I-V Characteristics, Kirchhoff's laws and Resistor Applications

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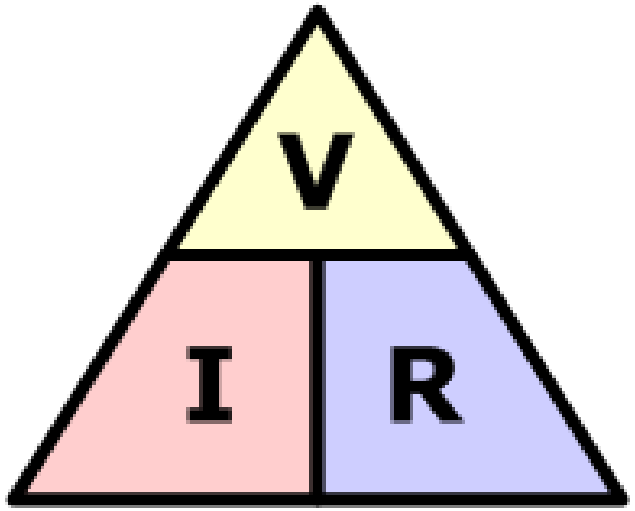
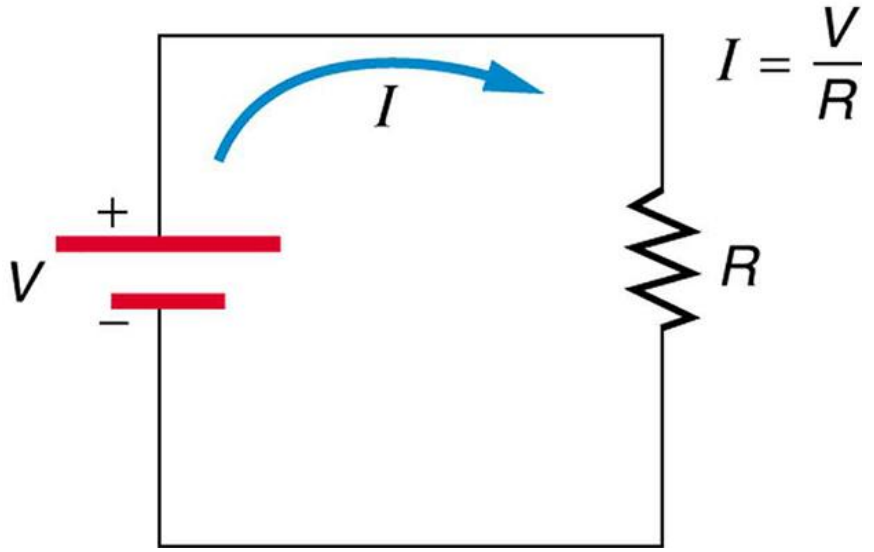
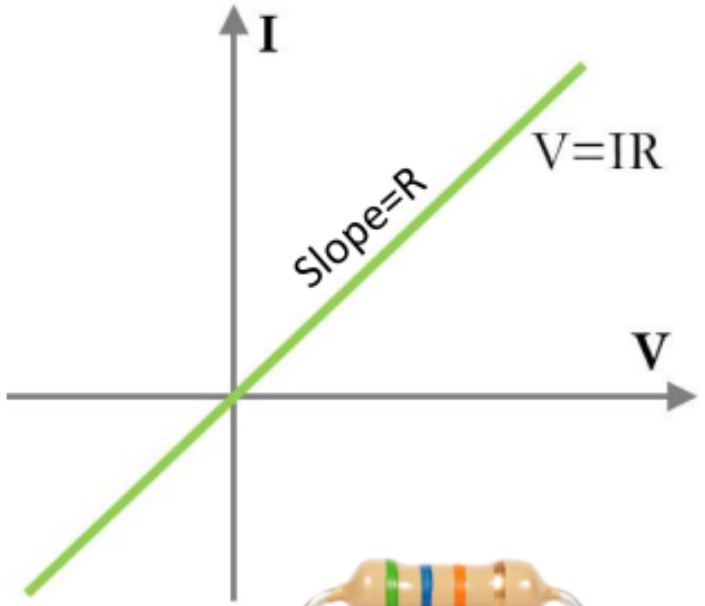
Ohm’s law

In an electrical circuit, the current passing through most materials is directly proportional to the potential difference applied across them.





