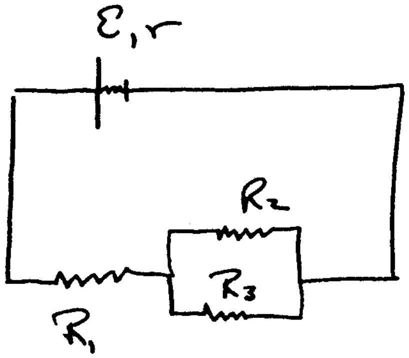
EXAMPLE



$\mathcal{E} = 18V$

$R_1 = 2\,\Omega$

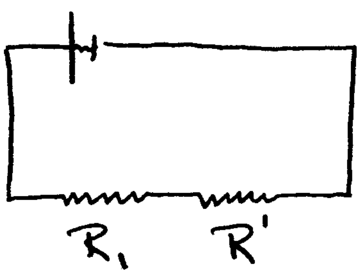
$R_2 = 6\,\Omega$

$R_3 = 3\,\Omega$

$r = 2\,\Omega$

What are currents, p.d. in above circuit

1) Replace $R_2 + R_3$ w/ equivalent resistance R'



(PARALLEL)

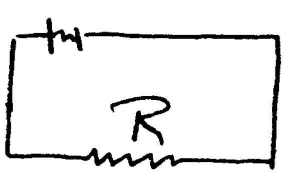
$$\frac{1}{R'} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{R_3 + R_2}{R_2 R_3}$$

$$R' = \frac{R_2 R_3}{R_2 + R_3}$$

$$R' = \frac{6\,\Omega \cdot 3\,\Omega}{6\,\Omega + 3\,\Omega} = \frac{18\,\Omega^2}{9\,\Omega}$$

$$\underline{R' = 2\,\Omega}$$

2) Can replace $R_1 + R'$ w/ equivalent resistance R



(SERIES)

$$R = R_1 + R' = R_1 + \frac{R_2 R_3}{R_2 + R_3}$$

$$R = R_1 + R' = 2\,\Omega + 2\,\Omega$$

$$\underline{R = 4\,\Omega}$$

$$I = \frac{\Sigma \mathcal{E}}{\Sigma R} = \frac{\mathcal{E}}{R+r}$$

$$= \frac{\mathcal{E}}{r + R_1 + \frac{R_2 R_3}{R_2 + R_3}}$$

$$I = \frac{18V}{4\Omega + 2\Omega}$$

$$\underline{I = 3\ A}$$

$$V_1 = I R_1 = \left(\frac{\mathcal{E}}{r + R_1 + \frac{R_2 R_3}{R_2 + R_3}} \right) R_1$$

$$V_1 = 3A \cdot 2\Omega$$

$$\underline{V_1 = 6V}$$

$$V_2 = I R' = V_3$$

$$V_2 = 3A \cdot 2\Omega$$

$$V_{2,3} = 6V$$

$$I_2 = \frac{V_2}{R_2}$$

$$I_2 = \frac{6V}{6\Omega}$$

$$I_2 = 1\ A$$

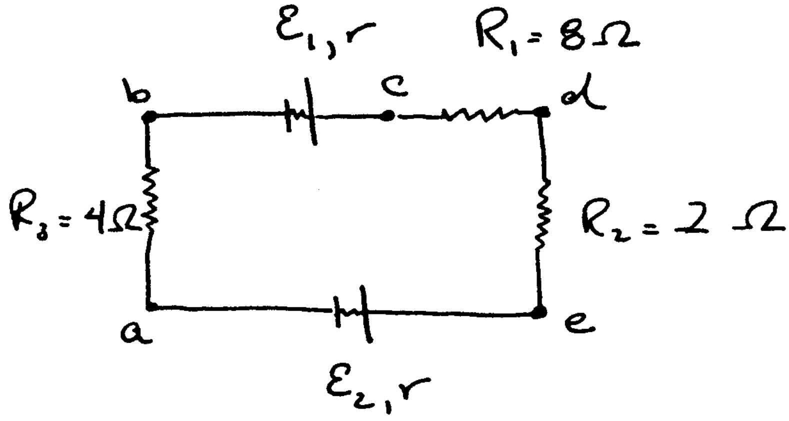
$$I_3 = \frac{V_3}{R_3}$$

$$I_3 = \frac{6V}{3\Omega}$$

$$I_3 = 2\ A$$

nb $I_2 + I_3 = I$

$I = 2A + 1A = 3A$ ✓



$\mathcal{E}_1 = 10V \quad \mathcal{E}_2 = 18V \quad r = 1\Omega$

1) Select (arbitrarily, its OK) current direction in ckt above its pretty easy to see that current will be ccw, but it doesn't matter. Assume I cw

