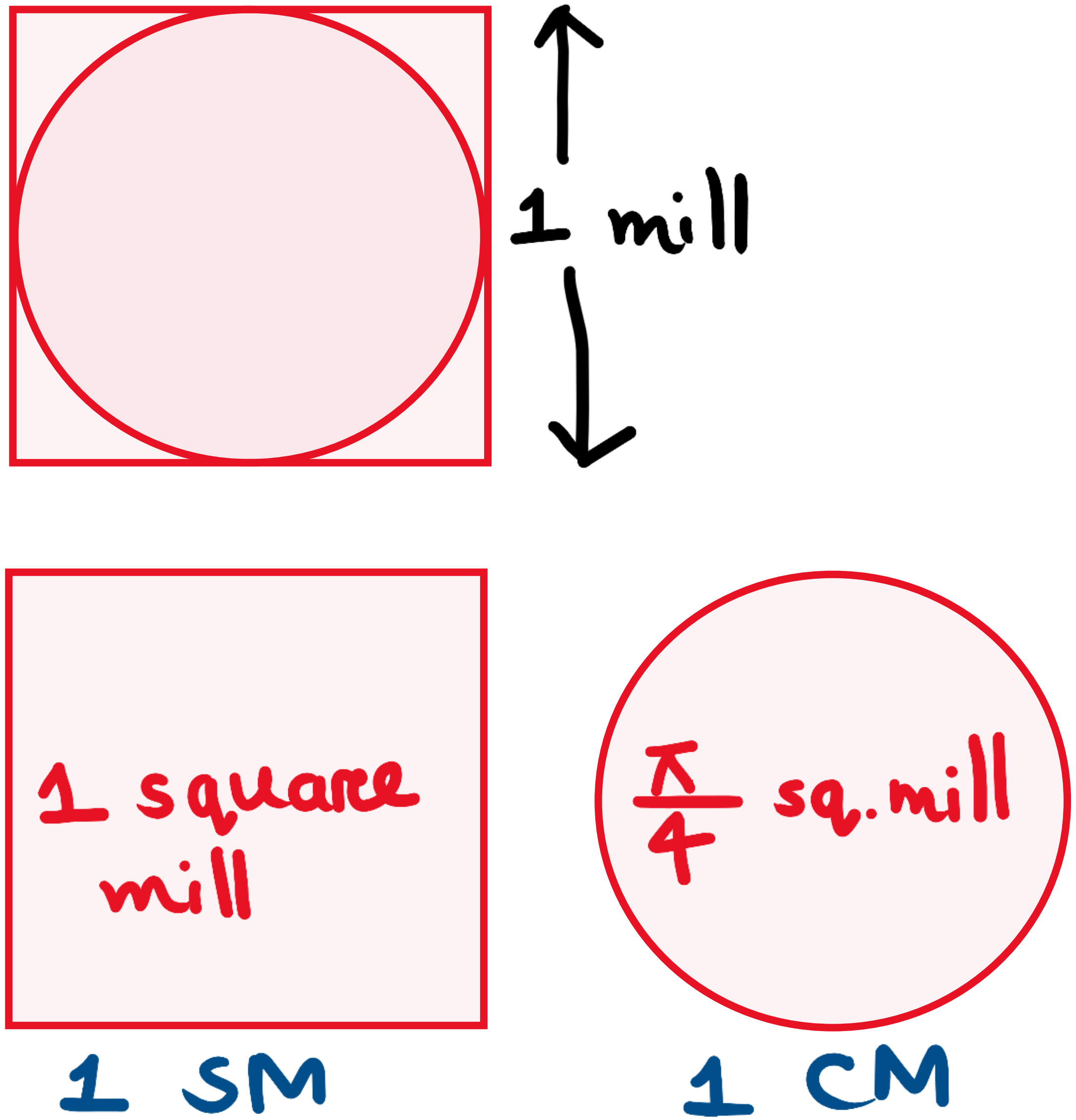
ELECTRICAL CIRCUITS

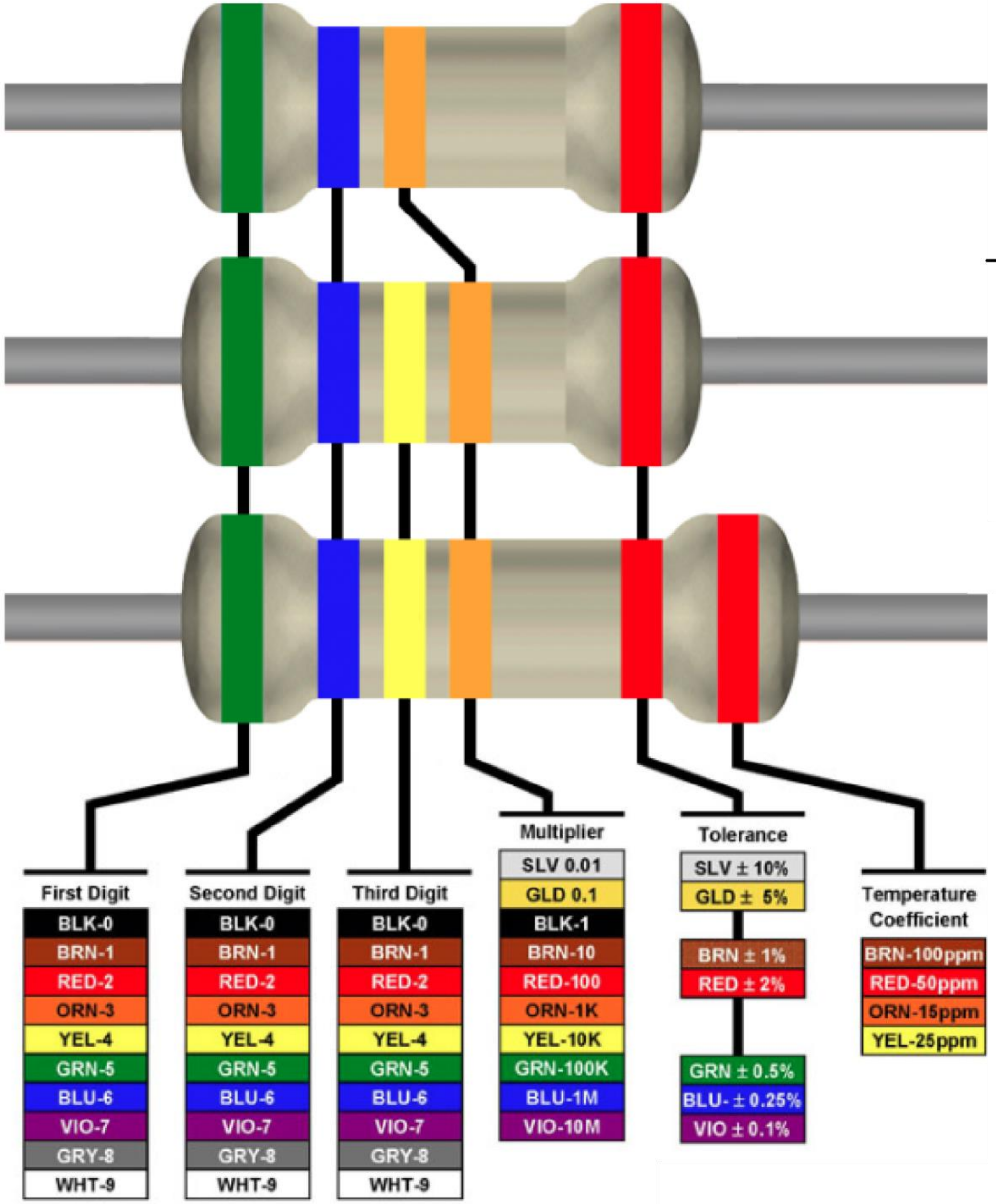
Jubair Ahammad Akter
Undergraduate Student of B.Sc.(CSE)
University of Dhaka