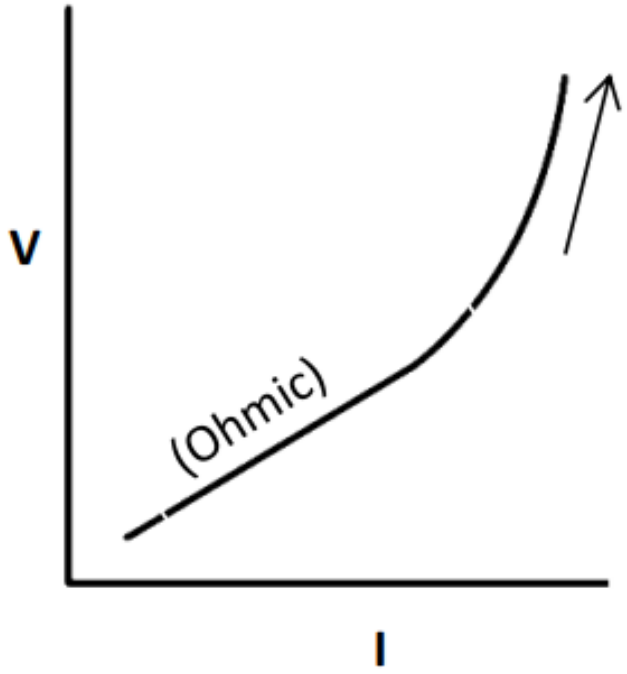
I-V curves of a resistor



Carbon film

FIXED

Ideal resistor



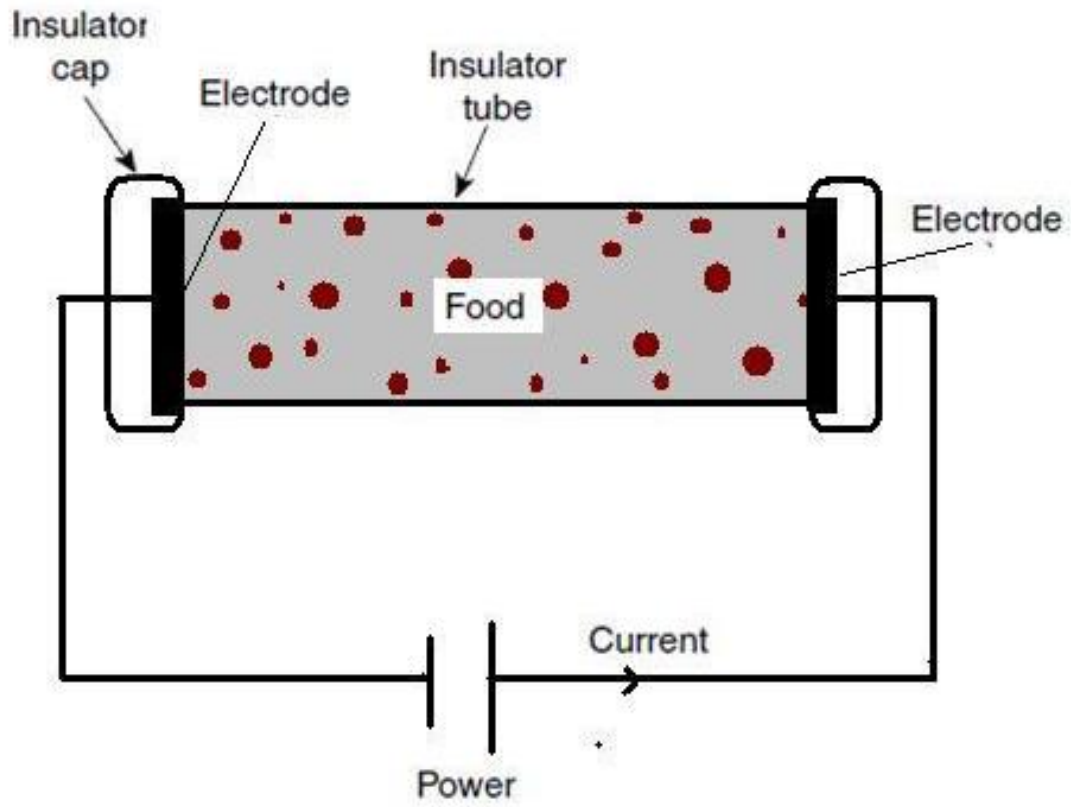
Joule heating
(non-ohmic, and usually happens only at very high currents)

