5.11.1

AI25BTECH11002 - Ayush Sunil Labhade

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Question: Determine the loop currents in Fig. 5.11.1.1.

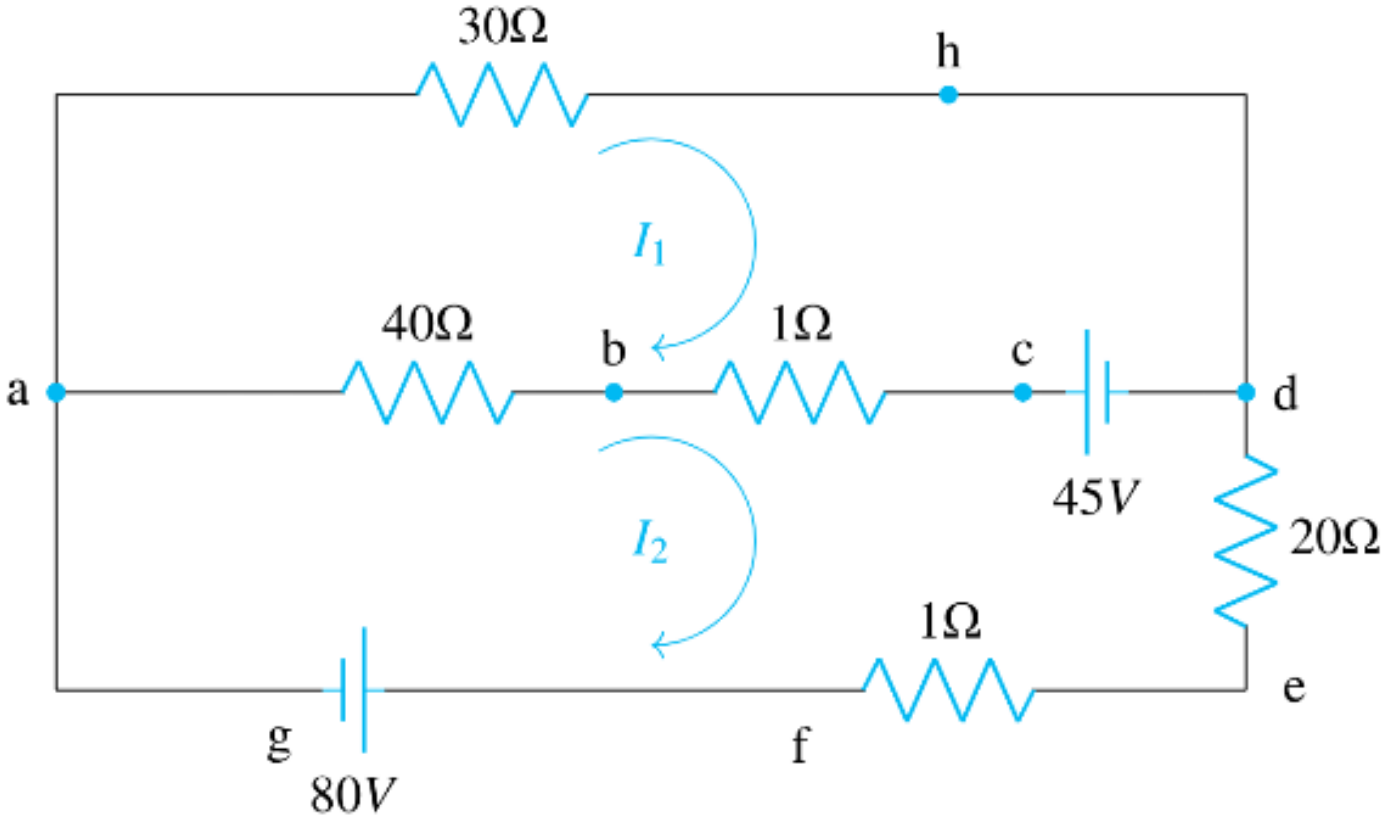

Fig. 5.11.1.1

Solution:

Using mesh current analysis with Kirchhoff's Voltage Law (KVL):

Let the loop currents be I_1 and I_2 as shown in Fig. 5.11.1.1.

Applying KVL to loop (a-b-c-d-h-a):

$$30I_1 + 40(I_1 - I_2) + 1(I_1 - I_2) - 45 = 0 \tag{0.1}$$

$$\Rightarrow 71I_1 - 41I_2 = 45 \tag{0.2}$$

Applying KVL to loop (a-b-c-d-e-f-g-a):

$$40(I_2 - I_1) + 1(I_2 - I_1) + 20I_2 + 1I_2 - 80 + 45 = 0 \tag{0.3}$$

$$\Rightarrow -41I_1 + 62I_2 = 35 \tag{0.4}$$

Hence, the two mesh equations are:

$$71I_1 - 41I_2 = 45 \tag{0.5}$$

$$-41I_1 + 62I_2 = 35 \tag{0.6}$$

Let

$$\mathbf{M} = \begin{pmatrix} 71 & -41 \\ -41 & 62 \end{pmatrix}, \quad \mathbf{x} = \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}, \quad \mathbf{V} = \begin{pmatrix} 45 \\ 35 \end{pmatrix}$$

$\therefore$ for finding I_1 and I_2

$$\mathbf{Mx} = \mathbf{V} \tag{0.7}$$

$$\begin{pmatrix} 71 & -41 \\ -41 & 62 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} 45 \\ 35 \end{pmatrix} \tag{0.8}$$

Solving by Row Transformations:

$$\left(\begin{array}{cc|c} 71 & -41 & 45 \\ -41 & 62 & 35 \end{array}\right) \tag{0.9}$$

Row Transformation-1: $R_2 \rightarrow 71R_2 + 41R_1$

$$\left(\begin{array}{cc|c} 71 & -41 & 45 \\ 0 & 2831 & 3820 \end{array}\right) I_2 = \frac{3820}{2831} = 1.35\,A \tag{0.10}$$

Substitute in (1):

$$71I_1 - 41(1.35) = 45 \tag{0.11}$$

$$\Rightarrow I_1 = 1.52\,A \tag{0.12}$$

$[I_1 = 1.52\,A, \quad I_2 = 1.35\,A]$