2) Apply source rule

$$I = \frac{V}{R} = \frac{\Sigma \mathcal{E}}{\Sigma R}$$

with the following convention

$\mathcal{E}$ is positive if I from − to + internally
$\mathcal{E}$ " negative I " + to − "

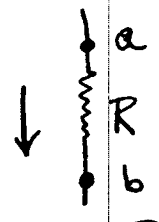
$$\mathcal{E}_1 = +10V \quad \mathcal{E}_2 = -18V$$

$$I = \frac{10V - 18V}{8\Omega + 2\Omega + 4\Omega + 2 \cdot 1\Omega}$$

$$= -\ 8V/16\Omega = -\frac{1}{2}\ \text{Amp}$$ (− sign tells us current is opposite dir

Look at p.d. a – d

Consider the following common sense rules

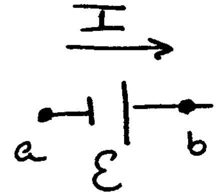


1) Potential is higher "upstream" of resistance – resistor dissipates energy thus current has higher energy before resistor

$V_{ab} = IR$

$V_a = V_b + IR$

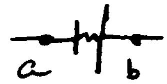
2) When current is "with" source of EMF source is "pump" elevating ckt to higher potential – Potential is higher "downstream



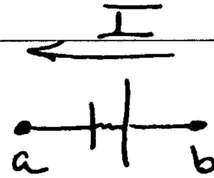
$V_b = V_a + \mathcal{E}$

$V_{ba} = -V_{ab} = \mathcal{E}$

(n.b. if there is internal resistance a little of the energy gained is lost to dissipation

$V_{ba} = \mathcal{E} - Ir$ 

3) When current is "against" source work is done against mechanical or chemical "non-electrostatic force (and also against internal resistance) Energy is higher upstream



$$V_b = V_a + \mathcal{E} + Ir$$

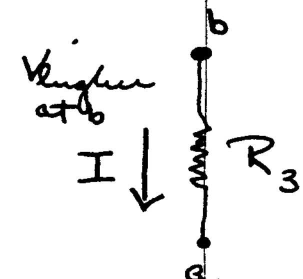
$$V_{ba} = -V_{ab} = \mathcal{E} + Ir$$

[note that potential is always higher at positive terminal of source

$\mathcal{E} - Ir$ current with source

$\mathcal{E} + Ir$ current against source

Now <u>a - b</u>

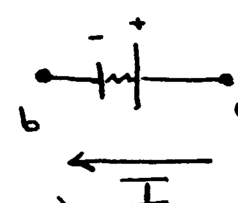


$$V_{ba} = IR_3 = \tfrac{1}{2}A \cdot 4\Omega = \underline{2V}$$

[remember this is potential at b wrt a $V_{ba} = V_b - V_a = -V_{ab}$]

b is uphill from a

<u>b - c</u>

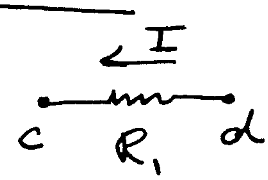


$V_{cb} = \mathcal{E}_1 + Ir$ (since current is against source)

$$= 10V + \tfrac{1}{2}A \cdot 1\Omega = \underline{10\tfrac{1}{2}\,V}$$

c is uphill from b

c - d



$$V_{dc} = IR_1 = \tfrac{1}{2}A \cdot 8\Omega = \underline{4V}$$

d is uphill from c

$$V_{da} = V_{dc} + V_{cb} + V_{ba} = 4V + 10\tfrac{1}{2}V + 2V$$

$$= \underline{16\tfrac{1}{2}\,V}$$