Joule heating is expressed in terms of I^2R

Note: Here **V** and **I** axis are switched

Non-ideal resistor

Usage of Ohmic heating

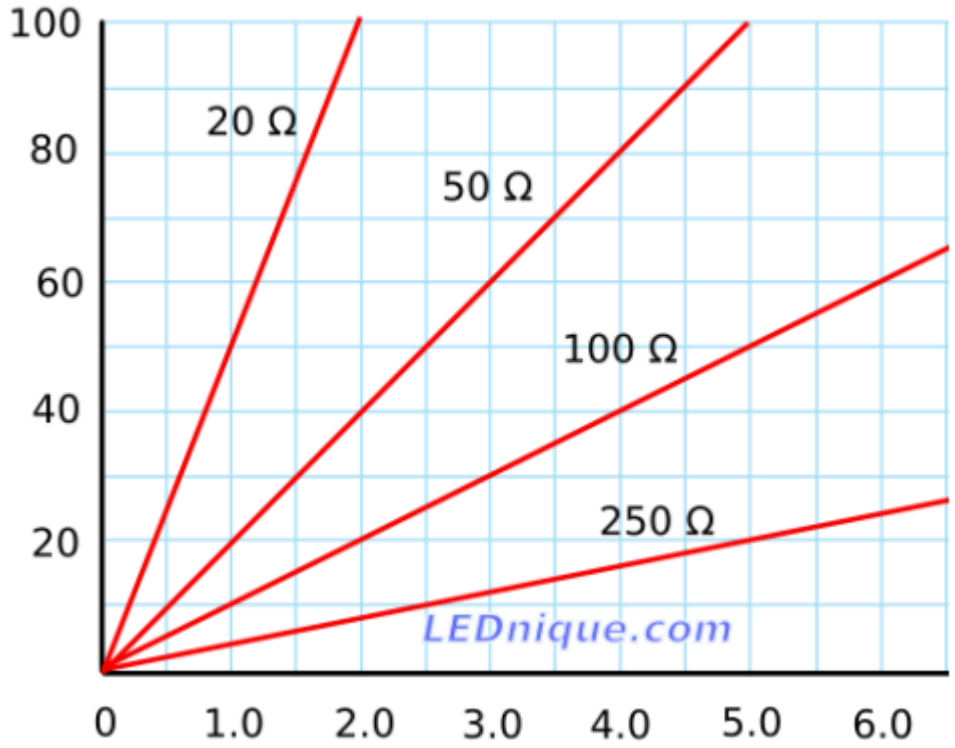


Food preservation

Ohmic heater

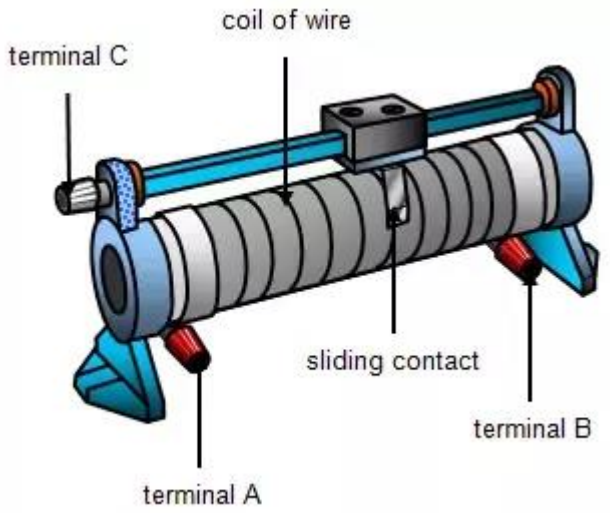
I-V curves of a variable resistor

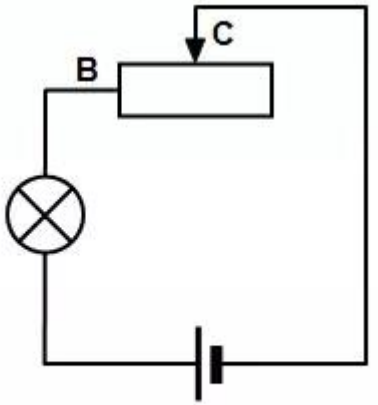
Variable resistor



Variable resistor I-V curve

Variable resistor: Rheostat

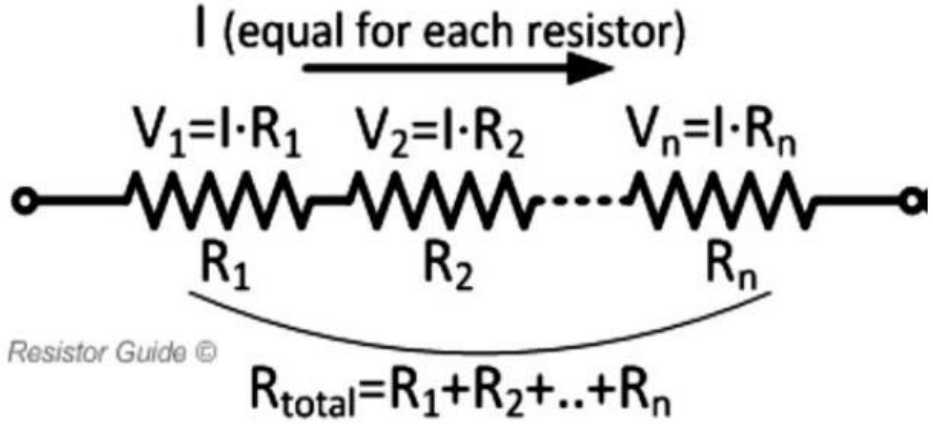


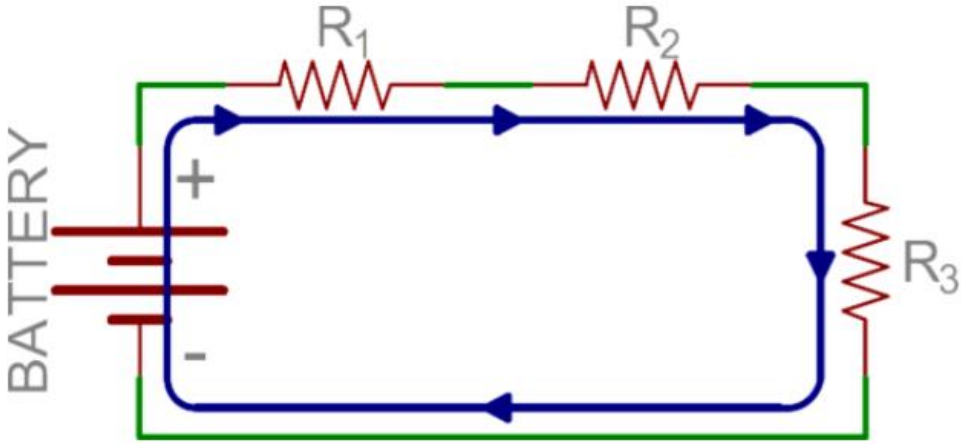


