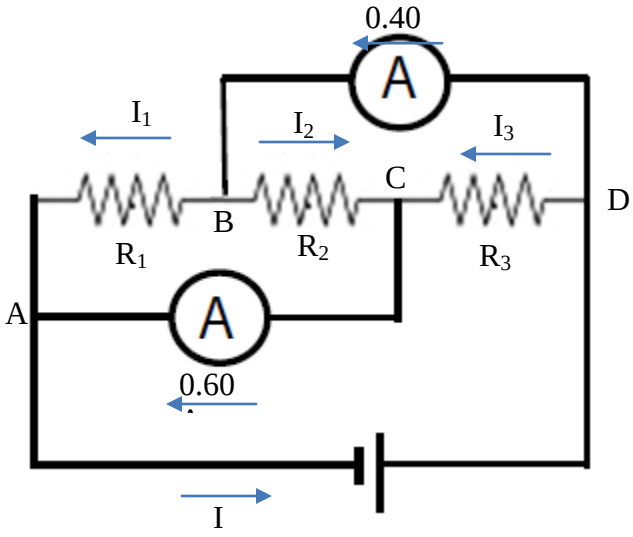
Physics Challenge for Teachers and Students

Solution to the April, 2017 Challenge**, Bait and switch.**

Since the ammeters are ideal, they behave just as wires, and *the three resistors are effectively in parallel*. Some this observation, it follows that:

- Each resistor will draw a current $I_i = \frac{V}{R_i}$. This current is not affected by any swapping of resistors that may occur.
- The current through the battery is $I = I_1 + I_2 + I_3$ and will not be affected by any swapping of resistors.
- The directions of the currents in each of the branches may be determined, and are shown below.

We may, without loss of generality, arbitrarily assign the given currents to individual ammeters.



By junction rule at B: $I_1 + I_2 = 0.40A$
By junction rule at C: $I_2 + I_3 = 0.60A$
If any two of the three resistors are swapped with each other, the remaining third resistor stays in place, and the current through the corresponding branch is unchanged. By the two junction rule equations, if any one of the three currents is unchanged, so will the other two. This implies that the two swapped resistors must have equal resistance and carry equal currents.
The swapped resistors could not possibly be R_1 and R_3, because that would imply $R_1 = R_3$ and by symmetry, the two ammeters would have identical readings.

We investigate what happens for each remaining possibility:
If R_1 does not move: From the reasoning above, $I_2 = I_3$. This and the two junction rule equations yield $I_2 = I_3 = 0.30A$, $I_1 = 0.10A$, and $I = I_1 + I_2 + I_3 = 0.70A$.
If R_3 does not move: $I_1 = I_2$. This and the two junction rule equations yield $I_1 = I_2 = 0.20A$, $I_3 = 0.40A$, and $I = I_1 + I_2 + I_3 = 0.80A$.

In conclusion, we observe that the question does not specify which two resistors are swapped. The two outside resistors could not possibly be the swapped resistors as this would reverse the asymmetry of the circuit and reverse the readings of the ammeters.

If the two swapped resistors are the ones on the left, the battery current is $0.80\ A$, and if the two swapped resistors are the ones on the right, the battery current is $0.70\ A$.

(Submitted by Pascal Renault, John Tyler Community College, Midlothian, VA)

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Guidelines for contributors

- We ask that all solutions, preferably in Word format, be submitted to the dedicated email address ***challenges@aapt.org***. Each message will receive an automatic acknowledgment.
- If your name is—for instance—Sean Spicer, please name the file "**Spicer17May**" (do not include your first initial) when submitting the May 2017 solution.
- The subject line of each message should be the same as the name of the solution file.
- The deadline for submitting the solutions is the last day of the corresponding month.

– Each month, a representative selection of the successful solvers' names will be published in print and on the web.
– If you have a message for the Column Editor, you may contact him at ***korsunbo@post.harvard.edu***; however, please do not send your solutions to this address.

Many thanks to all contributors; we hope to hear from many more of you in the future.

As always, reader-contributed Challenges are very welcome.

Boris Korsunsky, Column Editor