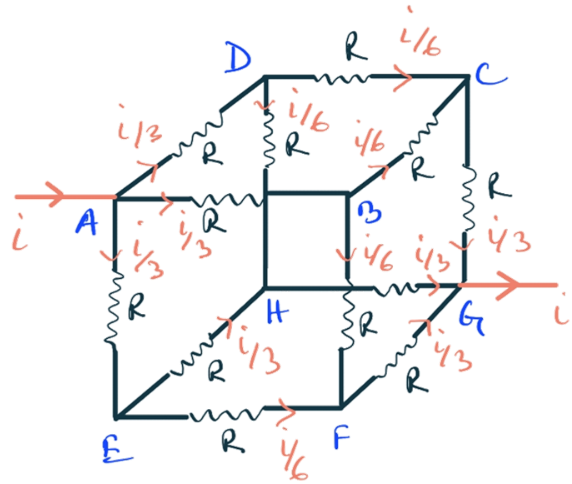
Quiz 1

BE - ECE113

Q1: Solution



Let the current i enter at the point A and leave at the point G. From KCL and by symmetry, the current i at A divides equally along AB, AD and AE. The current in each of these path is therefore $i/3$. Similarly, the current in the three paths HG, FG and CG, which meet at G, are each $i/3$.

Again the currents at B, E, and D devide into two equal parts, each being $i/6$. Thus, all currents in all the twelve resistances forming the cube are determined.

KVL can now be applied to any path between A & G. For example, choosing the path ABCG we have,

$$V = \frac{i}{3}R + \frac{i}{6}R + \frac{i}{3}R = \frac{5}{6}Ri$$

where V is the potential between A & G.

If the effective resistance between A & G is R_{eq}, then

$$V = R_{eq}\, i \Rightarrow \boxed{R_{eq} = \frac{5}{6}R}$$

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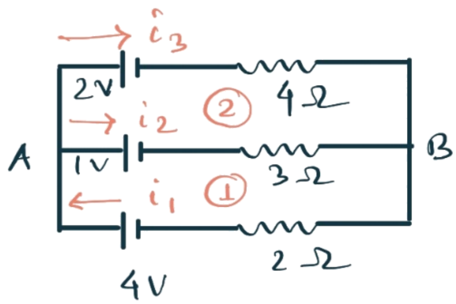
Q2: Solution



Let i_1, i_2, i_3 be the currents in the three branches as shown in fig.

Applying KCL at point A we obtain,

$$i_1 = i_2 + i_3 \quad \text{—(I)}$$

We need two more independent eqns to solve for the three unknowns i_1, i_2, i_3

These are obtained by applying KVL to loop 1 & 2.

For loop 1

$$4 = 1 + 3i_2 + 2i_1$$

$$\Rightarrow 3i_2 + 2i_1 = 3 \quad \text{—(II)}$$

For loop 2

$$1 = 2 + 4i_3 - 3i_2$$

$$\Rightarrow 3i_2 - 4i_3 = 1 \quad \text{—(III)}$$

Using (I) in (III), we obtain,

$$3i_2 - 4(i_1 - i_2) = 1$$

$$\Rightarrow 7i_2 = 1 + 4i_1 \quad \text{—(IV)}$$

Substituting for i_2 from (IV) in eqn (II), we get,

$$2i_1 = -3\frac{(1+4i_1)}{7} + 3$$

$$\Rightarrow \left(2 + \frac{12}{7}\right) i_1 = \frac{-3}{7} + 3$$

$$\Rightarrow \boxed{i_1 = \frac{9}{13}\,A}$$

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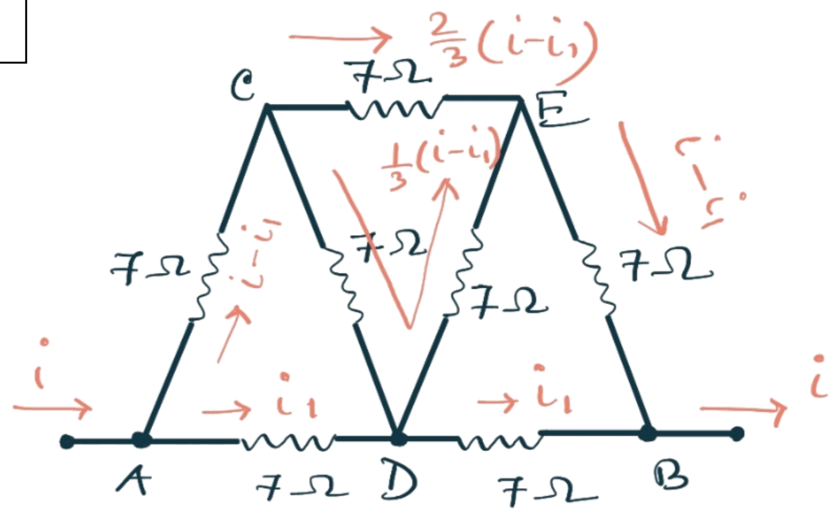
Q3: Solution



We can redraw the circuit like above.

Here, the arms AD and DB are symmetrically placed; so the arms AC and EB. Hence the current in AC and EB, and those in AD and DB are equal.

Let the current i enter the point A. One part of the current, say i_1, flows in AD. So, by KCL, the current in AC is $(i-i_1)$.
So, the current in DB is i_1 and that in EB is $(i-i_1)$.

The current $(i-i_1)$ in AC is devided at C; a part flows along CE and the rest along CDE. As the resistance of CE is half that of CDE, the current in CE is $\frac{2}{3}(i-i_1)$ and that in CDE is $\frac{1}{3}(i-i_1)$.

Let V is the potential difference between A & B. Consider the path ADB

$$V = 7i_1 + 7i_1 = 14 i_1 \quad \text{--- (i)}$$

considering the path ACEB,

$$V = 7(i-i_1) + 7\times\frac{2}{3}(i-i_1) + 7(i-i_1)$$

$$= \frac{8}{3}\times 7(i-i_1) \quad \text{--- (ii)}$$

Putting the value of i_1 from (i) in (ii),

$$V = \frac{56}{3}\left(i - \frac{V}{14}\right) \Rightarrow V = 8i$$

So, the effective resistance between A & B is $\boxed{R_{eq} = \frac{V}{i} = 8\ \Omega}$