Rheostat function on a circuit

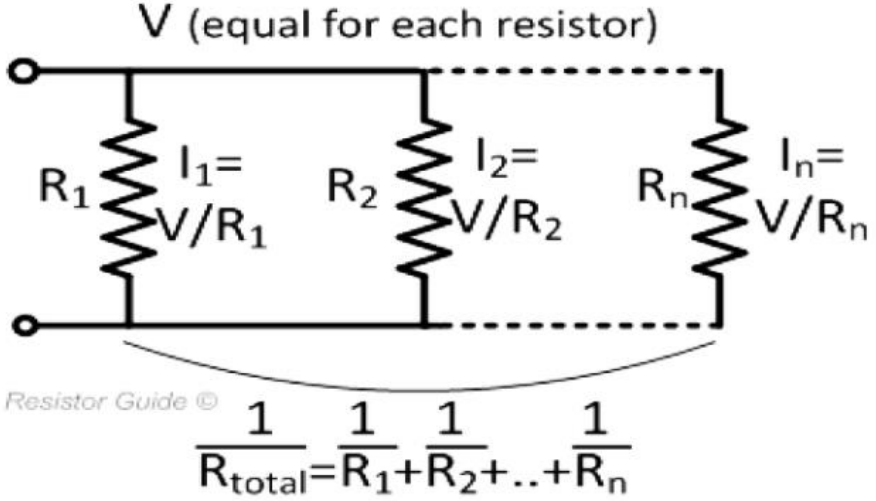
Resistor configuration

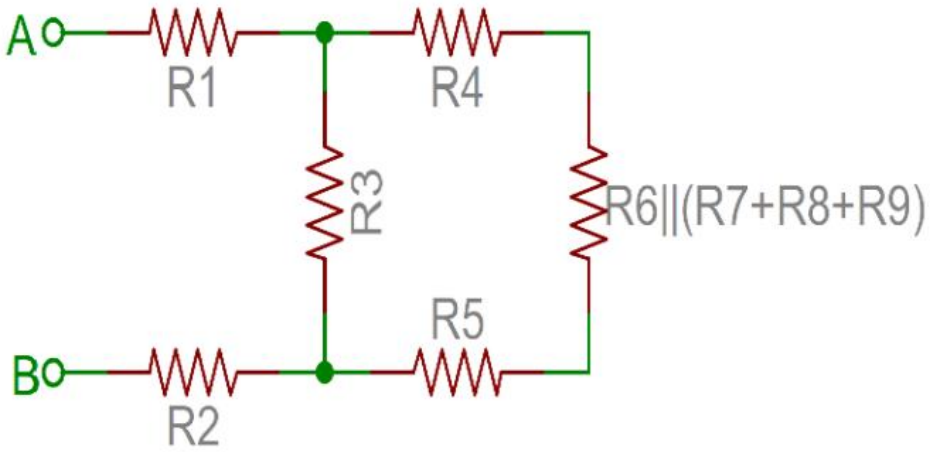
Series



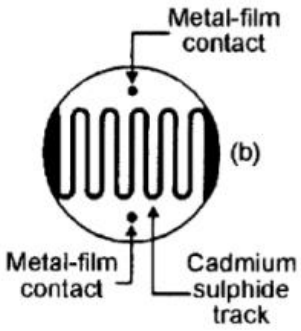


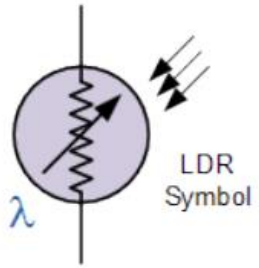
Parallel

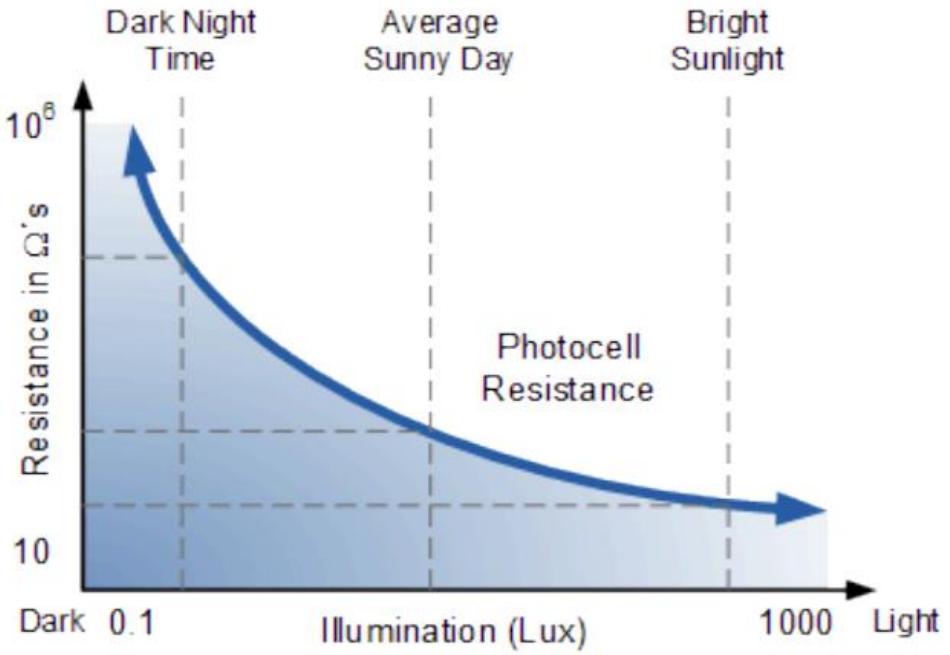




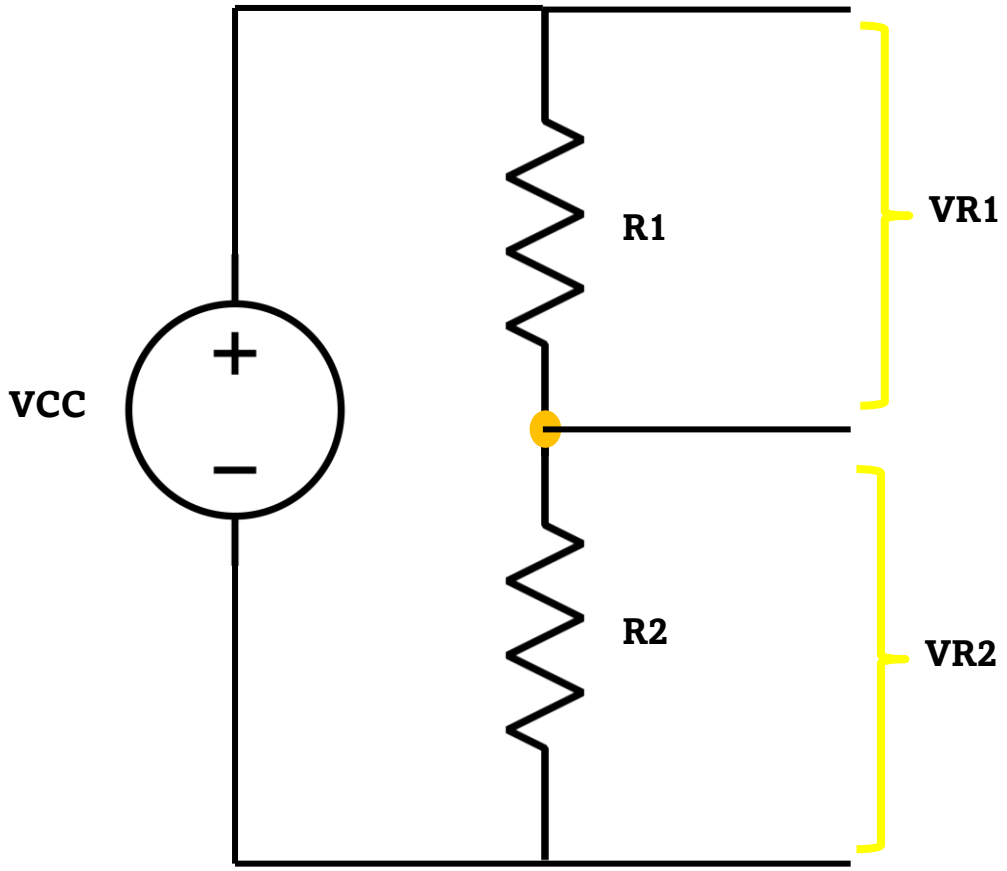
Light Dependent Resistors (LDR)







Voltage divider

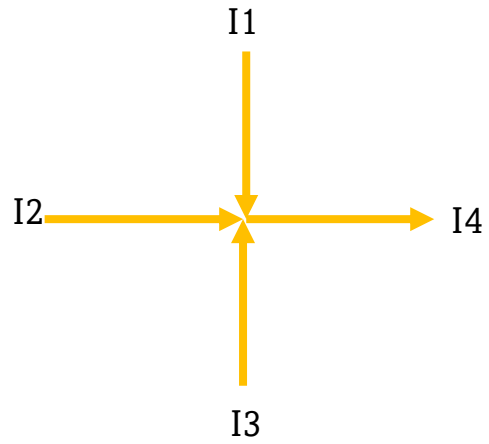


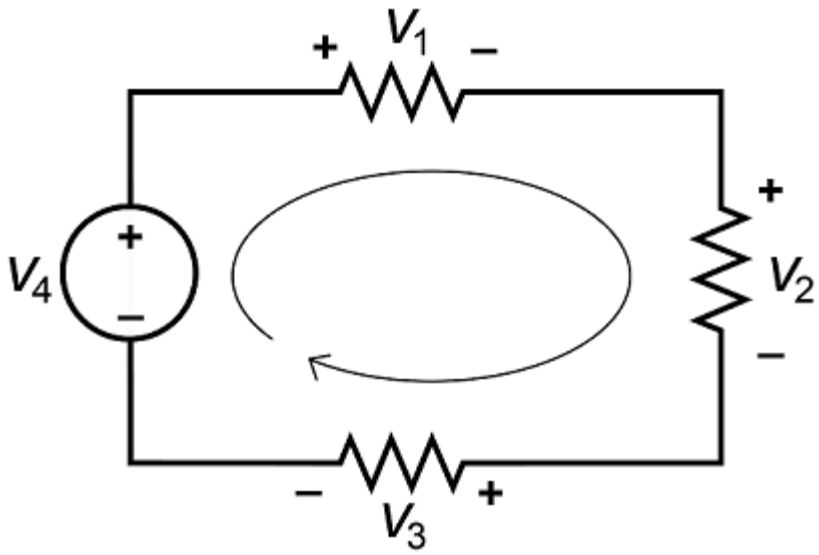
The voltage is depended on it's own resistance

