolerance ranges anyway), but find a value that lies between 1.25 and 1.35 kΩ. (In real life, you would want to find the design that would use the minimum number of resistors, ideally just two. In this problem, however, feel free to use more if you find that easier.)

4 The first figure, on the left below, shows a battery lighting three lightbulbs. In the second, right-hand figure, an extra wire has been added. Describe what happens when the extra wire is added.





5 In the circuit below, let the currents in the top, middle, and bottom branch be I_1, I_2, and I_3, respectively, all defined to be positive if the current is to the right. Find the three currents.



Answer to problem 1
$R = (3.8 \times 10^{-2}\ \text{V})/(4.2 \times 10^{-5}\ \text{A}) = 900\ \Omega$.

Answer to problem 2
(a) Voltage doesn't flow anywhere. What flows is current.
(b) The heating element gets hot because it has a *low* resistance. The power dissipared in it is $P = IV = (V/R)V = V^2/R$, so a big resistance would give *less* power.
(c) Energy is dissipated (turned into heat energy). Charge can't be dissipated, because charge is conserved.

Answer to problem 3
There are many possible ways of doing this, and finding one just takes a little trial and error. One possibility is to use three 3.9 kΩ resistors in parallel.

Answer to problem 4
In the modified circuit, all of the wires are connected, and therefore all of the wires are at the same voltage. There is no voltage difference across any of the bulbs, and all three bulbs go out. This is a short circuit, and it will kill the battery and get hot.

Answer to problem 5
Let V_1 be the voltage drop across the top resistor, defined positive if the left side is higher in voltage, and define V_2 and V_3 similarly for the middle and bottom resistors. Ohm's law lets us eliminate these unwanted variables, since $V_1 = I_1 R$, etc. Kirchoff's loop rule for the top loop is $V_1 = V + V + V_2$, and applying Ohm's law to eliminate V_1 and V_2 gives

$$I_1 R = V + I_2 R.$$

Similarly, the loop rule for the outside loop is

$$I_1 R = -V + I_3 R.$$

We could also write down the loop rule for the bottom loop, but this would not be independent of the first two equations. We have three unknowns, so we need three equations. For our third equation, we use the junction rule:

$$I_1 + I_2 + I_3 = 0.$$

Solving the first equation for $I_1 = V/R + I_2$, we eliminate I_1 in the other two equations. This reduces the system to two equations in two unknowns:

$$\frac{2V}{R} + I_2 - I_3 = 0$$
$$\frac{V}{R} + 2I_2 + I_3 = 0.$$

Solving the first equation for I_3 gives $I_3 = 2V/R + I_2$. We plug this in to the second equation to eliminate I_3, and find

$$I_2 = -V/R.$$

Plugging this back in to the other equations then gives

$$I_3 = V/R$$

and

$$I_1 = 0.$$

With hindsight, this sort of makes sense. If no current flows through the top branch, then we get a consistent solution in which the bottom two branches act like a single-loop circuit with a voltage source $2V$ in series with a resistance $2R$.