1000 mill = 1 inch

$$\boxed{\therefore 1\ CM = \frac{\pi}{4}\ SM}$$

Square Mill vs Circular Mill



56x10^3

+-2%

56000x2%=1120

56000-1120= 54880
56000+1120=57120

54880-57120 (Ans)

564x10^3

+-2%

564000x2%=11280

564000-11280= 552720
564000+11280=575280

552720-575280 (Ans)

564x10^3

+-2%

50ppm

564000x2%=11280

564000-11280= 552720
564000+11280=575280

552720-575280 (Ans)

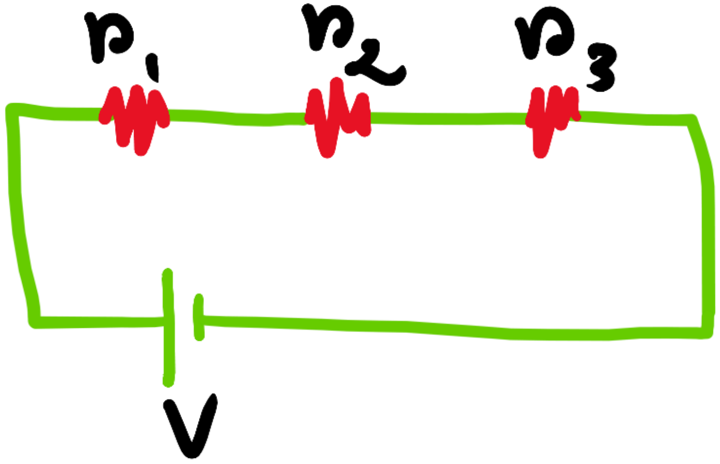
Color code of a resistance

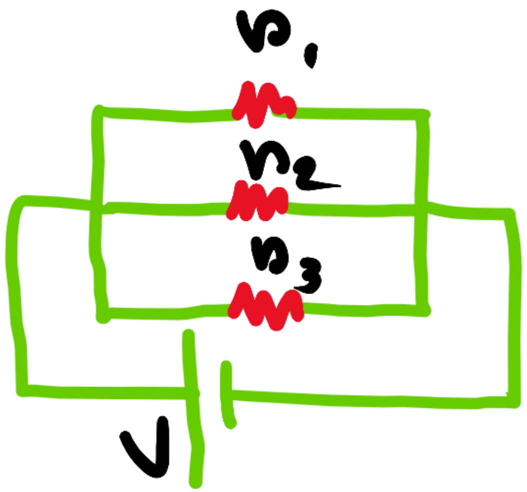
$R = \rho \frac{L}{A}$ $V = IR$ $W = QV$ $Q = It$

$$P = \frac{W}{t} = \frac{QV}{t} = VI = \frac{V^2}{R} = I^2R$$

1 watt = 1 J/s

1 HP = 746 watts





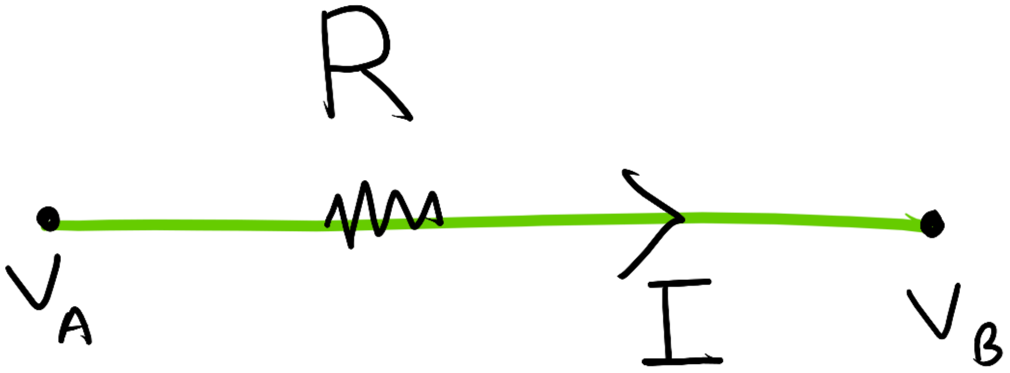
$$r_s = r_1 + r_2 + r_3$$

$$P_s = P_1 + P_2 + P_3$$

$$\frac{1}{r_p} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

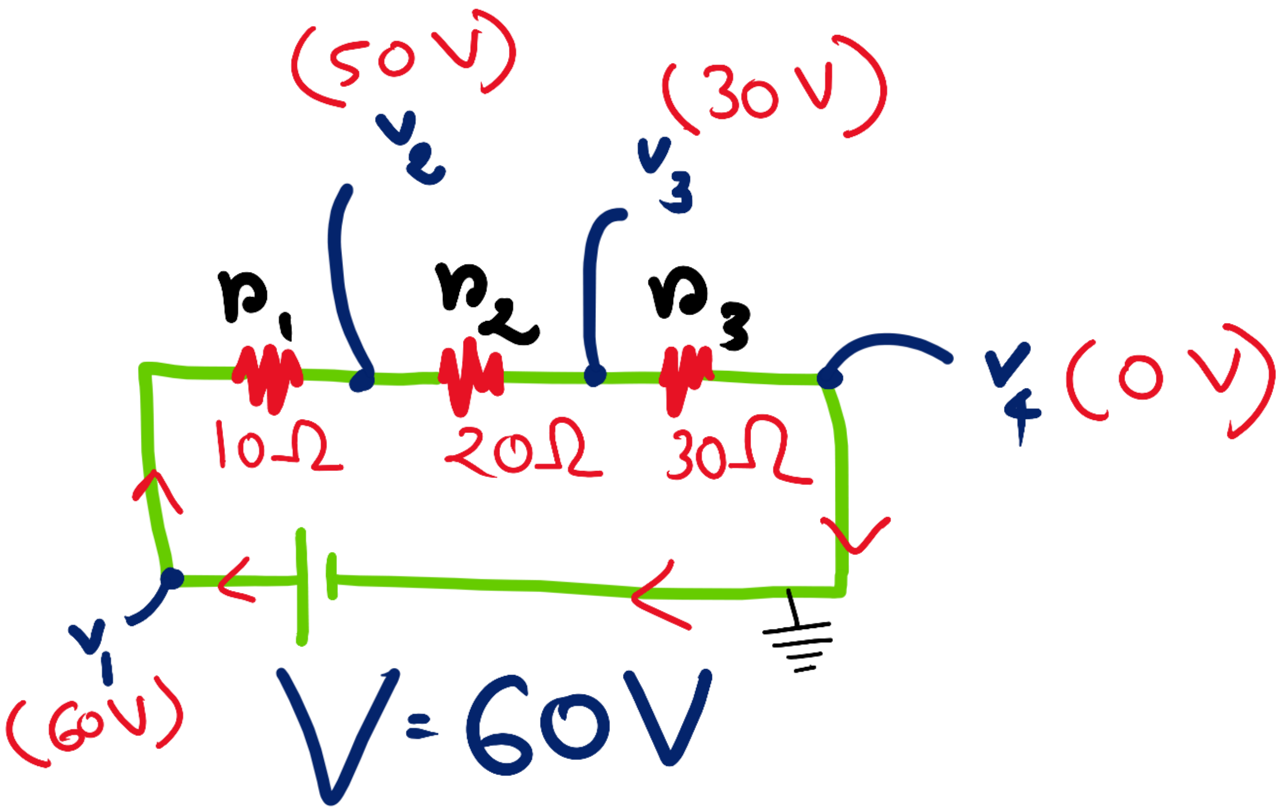
$$\frac{1}{P_v} = \frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3}$$