$$V_{R1} = Vcc \times \left(\frac{R_1}{R_1 + R_2} \right)$$

$$V_{R2} = Vcc \times \left(\frac{R_2}{R_1 + R_2} \right)$$

Kirchoff's Law





$$\textbf{KCL} : I_{in} = I_{out}$$

$$\textbf{KVL} : \sum V = 0$$

$$\textbf{KCL} : I_1 + I_2 + I_3 = I_4$$

$$\textbf{KVL} : V_1 + V_2 + V_3 = V_4$$

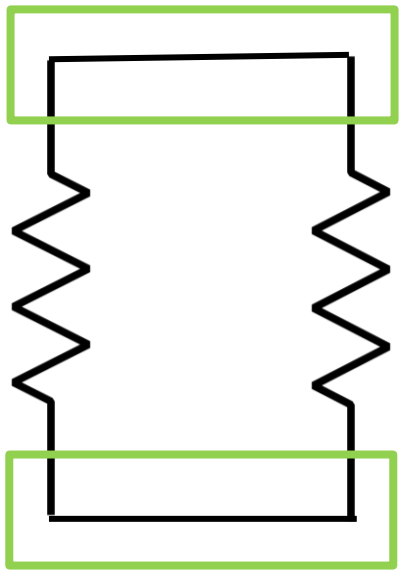
The sum of the current entering any point is equal to the sum of the current leaving the same point

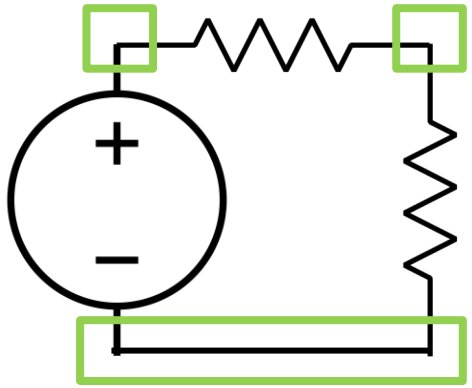
The sum of the voltage in any close loop is equal to zero

Sora

Nodal analysis

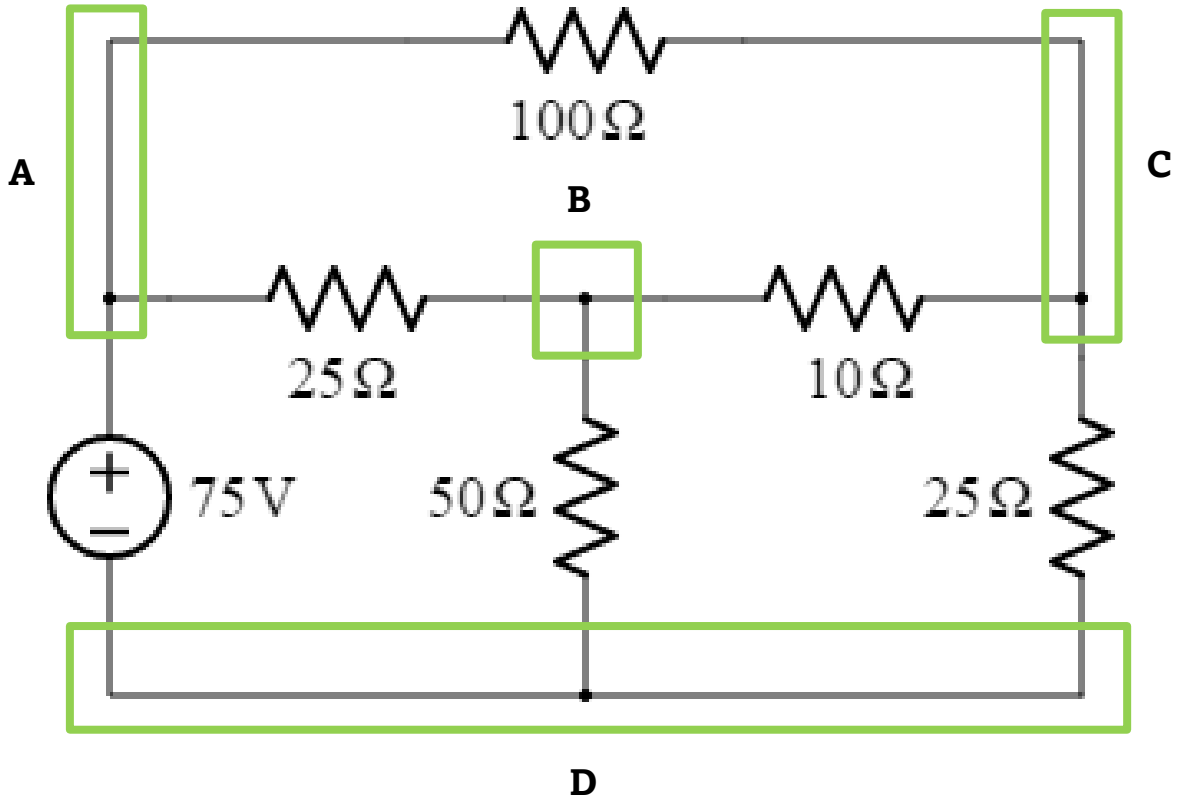
The connection point between two or more components





