Quiz # 2
Physics 222, Section 009
Feb. 1, 2007

---

1. In an *Ohm's Law* setup like the one you used last time, two resistors are connected to the power supply, once in the series configuration, and then another time in the parallel. The student who conducted the experiment neglected to label the readings as *series* and *parallel*, and got confused, which belongs to which. See if you can help that student by figuring out the equivalent resistance in each case, and then deciding which was which. In both cases the power supply gives out 6V, the reading of the current through the **first** combination was 3.4 on a scale setting of 100mA, and through the **second** combination the current was 5.6 on a scale setting of 10mA. In both cases the given readings are actual needle deflections that the student saw, i.e. **without conversion**, on a scale showing 10 at full-scale-deflection.

   Convert each deflection to a current reading, and determine which one belongs to parallel and which belongs to series:
   First combination was: ___________________, second combination was _______________.
   Choose the values of resistance that would reproduce these readings (in Ω):
   (a) 1340 and 2120.
   ✓(b) 220 and 850.
   (c) 70 and 90.
   (d) 310 and 760.
   (e) 420 and 100.

2. Mention the two uses of *Instrument Amplifiers* that we are going to investigate in today's experiment.

Solution

1. **(2.5 points)** We can do this in brute force way, and we can do it the smart way. Let's do it both ways, starting with the quick and "smart" way, then compare that with what we should get using the direct "not so smart" calculation. The first step in either case is to get the equivalent resistance. The first reading of current was 3.4 on a scale setting of 100mA. The scale setting used by the student in both cases had a full-scale deflection of 10, which means that the full scale deflection in the first reading corresponds to 100mA, and using simple proportionality, we can easily see that the 3.4 is actually 3.4 × 100 / 10 = 34mA, let's call this I_1. Moving now to the second current, where the scale is now 10mA. In this case, the current I_2, is 5.6 × 10 / 10 = 5.6mA. The voltage across the two combinations is the same, which means that the equivalent resistances are, R_{eq1} = 6V / 34mA = 176.5 Ω, and R_{eq2} = 6V / 5.6mA = 1071 Ω, respectively. One main implication one should always bear in mind regarding how we combine resistance, is that *the equivalent resistance for two resistors connected in parallel is less than either one of the two resistors individually, whereas the series combination gives an equivalent resistance equal to the sum, and hence larger than either one of the two resistances on its own*. This means that R_{eq1} is the parallel combination, and R_{eq2} the series combination.

   (2.5 points) Now, let's look at the options given, (a) gives two resistances that are greater than both equivalent resistances, and must therefore be discarded based on the above implication. (c) Gives a sum less than either one of the two R_{eq}'s, and is also discarded. (e) is discarded for the same reason. Now, (b) and (d) do give the right equivalent series resistance, so we should choose between them. We can use the parallel resistance to decide which. The parallel equivalent for the (b) pair is:

$$\frac{1}{R_p} = \frac{1}{220} + \frac{1}{850} \Rightarrow R_p = 174.8\Omega$$

   This is the right value, which means that **(b) is the answer**, but let's calculate the one from (d) anyway:

$$\frac{1}{R_p} = \frac{1}{310} + \frac{1}{760} \Rightarrow R_p = 220.2\Omega$$

   Now, what if we want to do this the long way (long way?? longer than this?? Well, you be the judge).

$$\frac{1}{R_p} = \frac{1}{176.5} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_s = 1071 = R_1 + R_2 \Rightarrow R_2 = 1071 - R_1 \Rightarrow \frac{1}{176.5} = \frac{1}{R_1} + \frac{1}{1071 - R_1} = \frac{1071}{1071R_1 - R_1^2}$$

$$\Rightarrow R_1^2 + 176.5 \times 1071 - 1071R_1 = 0$$

$$\Rightarrow R_1 = \frac{1071 \pm \sqrt{1071^2 - 4 \times 176.5 \times 1071}}{2} = 848.1\Omega \text{ or } 222.8\Omega$$

   Not too long I guess. I did skip a couple of steps though.

2. **(2.5 points per item)** Decreasing % disturbance, and increasing sensitivity.