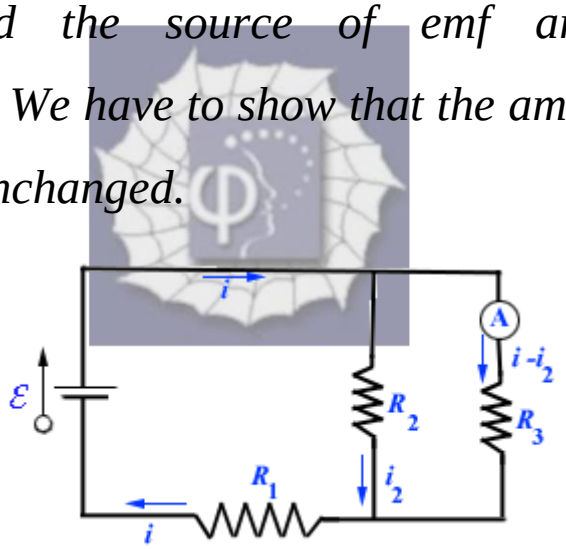
414.

Problem 33.39 (RHK)

In the circuit shown in the figure initially an ammeter is inserted in the branch containing R_3. *We have to calculate the current that the ammeter will read, assuming* $\mathrm{E} = 5.0\ \mathrm{V}$, $R_1 = 2.0\ \Omega$, $R_2 = 4.0\ \Omega$, *and* $R_3 = 6.0\ \Omega$. (b) *In the next part of the problem the ammeter and the source of emf are physically interchanged. We have to show that the ammeter reading will remain unchanged.*



Solution:

Data of the problem are

$\mathrm{E} = 5.0\ \mathrm{V}$, $R_1 = 2.0\ \Omega$, $R_2 = 4.0\ \Omega$, and $R_3 = 6.0\ \Omega$.

We note that in the circuit shown above the total resistance is the series sum of the resistance R_1 and that of the equivalent resistance of the resistances R_2 and R_3

connected in parallel. From Ohm's law we note that the current flowing out of the battery, the source of emf, will be

$$i = \frac{\mathrm{E}}{R_1 + \dfrac{R_2 R_3}{R_2 + R_3}}.$$

The current through the ammeter is $i - i_2$.

From the circuit shown above, we note that

$i_2 R_2 = (i - i_2) R_3$,

or

$$i_2 = \frac{iR_3}{R_2 + R_3}.$$

Therefore, the current measured by the ammeter will be

$$i - i_2 = i\left(1 - \frac{R_3}{R_2 + R_3}\right) = \frac{\mathrm{E}}{R_1 + \dfrac{R_2 R_3}{R_2 + R_3}} \times \left(1 - \frac{R_3}{R_2 + R_3}\right)$$

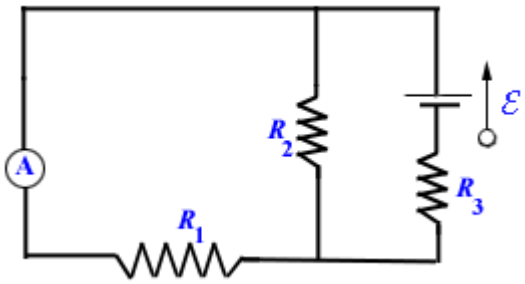
$$= \frac{\mathrm{E}R_2}{R_1 R_2 + R_1 R_3 + R_2 R_3}.$$

Substituting the data, we get

$$i - i_2 = \frac{20}{44}\ \mathrm{A} = 454\ \mathrm{mA}.$$

In the second part of the problem it is given that in the circuit the source of emf and the ammeter are physically

interchanged. The new circuit is as shown in the following figure.



Let us note that it is the same circuit as was the circuit for the first part of the problem except that resistances R_1 and R_3 have been interchanged. The expression for current through the ammeter calculated in the first part of the problem

$$i - i_2 = \frac{\mathrm{E}R_2}{R_1R_2 + R_1R_3 + R_2R_3},$$

is invariant with respect to the interchange $R_1 \in R_3$.

Therefore, the current measured by the ammeter will remain unchanged.