Difference between voltage and voltage difference



$$V_A - V_B = IR$$

Difference between voltage and voltage difference



$$V_1 - V_2 = I r_1$$

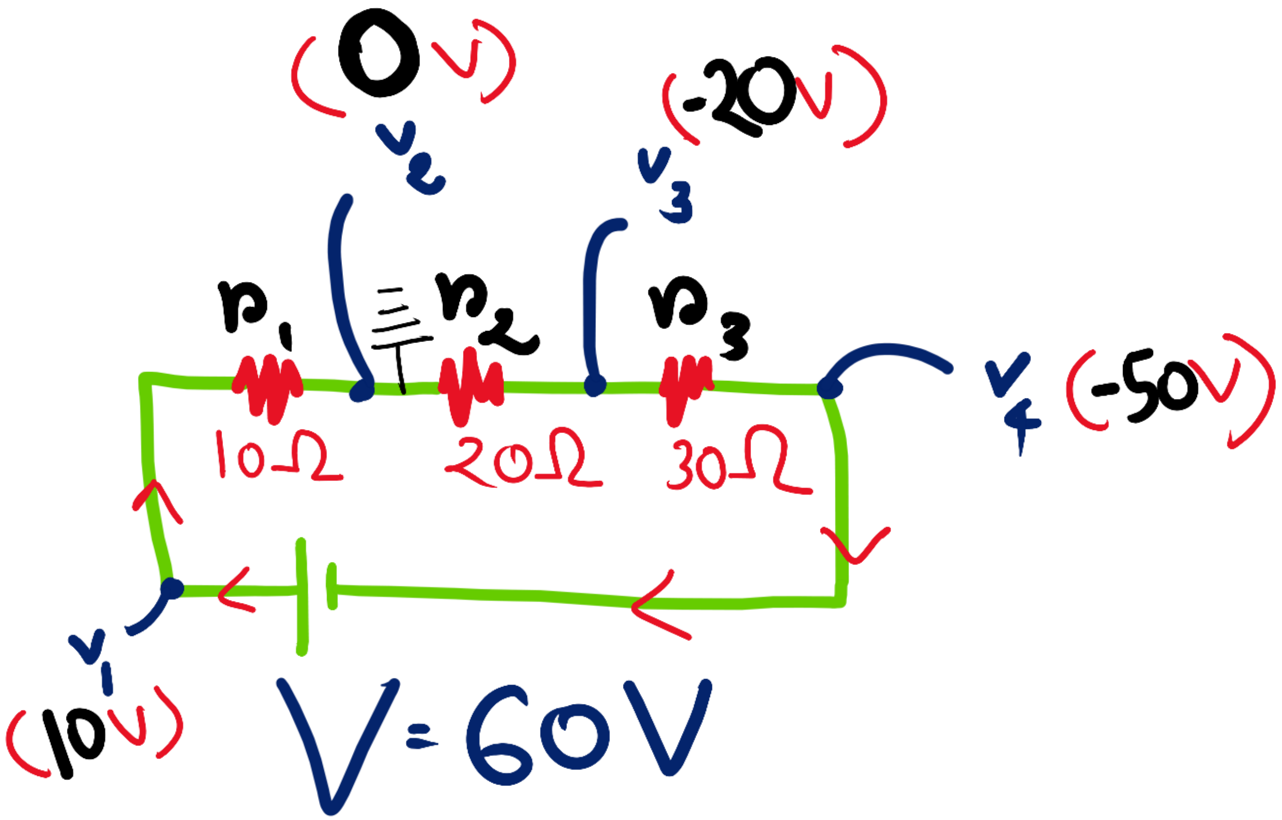
$$V_2 - V_3 = I r_2$$

$$V_3 - V_4 = I r_3$$

$$V_1 - V_4 = 60$$

V1=	60V	v2=	50V	v3=	30V	v4=	0V

Difference between voltage and voltage difference

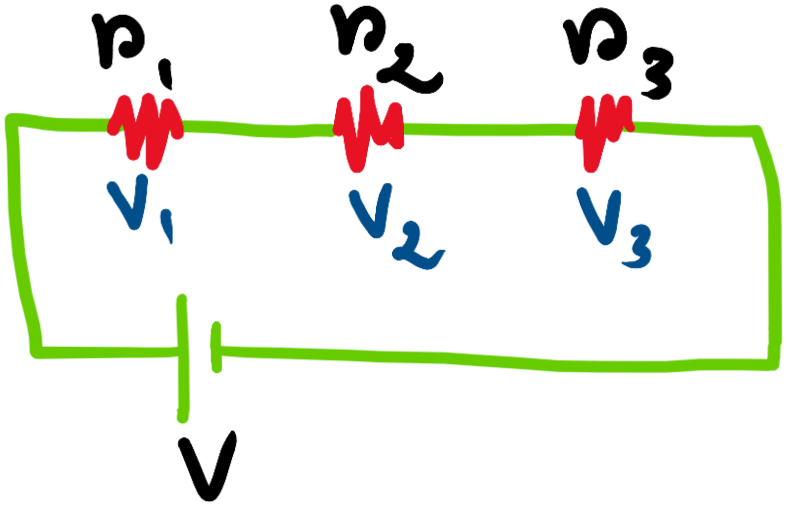


$$V_1 - V_2 = Ir_1$$
$$V_2 - V_3 = Ir_2$$
$$V_3 - V_4 = Ir_3$$
$$V_1 - V_4 = 60$$

