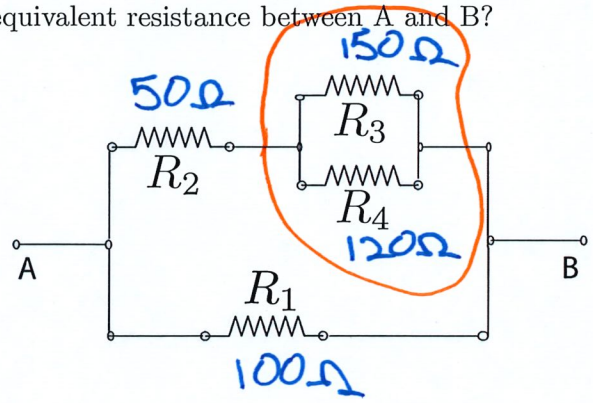
12-6-Example
-DC circuits3

DC circuits - III

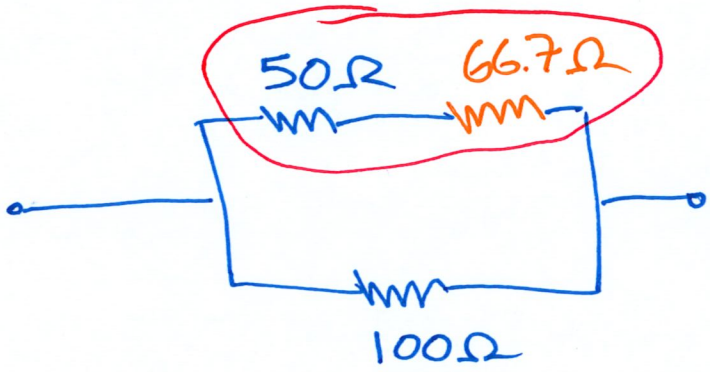
In the diagram $R_1 = 100\Omega$, $R_2 = 50\Omega$, $R_3 = 150\Omega$ and $R_4 = 120\Omega$. What is the equivalent resistance between A and B?



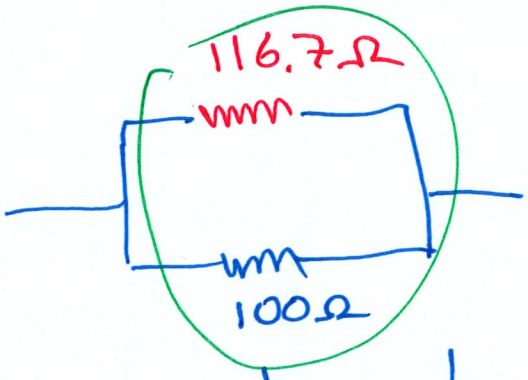
R_{eq}: $\frac{1}{R_{eq}} = \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{150\Omega} + \frac{1}{130\Omega}$

$= \frac{4}{600\Omega} + \frac{5}{600\Omega} = \frac{9}{200\Omega}$

$R_{eq} = 66.7\Omega$



$$R_{eq2} = R_2 + R_{eq1} = 50\Omega + 66.7\Omega = 116.7\Omega$$



$$\frac{1}{R_{eq3}} = \frac{1}{R_1} + \frac{1}{R_{eq2}} = \frac{1}{100\Omega} + \frac{1}{116.7\Omega}$$

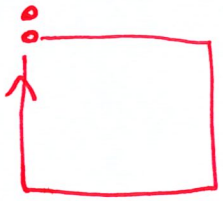
$$= 0.0186\,\frac{1}{\Omega}$$

$$R_{eq3} = 53.85\Omega$$

Kirchoff's Laws

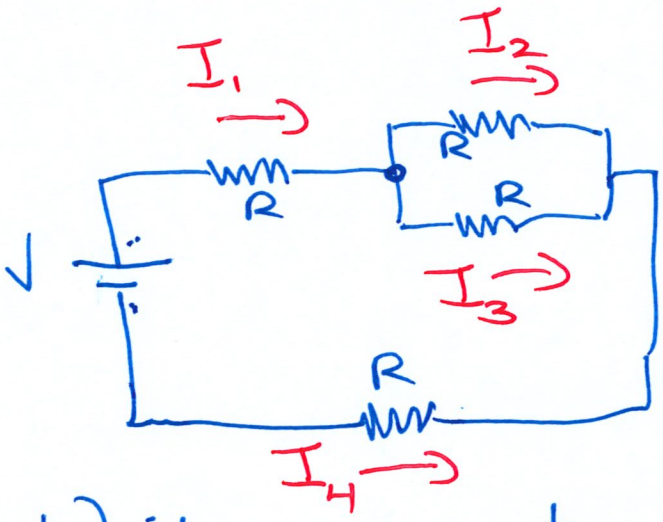
What these do is help us set up systems of linear equations to find the current in any part of a circuit.