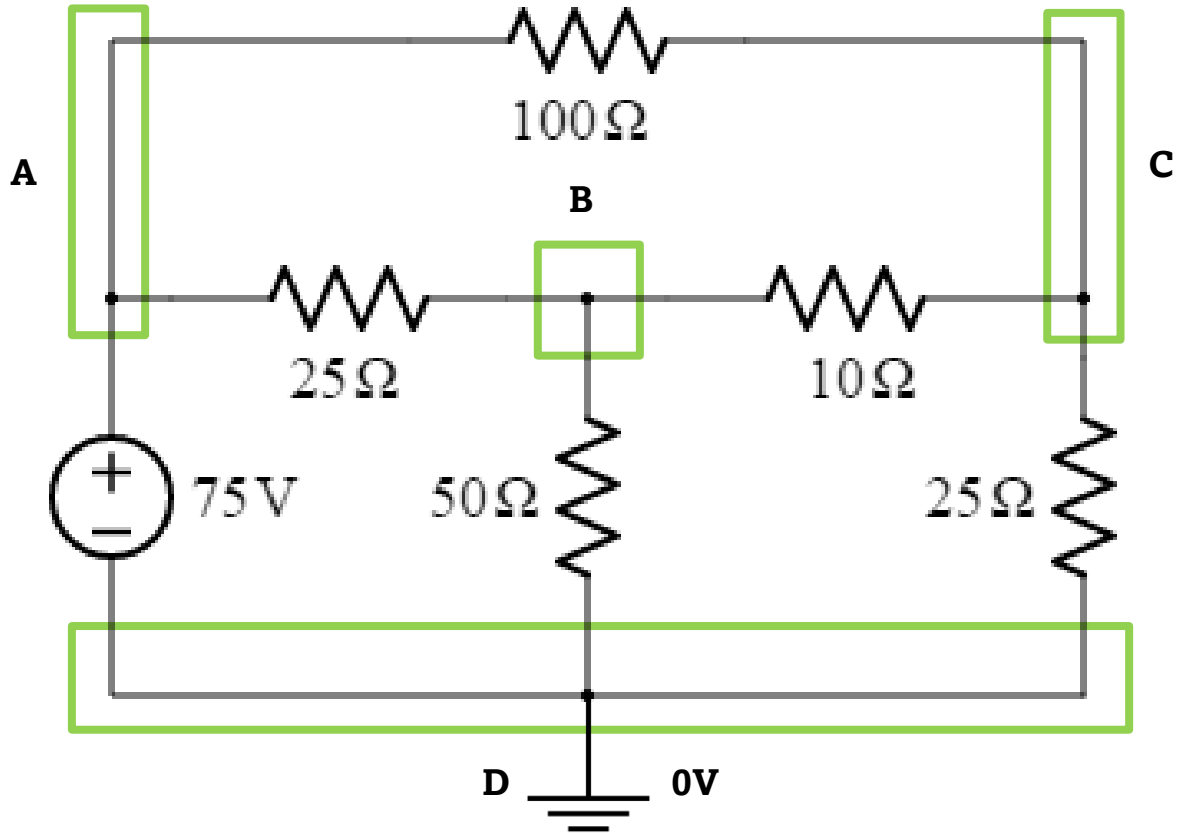
Nodal analysis

The connection point between two or more components



Nodal analysis

STEP 1: Select 1 node as ground (Reference point)



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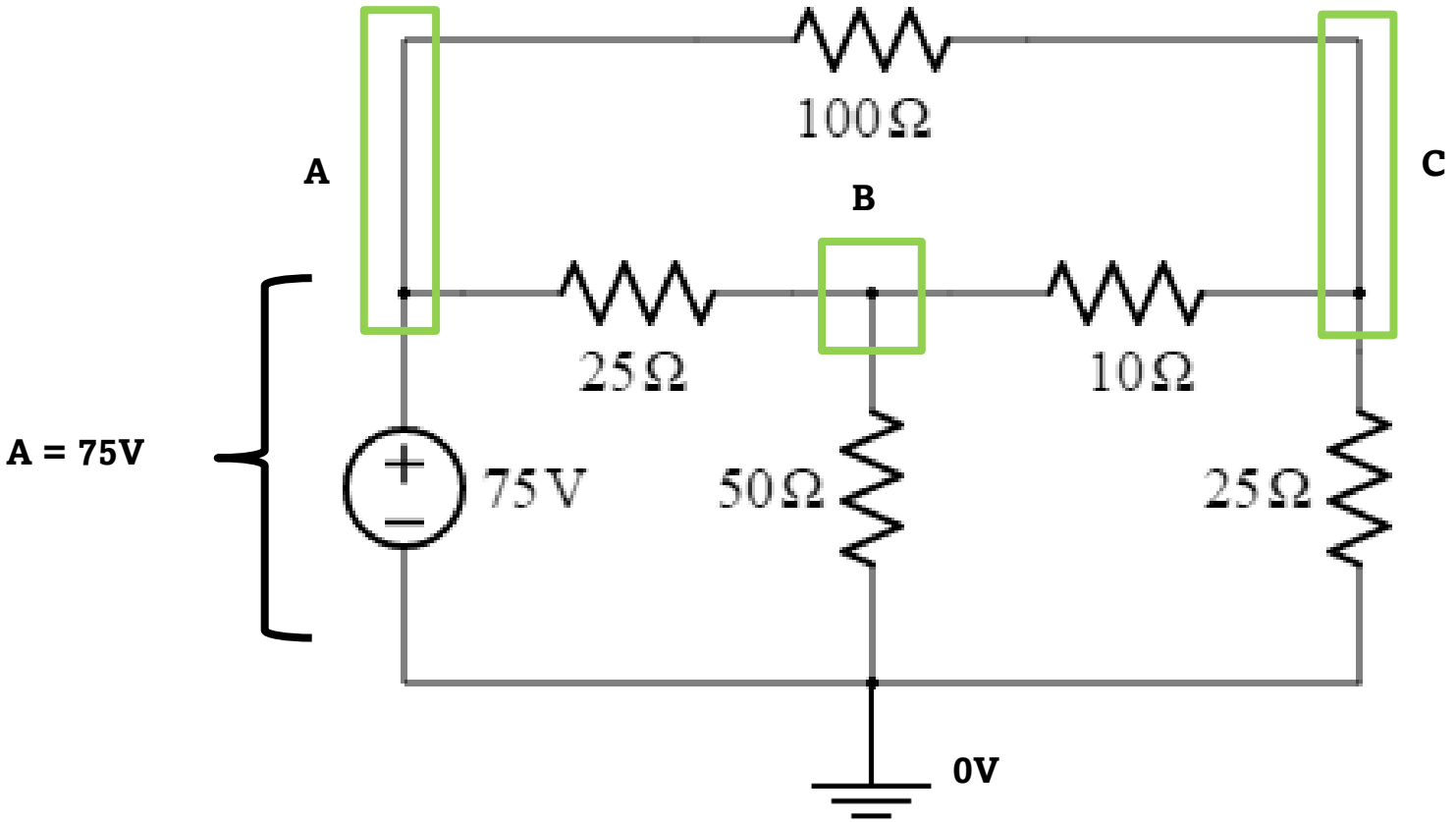
Nodal analysis

STEP 2: Extract the most information possible from the circuit to minimize the numbers of analysis.