V1=	10V	v2=	0V	v3=	-20V	v4=	-50V

Voltage devider Rule

VDR

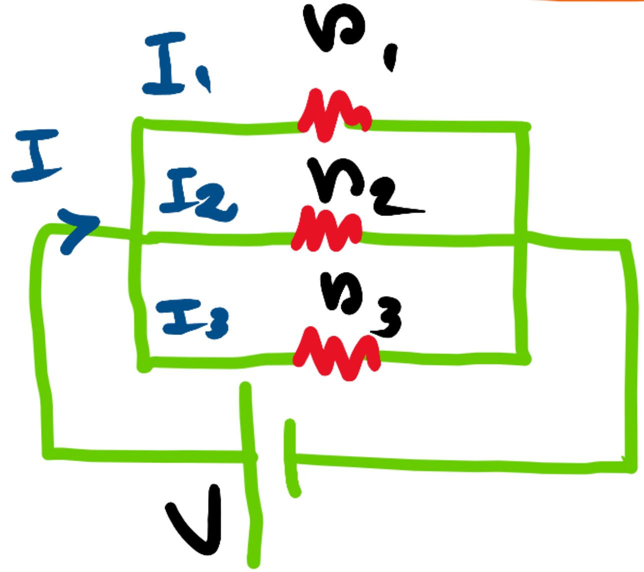


$$\frac{V}{r_T} = \frac{V_1}{r_1} = \frac{V_2}{r_2} = \frac{V_3}{r_3}$$

$$\therefore V_x = \frac{r_x}{r_T} \cdot V$$

Current Devider Rule

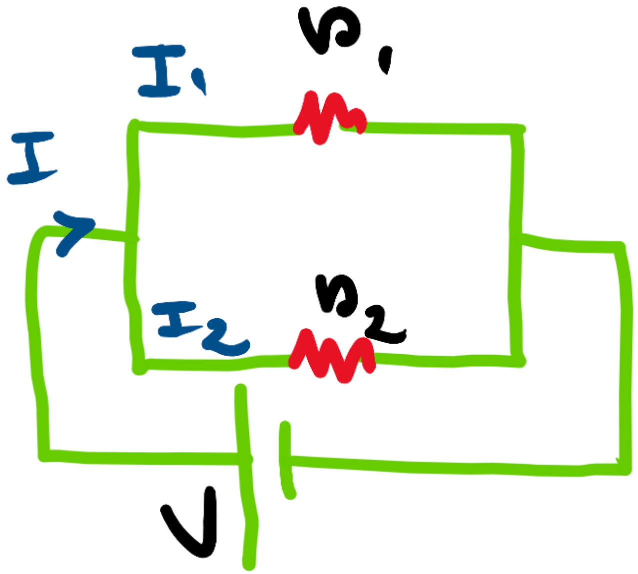
CDR



$$V = I r_p = I_1 r_1 = I_2 r_2 = I_3 r_3 \cdots$$

$$I_x = \frac{r_p}{r_x} \cdot I$$

CDR with two Resistance only



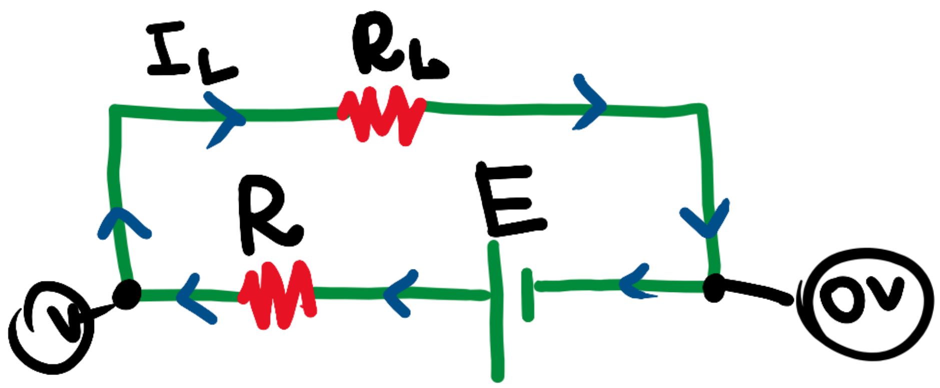
$$V = I r_p = I_1 r_1 = I_2 r_2$$

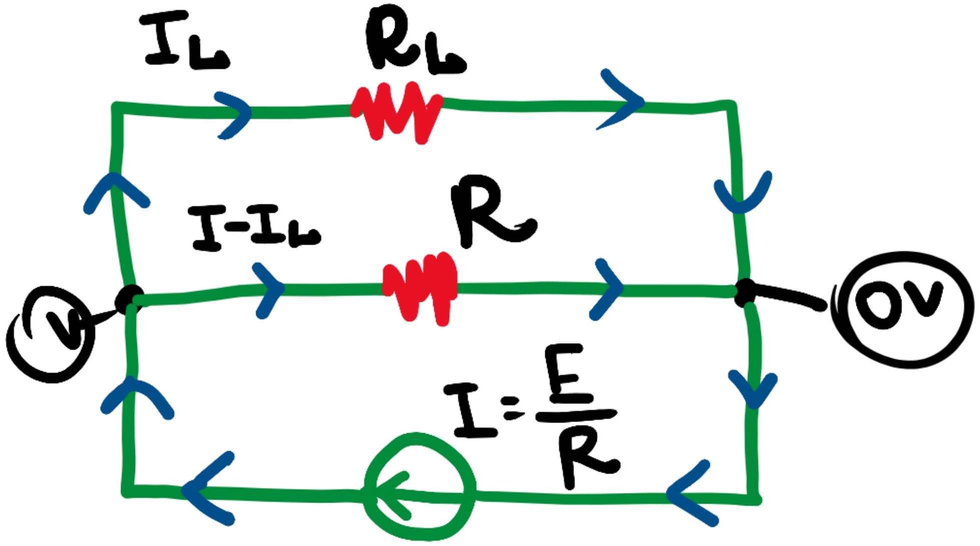
$$= I \frac{r_1 r_2}{r_1 + r_2} = I_1 r_1 = I_2 r_2$$

$$\therefore I_1 = I \frac{r_2}{r_1 + r_2}$$

$$\therefore I_2 = I \frac{r_1}{r_1 + r_2}$$

Source Conversion





$$E - I_L R = V \quad \text{(i)}$$

$$V = I_L R_L = (I - I_L) R$$

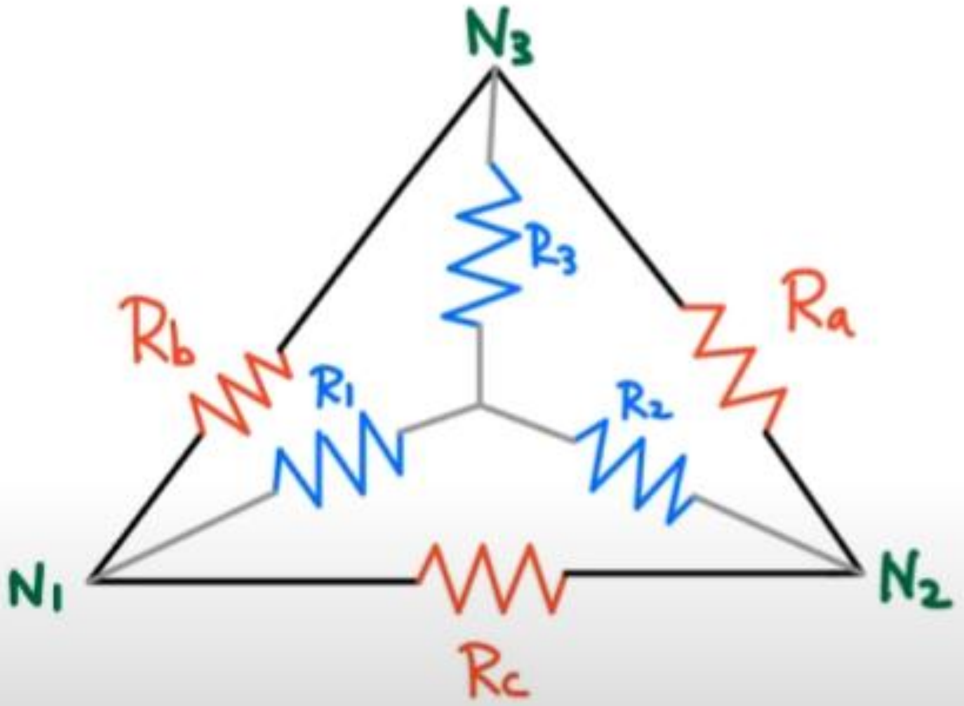
$$\therefore V = IR - I_L R \quad \text{(ii)}$$