- The total ΔV around any closed loop is 0
  (conservation of energy)



- There are no current "sources" or "sinks"
  Current in is same as current out

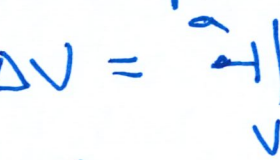
12-7 Theory Kirchhoff's Laws

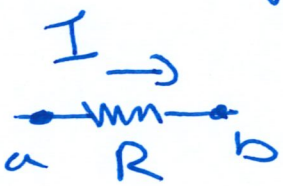


① Write currents + guess direction

② Get a set of equations for those I's based on Kirchoff's laws

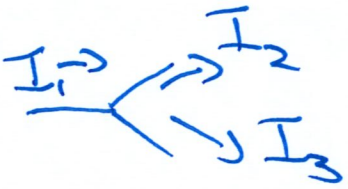
One per current

③ $\Delta V =$  $V_b - V_a = V$



$V_b - V_a = -IR$

Look at junctions



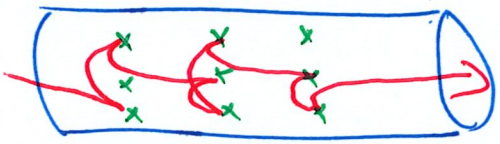
$I_1 = I_2 + I_3$

$I_1 - I_2 - I_3 = 0$

$I_2 + I_3 + I_4 = 0$

If $I < 0$ direction wrong.

Energy dissipation



Electron deposited energy
(heated resistor)
Has done work

What is rate work is done?

$\Delta V = -IR$

For charged particle

$$\Delta PE = q\Delta V = -qIR$$

Particle has done

qIR

work

What is rate?

$$P = \frac{W_{total}}{\text{time taken}}$$

$$= \frac{Q_{total}}{\text{how long}} \; IR$$

$$= I(IR)$$

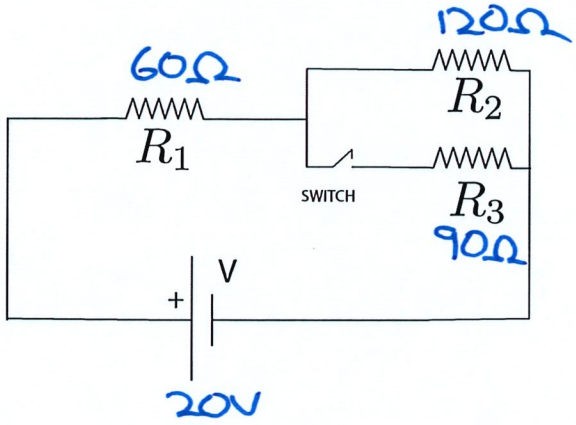
$$= I^2R$$

$$= \frac{(\Delta V)^2}{R}$$

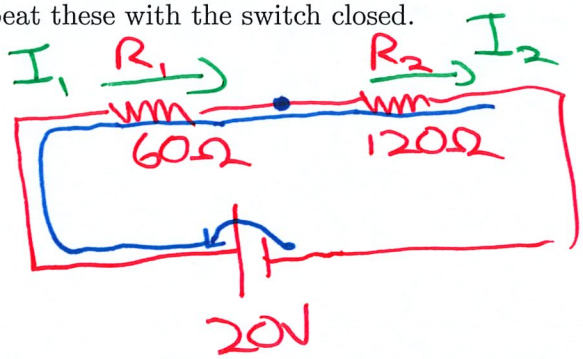
12-9-Example-DC circuits 4

DC circuits - IV

A battery with terminal voltage of $20V$ is connected to three resistors and a switch. $R_1 = 60\Omega$, $R_2 = 120\Omega$, and $R_3 = 90\Omega$.



- When the switch is open so no current flows through R_3 what is the current in each resistor.
- When the switch is open so no current flows through R_3 what is the energy dissipation rate in each resistor.
- Repeat these with the switch closed.