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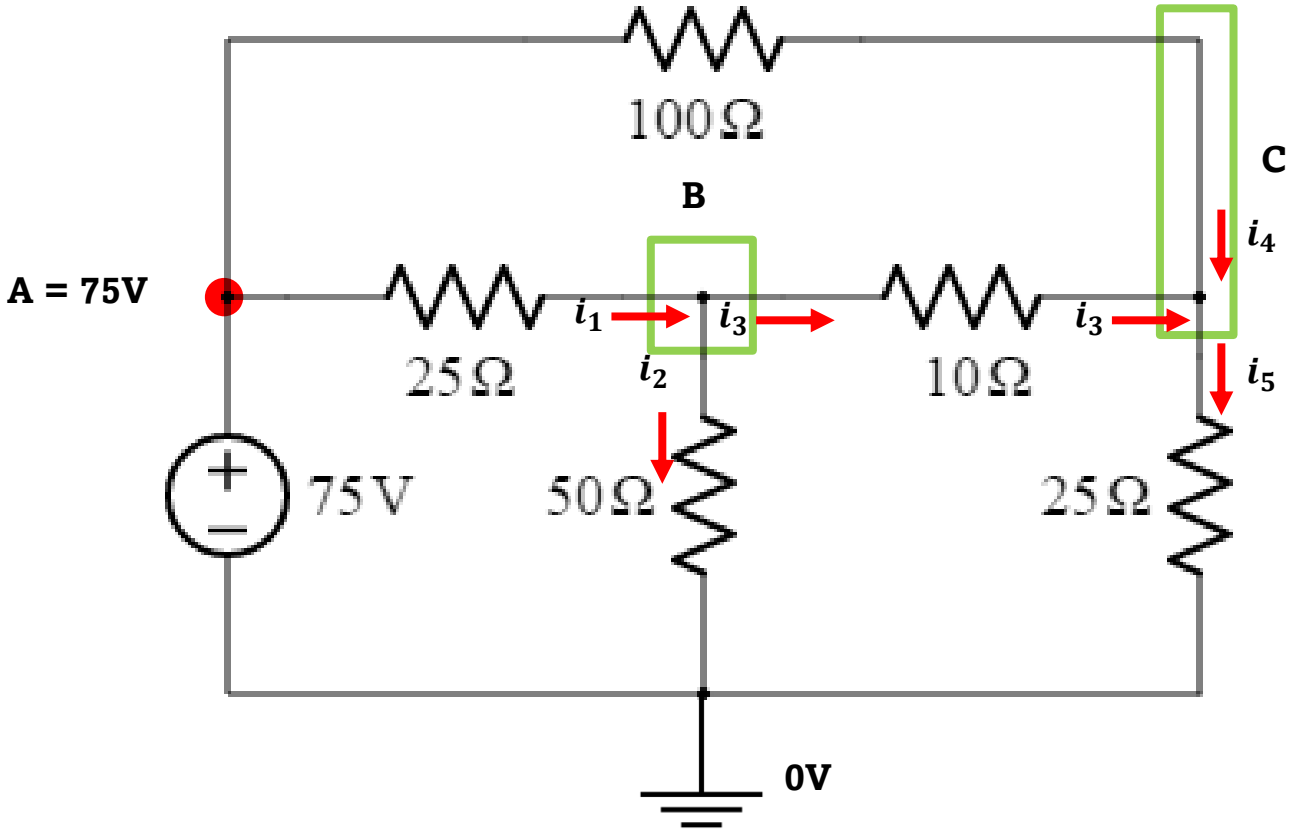
Nodal analysis

STEP 3: Apply the KCL at the remaining nodes



$$@node\ B\colon\ i_1 = i_2 + i_3$$

$$@node\ C\colon\ i_5 = i_3 + i_4$$

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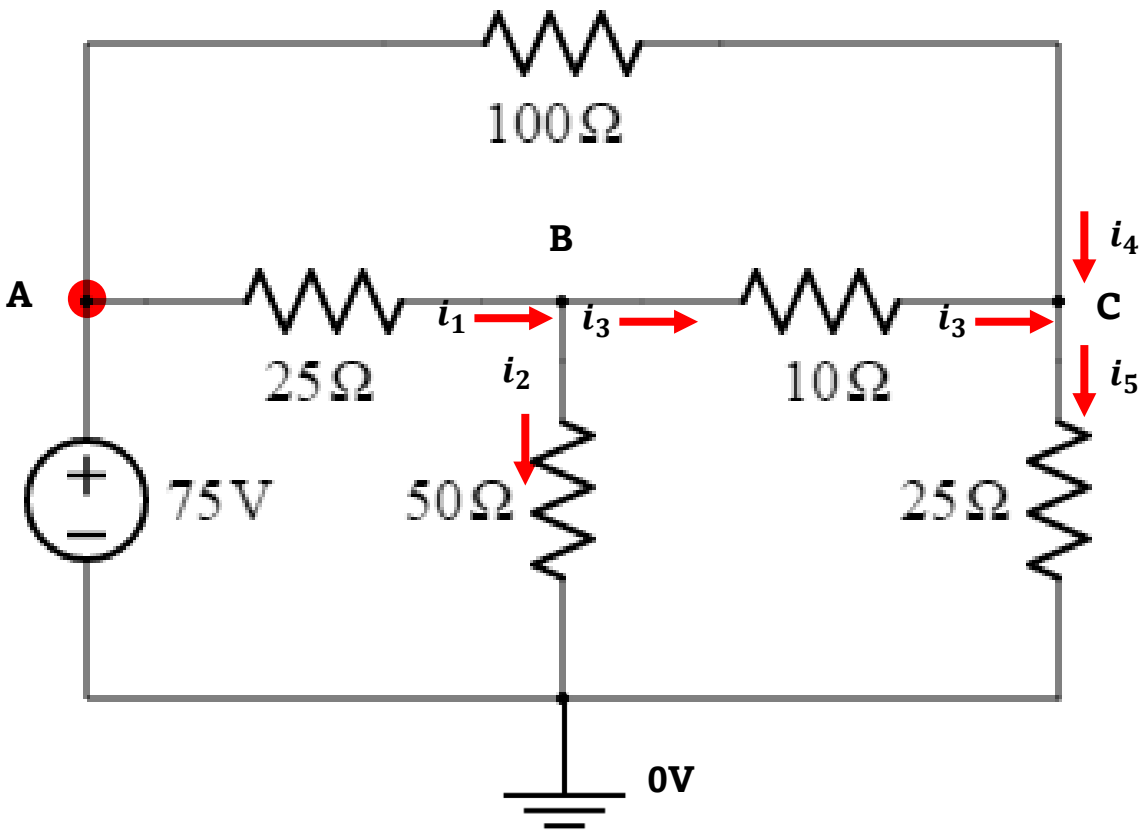
Nodal analysis

STEP 4: Substitute the Ohm's law to minimize the numbers of variable.