from (i) & (ii), $E - I_L R = IR - I_L R$

$$\therefore E = IR$$

$$\boxed{\therefore I = \frac{E}{R}}$$

$\Delta \leftrightarrow Y$ transform



$Y \leftarrow \Delta$

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$$

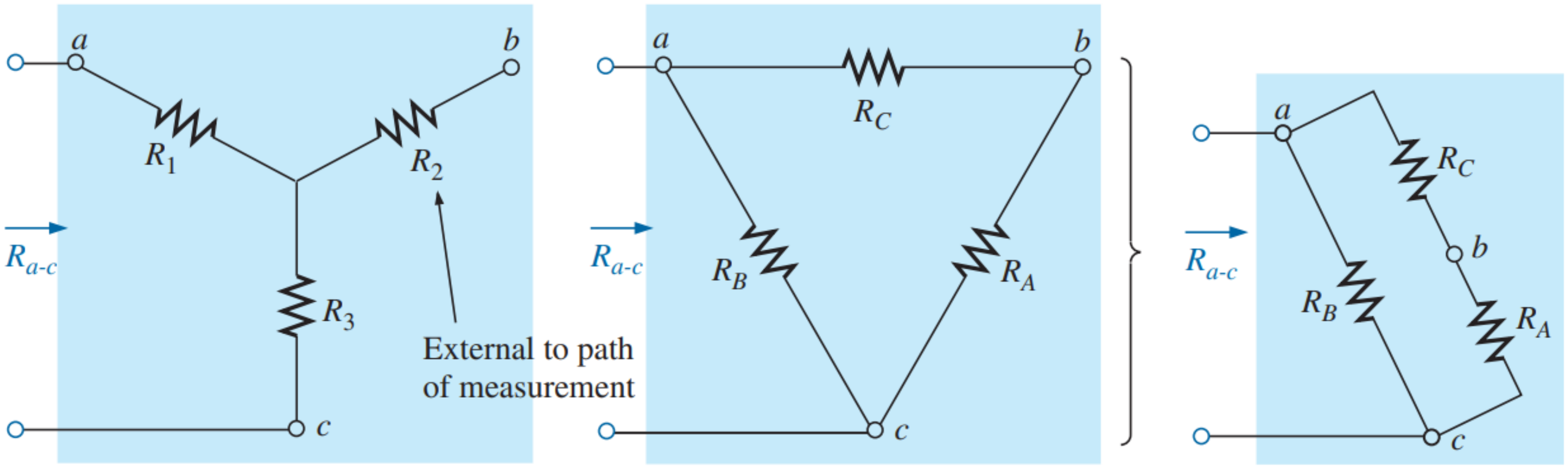
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

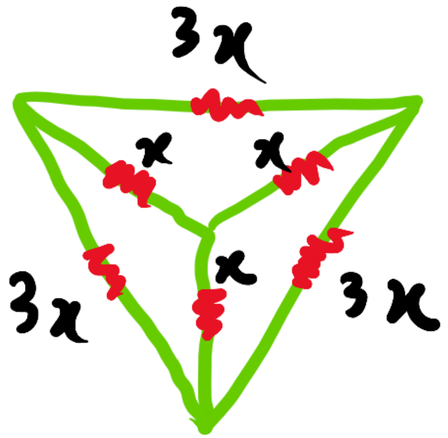
$\Delta \leftarrow Y$

$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$





$$R_{a\text{-}c} = R_1 + R_3 = \frac{R_B(R_A + R_C)}{R_B + (R_A + R_C)}$$

$$R_{a\text{-}b} = R_1 + R_2 = \frac{R_C(R_A + R_B)}{R_C + (R_A + R_B)}$$

$$R_{b\text{-}c} = R_2 + R_3 = \frac{R_A(R_B + R_C)}{R_A + (R_B + R_C)}$$

$Y \leftarrow \Delta$

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

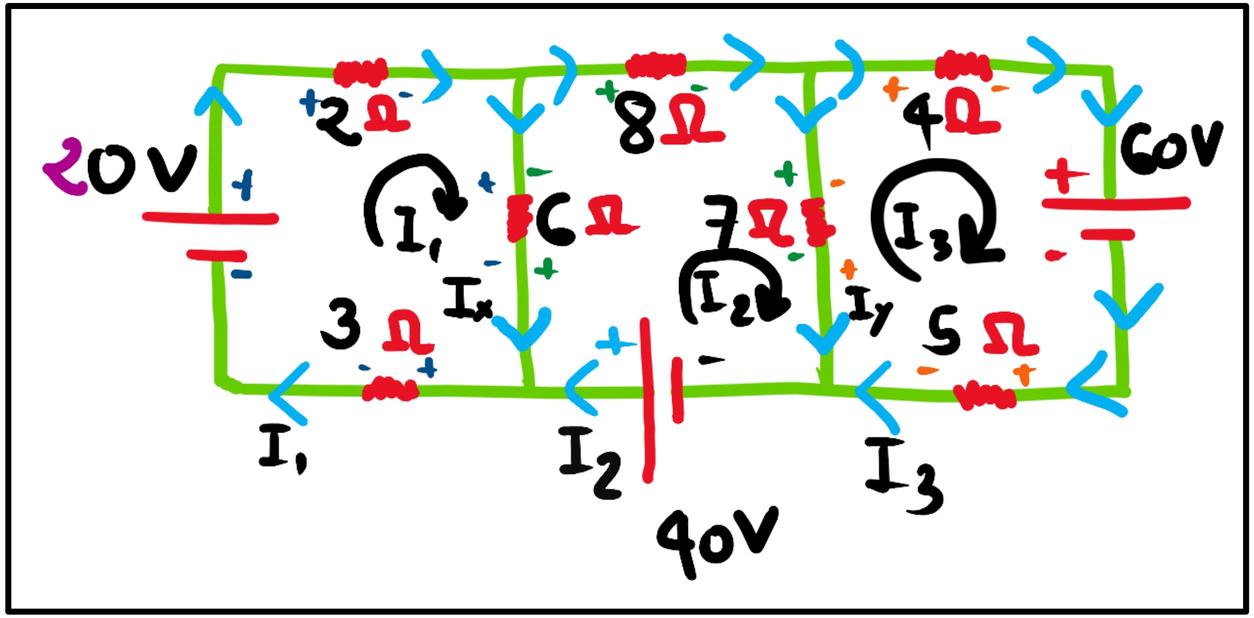
$\Delta \leftarrow Y$

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

$$R_c = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

Mesh Analysis



$$I_x = I_1 - I_2$$

$$I_y = I_2 - I_3$$

[Format Approach]

$$(2+3+6)I_1 + (-6)I_2 + 0.I_3 - 20 = 0$$

$$(-6)I_1 + (6+8+7)I_2 + (-7)I_3 - 40 = 0$$

$$0.I_1 + (-7)I_2 + (5+7+4)I_3 + 60 = 0$$

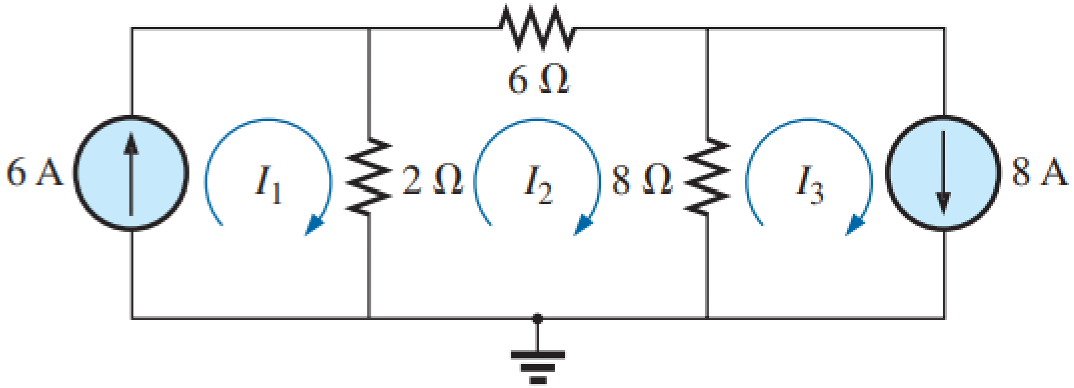
[Normal Approach]

