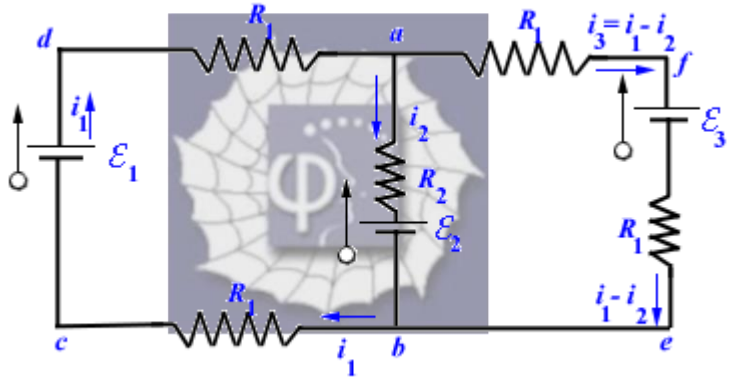
**413.**

**Problem 33.37 (RHK)**

*We have to calculate* (a) *the current through each source of emf in the circuit shown in the figure.* (b) *We have to calculate* $V_b - V_a$. *We may assume that* $R_1 = 1.20\ \Omega$, $R_2 = 2.30\ \Omega$, $\mathrm{E}_1 = 2.00\ \mathrm{V}$, $\mathrm{E}_2 = 3.80\ \mathrm{V}$, *and* $\mathrm{E}_3 = 5.00\ \mathrm{V}$.




**Solution:**

In the circuit shown above currents have been indicated in the different branches, and its multi-loops can be fixed by affixing labels to corners and intersections.

Data of the problem are

$R_1 = 1.20\ \Omega$, $R_2 = 2.30\ \Omega$, $\mathrm{E}_1 = 2.00\ \mathrm{V}$, $\mathrm{E}_2 = 3.80\ \mathrm{V}$

and $\mathrm{E}_3 = 5.00\ \mathrm{V}$.

(b)

We will solve this problem by applying Kirchoff's laws to different loops in the circuit.

Applying Kirchoff's laws to loops *dabcd* and *afeba*, we write the following two equations:

$$-i_1R_1 - i_2R_2 - \mathrm{E}_2 - i_1R_1 + \mathrm{E}_1 = 0,$$

or

$$2i_1R_1 + i_2R_2 = \mathrm{E}_1 - \mathrm{E}_2. \qquad (\mathrm{A})$$

and

$$-(i_1 - i_2)R_1 - \mathrm{E}_3 - (i_1 - i_2)R_1 + \mathrm{E}_2 + i_2R_2 = 0$$

or

$$-2i_1R_1 + 2i_2R_1 + i_2R_2 = \mathrm{E}_3 - \mathrm{E}_2 \ . \quad (\mathrm{B})$$

Solving equations $(\mathrm{A})$ and $(\mathrm{B})$, we find

$$i_2 = \frac{\mathrm{E}_1 + \mathrm{E}_3 - 2\mathrm{E}_2}{2(R_1 + R_2)},$$

and

$$i_1 = \frac{(R_2 + 2R_1)\mathrm{E}_1 - 2R_1\mathrm{E}_2 - R_2\mathrm{E}_3}{4R_1(R_1 + R_2)}.$$

Substituting the data given above, we find

$i_2 = -85.7$ mA,

and

$i_1 = -668$ mA.

The current flowing through $\mathrm{E}_3$ is

$i_1 - i_2 = -582.3$ mA.

As we are interested in the magnitudes of currents and not their directions, the currents flowing through $E_1$, $E_2$ and $E_3$ are 668 mA, 85.7 mA and 582.3 mA, respectively.

(a)

From the section *ba* of the circuit, we calculate $V_a - V_b$. We have

$$V_a - V_b = E_2 + i_2 R_2 = \left(3.80 - 85.7 \times 2.3 \times 10^{-3}\right) \text{ V}$$
$$= 3.60 \text{ V}.$$