A = 75V

$$@node\ B\colon\ i_1 = i_2 + i_3$$

$$\frac{A-B}{25} = \frac{B-0}{50} + \frac{B-C}{10}$$

$$@node\ C\colon\ i_5 = i_3 + i_4$$

$$\frac{C-0}{25} = \frac{B-C}{10} + \frac{A-C}{100}$$

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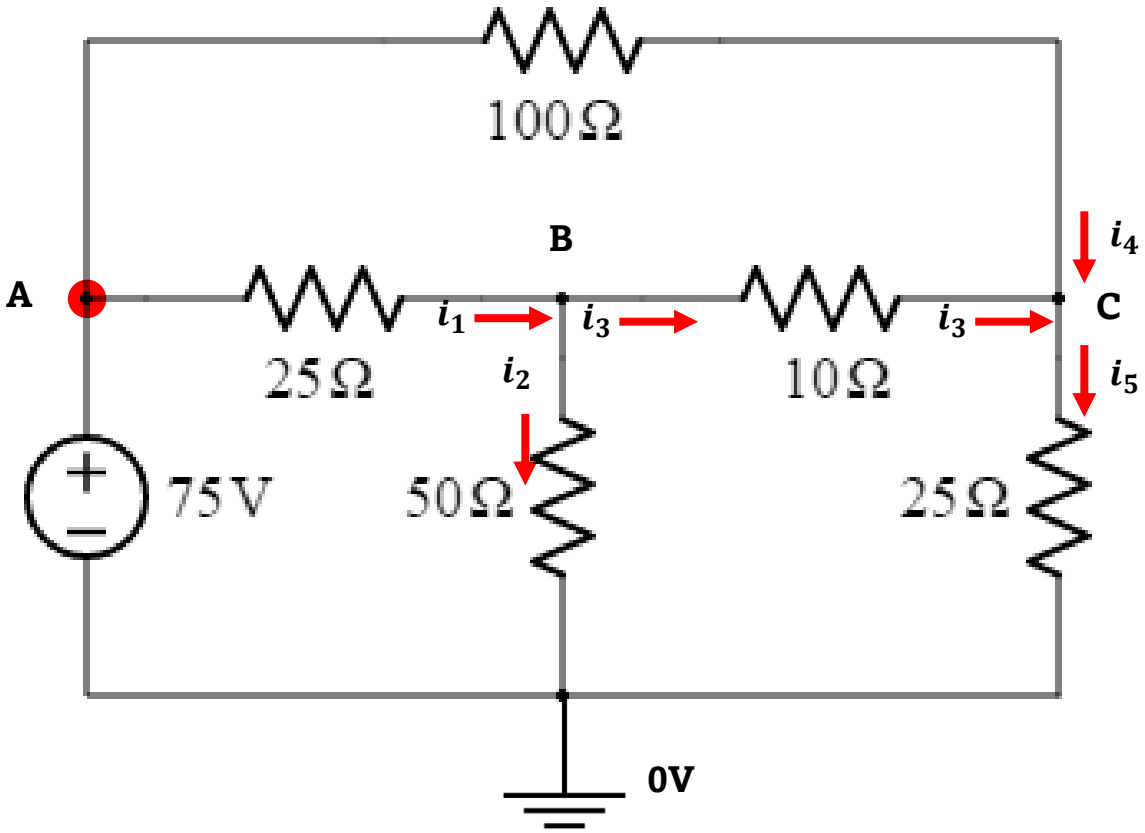
Nodal analysis

STEP 5: When the number of unknown variables is equal to the number of equations means the system of equation is solvable.



$$@node\ B:\ i_1 = i_2 + i_3$$

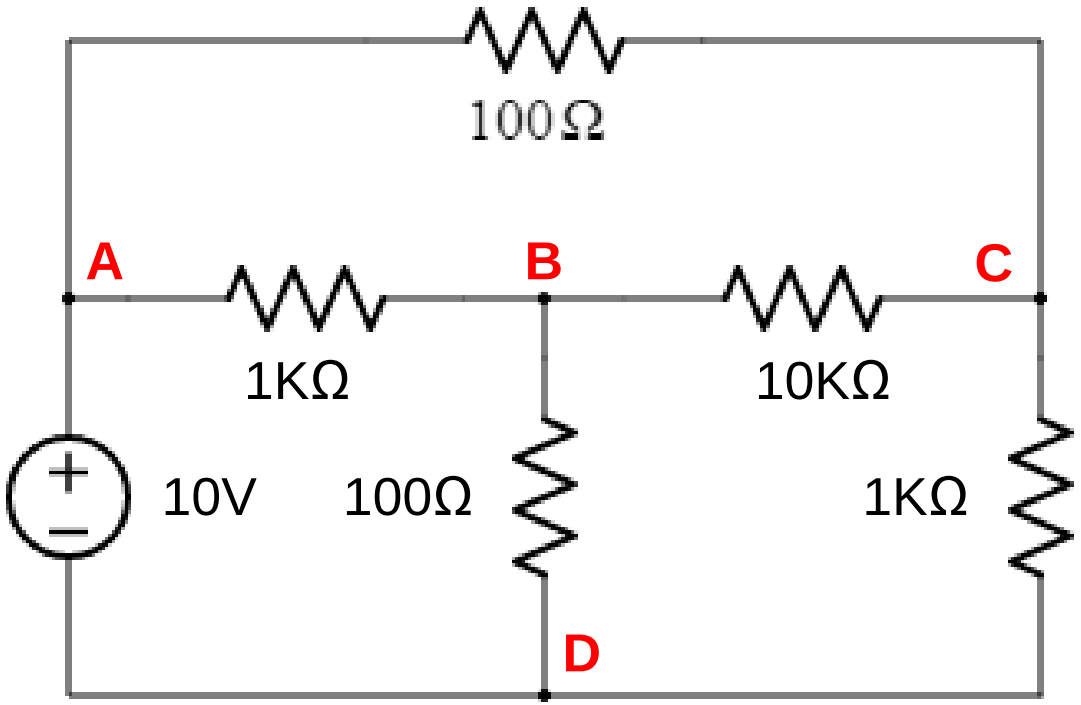
$$\frac{75 - B}{25} = \frac{B - 0}{50} + \frac{B - C}{10}$$

$$A = 75V \ \mid\ B = 37.5V \mid\ C = 30V$$

$$@node\ C:\ i_5 = i_3 + i_4$$

$$\frac{C - 0}{25} = \frac{B - C}{10} + \frac{75 - \mathrm{C}}{100}$$

Sora


100Ω
A
B
C
1KΩ
10KΩ
10V
100Ω
1KΩ
D