$$2I_1 + 6(I_1 - I_2) + 3I_1 - 20 = 0$$

$$6(I_2 - I_1) + 8I_2 + 7(I_2 - I_3) - 40 = 0$$

$$7(I_3 - I_2) + 5I_3 + 4I_3 + 60 = 0$$

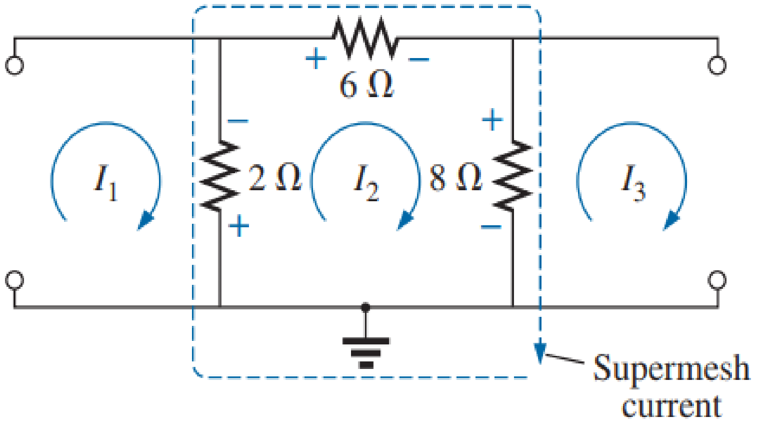
Super Mesh



Solution: The mesh currents are defined in Fig. 8.37. The current sources are removed, and the single supermesh path is defined in Fig. 8.38.

Applying Kirchhoff's voltage law around the supermesh path:

$$-V_{2\Omega} - V_{6\Omega} - V_{8\Omega} = 0$$
$$-(I_2 - I_1)2\ \Omega - I_2(6\ \Omega) - (I_2 - I_3)8\ \Omega = 0$$
$$-2I_2 + 2I_1 - 6I_2 - 8I_2 + 8I_3 = 0$$
$$2I_1 - 16I_2 + 8I_3 = 0$$



Introducing the relationship between the mesh currents and the current sources:

$$I_1 = 6\text{ A}$$
$$I_3 = 8\text{ A}$$

results in the following solutions:

$$2I_1 - 16I_2 + 8I_3 = 0$$
$$2(6\text{ A}) - 16I_2 + 8(8\text{ A}) = 0$$

and $$I_2 = \frac{76\text{ A}}{16} = \mathbf{4.75\ A}$$

Then $$I_{2\Omega}\downarrow = I_1 - I_2 = 6\text{ A} - 4.75\text{ A} = \mathbf{1.25\ A}$$

and $$I_{8\Omega}\uparrow = I_3 - I_2 = 8\text{ A} - 4.75\text{ A} = \mathbf{3.25\ A}$$

Again, note that you must stick with your original definitions of the various mesh currents when applying Kirchhoff's voltage law around the resulting supermesh paths.

Nodal Analysis

EXAMPLE 8.23 Write the nodal equations for the network in Fig. 8.59.

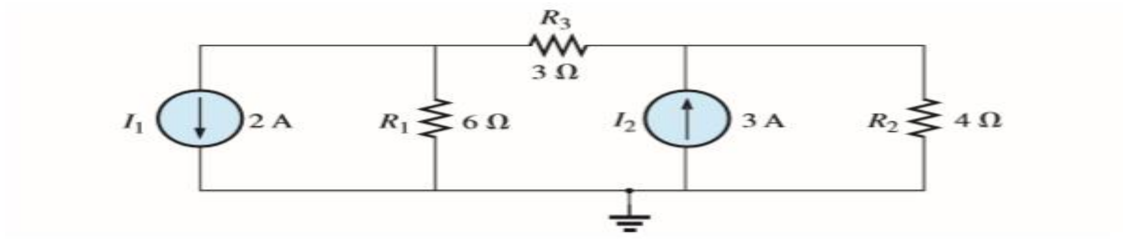
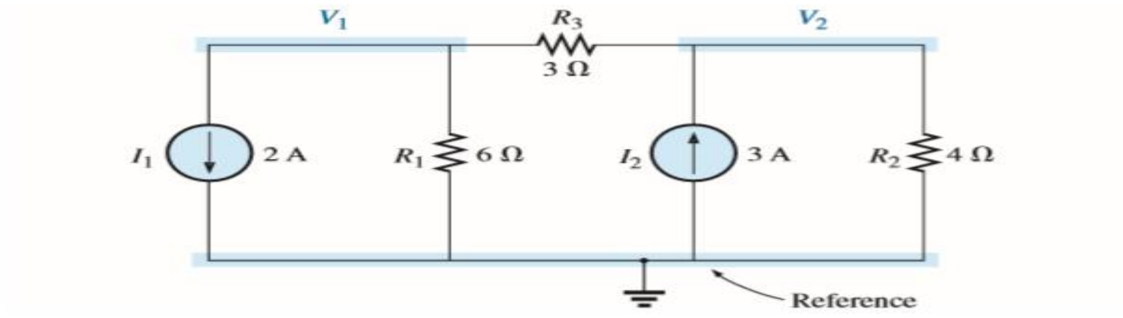


FIG. 8.59
Example 8.23.

Solution:

Step 1: Redraw the figure with assigned subscripted voltages in Fig. 8.60.



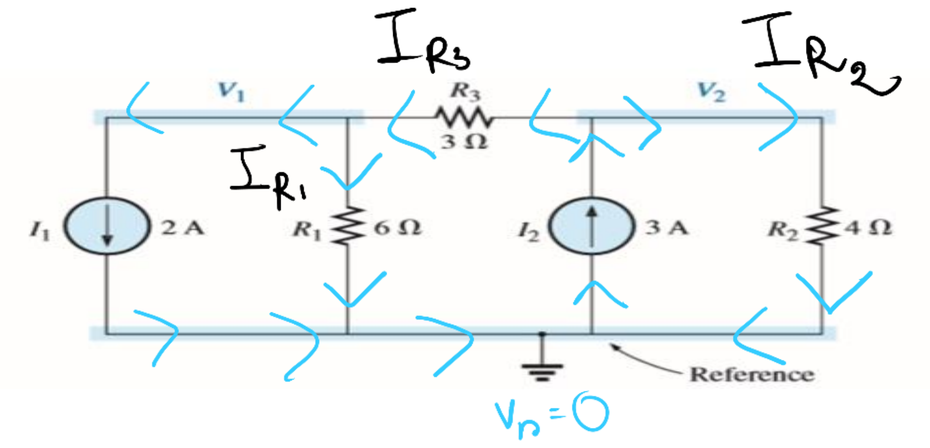
$$V_1: \quad \underbrace{\left(\frac{1}{6\ \Omega} + \frac{1}{3\ \Omega}\right)}_{\substack{\text{Sum of}\\ \text{conductances}\\ \text{connected}\\ \text{to node 1}}} V_1 - \underbrace{\left(\frac{1}{3\ \Omega}\right)}_{\substack{\text{Mutual}\\ \text{conductance}}} V_2 = \overset{\substack{\text{Drawing current}\\ \text{from node 1}\\ \downarrow}}{-2\ \text{A}}$$

out going

$$V_2: \quad \underbrace{\left(\frac{1}{4\ \Omega} + \frac{1}{3\ \Omega}\right)}_{\substack{\text{Sum of}\\ \text{conductances}\\ \text{connected}\\ \text{to node 2}}} V_2 - \underbrace{\left(\frac{1}{3\ \Omega}\right)}_{\substack{\text{Mutual}\\ \text{conductance}}} V_1 = \overset{\substack{\text{Supplying current}\\ \text{to node 2}\\ \downarrow}}{+3\ \text{A}}$$