$$I_1 = I_2$$

$$0 = 20V - I_1 R_1 - I_2 R_2$$

$$0 = 20V - I_2\, 60\Omega - I_2\, 120\Omega$$

$I_2 = 0.111\ A$

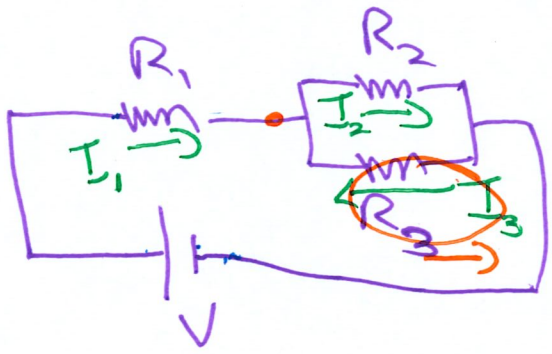
$I_1 = 0.111\ A$

$I_3 = 0\ A$

$P_{inR2} = I_2^2 R_2 = (0.111A)^2(120\Omega) = 1.48W$

$P_{inR1} = I_1^2 R_1 = 0.74W$

$P_{inR3} = 0\ W$



$I_1 + I_3 = I_2$

$0 = V - I_1 R_1 - I_2 R_2$

$0 = V - I_1 R_1 + I_3 R_3$

$0 = 20V - I_1\,60\Omega - (I_1 + I_3)\,120\Omega$

$0 = 20V - I_1\,60\Omega + I_3\,90\Omega$

$0 = 20V - I_1\,180\Omega - I_3\,120\Omega$

$0 = 20V - I_1\,60\Omega + I_3\,90\Omega$

$I_3 = 0.166A - I_1\,1.5$

$$0 = 20V - I_1 60\Omega + (0.166A - I_1)1.5\,90\Omega$$

$$0 = 20V + 15V - I_1(60\Omega + 135\Omega)$$

$$I_1 = 0.179A$$

$$I_3 = 0.166A - 1.5(0.179A)$$

$$= -0.102A$$

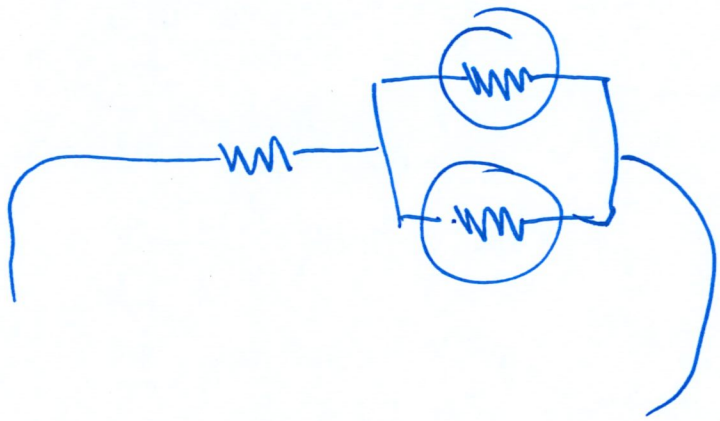
Made wrong guess re direction

$$I_2 = I_1 + I_3 = 0.077A$$

$$P_1 = I_1^2 R_1 = 1.92W$$

$$P_2 = I_2^2 R_2 = (0.077A)^2 120\Omega = 0.71W$$

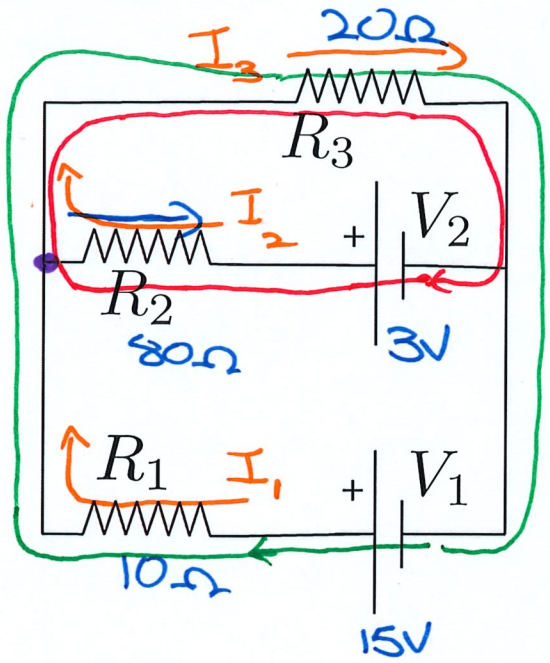
$$P_3 = I_3^2 R_3 = (-0.102A)^2 90\Omega = 0.94W$$



12-10-Example-DCcircuits5

DC circuits - V

Consider the circuit shown below:



If $R_1 = 10\Omega$, $R_2 = 80\Omega$, $R_3 = 20\Omega$, $V_1 = 15V$, and $V_2 = 3V$, find the current through and energy dissipated in each resistor.

$I_1 + I_2 = I_3$

$0 = 15V - I_1 10\Omega - I_3 20\Omega$

$0 = 3V - I_2 80\Omega - I_3 20\Omega$

$$0 = 15V - I_1 10\Omega - (I_1 + I_2) 20\Omega$$

$$0 = 3V - I_2 80\Omega - (I_1 + I_2) 20\Omega$$

$$0 = 15V - I_1 30\Omega - I_2 20\Omega$$

$$0 = 3V - I_1 20\Omega - I_2 100\Omega$$

$$I_2 = 0.03A - I_1 0.2$$

$$0 = 15V - I_1 30\Omega - (0.03A - 0.2 I_1) 20\Omega$$

$$0 = 15V - 0.6V - I_1 30\Omega + I_1 4\Omega$$

$$0 = 14.4V - 26\Omega I_1$$

$$I_1 = 0.554A \qquad P_1 = 3.07W$$

$$I_2 = -0.081A \qquad P_2 = 0.52W$$

$$I_3 = 0.473A \qquad P_3 = 4.47W$$