in-coming

Nodal Analysis



$$I_{R_3} + I_{R_2} = I_2$$

$$\Rightarrow \frac{V_2 - V_1}{R_3} + \frac{V_2 - 0}{R_2} = 3$$

$$\Rightarrow \frac{V_2 - V_1}{3} + \frac{V_2}{4} = 3$$

$$I_{R_3} = I_1 + I_{R_1}$$

$$\Rightarrow \frac{V_2 - V_1}{R_3} = 2 + \frac{V_1 - 0}{R_1}$$

$$\Rightarrow \frac{V_2 - V_1}{3} = 2 + \frac{V_1}{6}$$

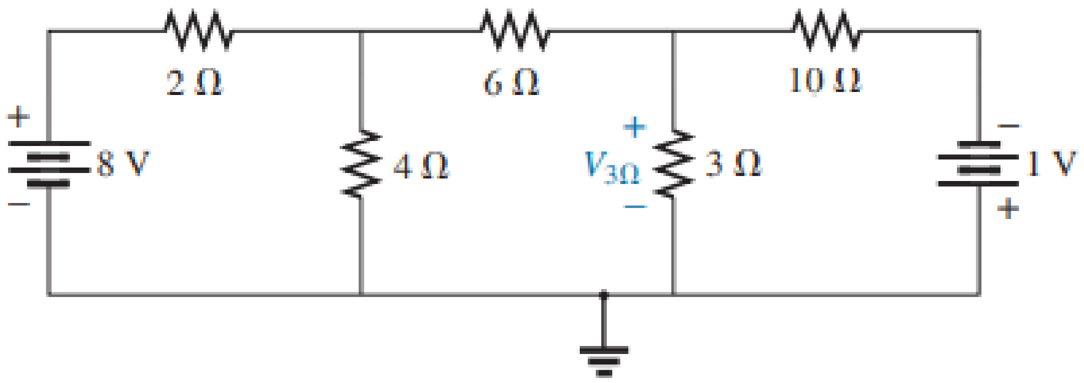
$$V_2: \quad \underbrace{\left(\frac{1}{4\,\Omega} + \frac{1}{3\,\Omega}\right)}_{\text{Sum of conductances connected to node 2}} V_2 - \underbrace{\left(\frac{1}{3\,\Omega}\right)}_{\text{Mutual conductance}} V_1 = \overset{\text{Supplying current to node 2}}{\overset{\downarrow}{+3\text{ A}}}$$

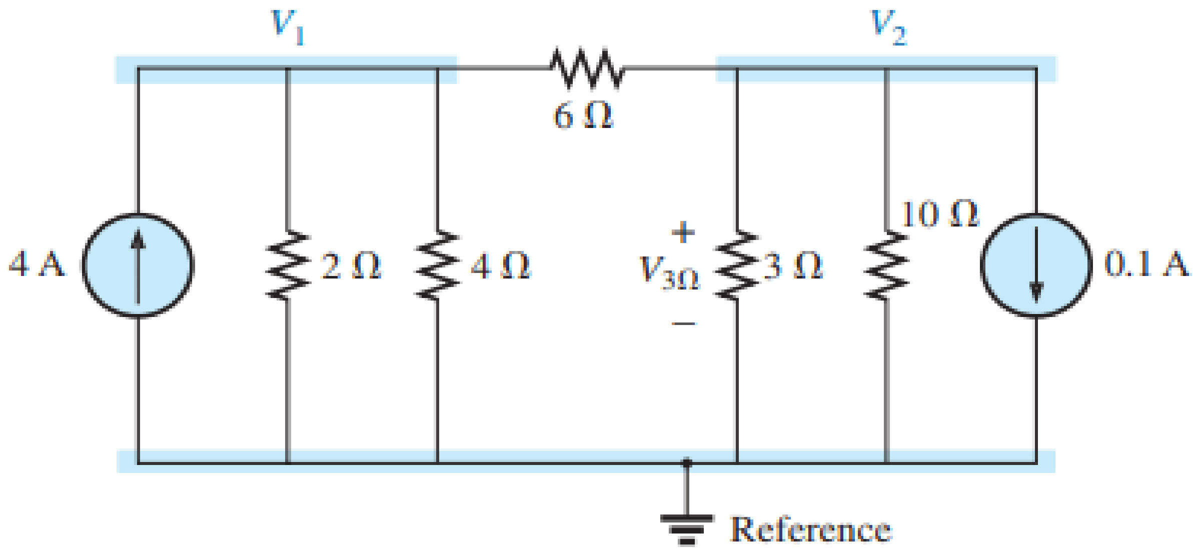
in - coming

$$V_1: \quad \underbrace{\left(\frac{1}{6\,\Omega} + \frac{1}{3\,\Omega}\right)}_{\text{Sum of conductances connected to node 1}} V_1 - \underbrace{\left(\frac{1}{3\,\Omega}\right)}_{\text{Mutual conductance}} V_2 = \overset{\text{Drawing current from node 1}}{\overset{\downarrow}{-2\text{ A}}}$$

out going

Another problem from Nodal Analysis

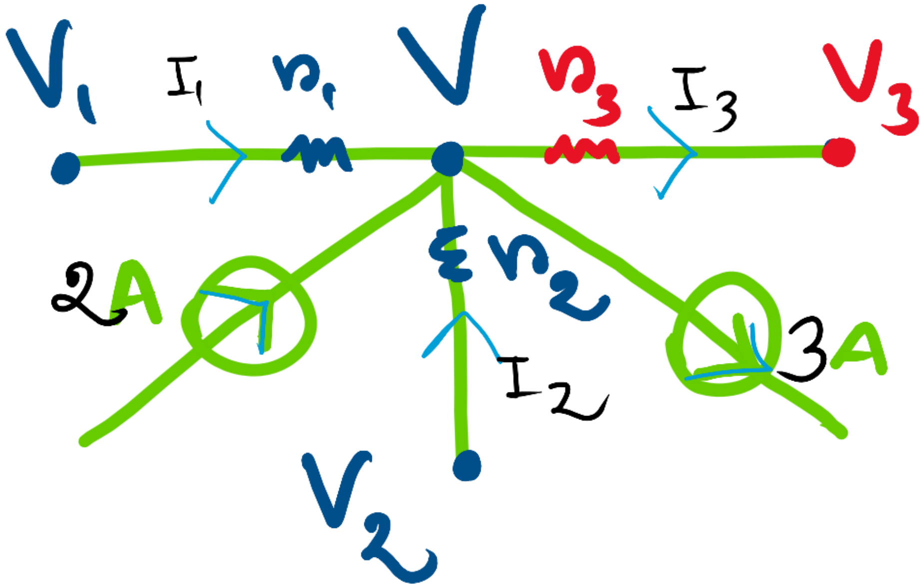




$$\left(\frac{1}{2\,\Omega}+\frac{1}{4\,\Omega}+\frac{1}{6\,\Omega}\right)V_1-\left(\frac{1}{6\,\Omega}\right)V_2=+4\text{ A}$$

$$\left(\frac{1}{10\,\Omega}+\frac{1}{3\,\Omega}+\frac{1}{6\,\Omega}\right)V_2-\left(\frac{1}{6\,\Omega}\right)V_1=-0.1\text{ A}$$

Concept of Nodal Analysis



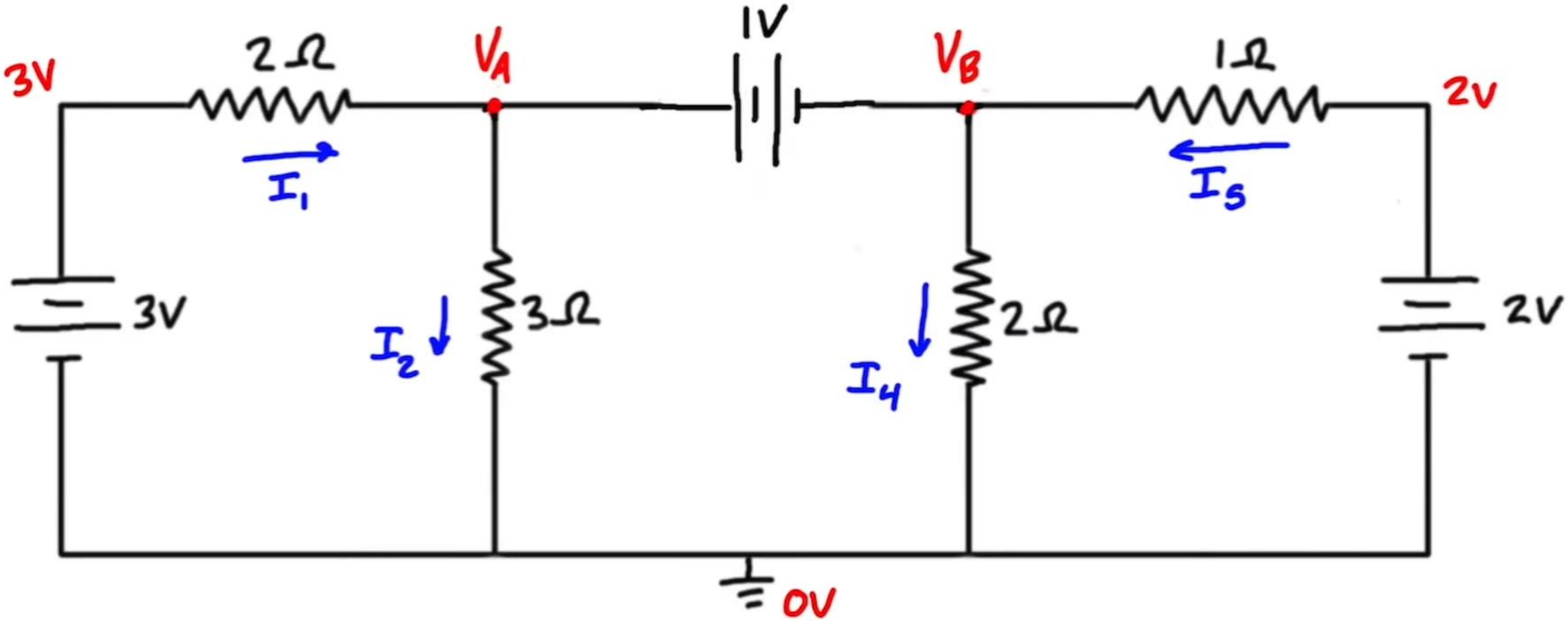
$$I_1 + I_2 + 2 = I_3 + 3$$

$$\Rightarrow \frac{V_1 - V}{r_1} + \frac{V_2 - V}{r_2} + 2 = \frac{V - V_3}{r_3} + 3$$

$$\therefore \frac{V_1}{r_1} + \frac{V_2}{r_2} + \frac{V_3}{r_3} - V\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right) + 2 - 3 = 0$$

or, $$V\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right) - \left(\frac{V_1}{r_1} + \frac{V_2}{r_2} + \frac{V_3}{r_3}\right) + 3 - 2 = 0$$

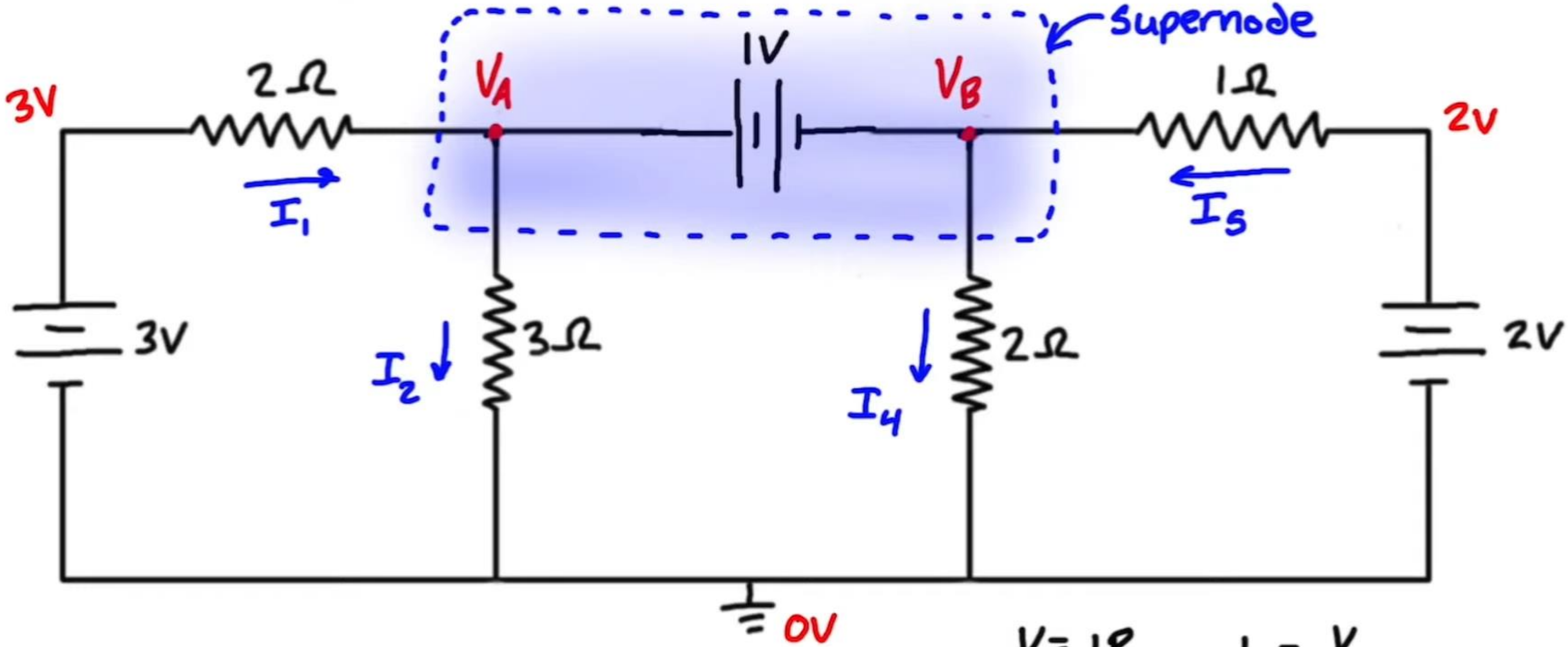
Super Node



KCl A: $I_1 = I_2 + I_3$

KCl B: $I_3 + I_5 = I_4$

$V = IR$ $\quad I = \frac{V}{R}$



$V = IR \qquad I = \frac{V}{R}$

KCl supernode

$I_1 + I_5 = I_2 + I_4$

$\left(\frac{3V - V_A}{2\Omega}\right) + \left(\frac{2V - V_B}{1\Omega}\right) = \frac{V_A}{3\Omega} + \frac{V_B}{2\Omega}$

supernode eqation

$V_A = V_B + 1$

THANK YOU