D.C. Circuits. Kirchhoff's Laws

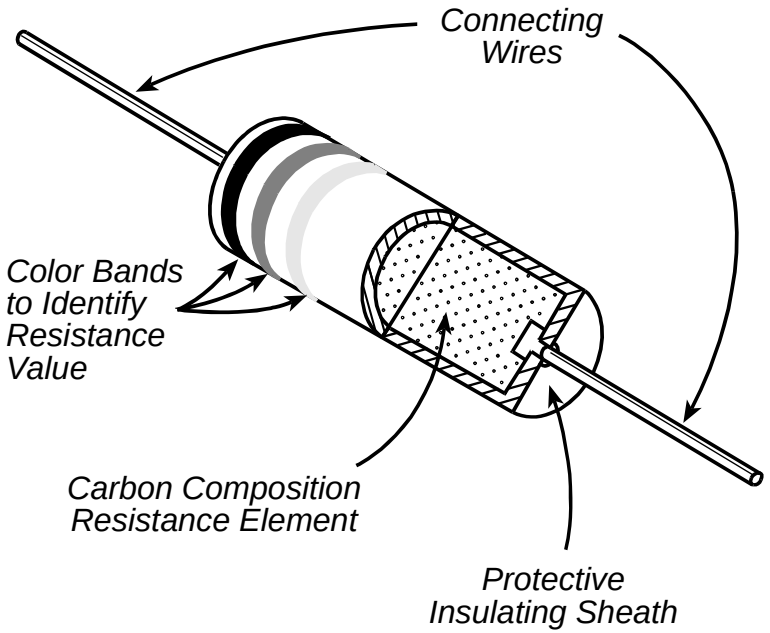
Resistance and Conductance

- The voltage-to-current ratio is called the **resistance**, *R*.
- The unit of resistance is the **ohm** (symbol Ω). A resistance of 1 Ω will have a current of 1 A flowing through it when the potential difference across it is 1 V.

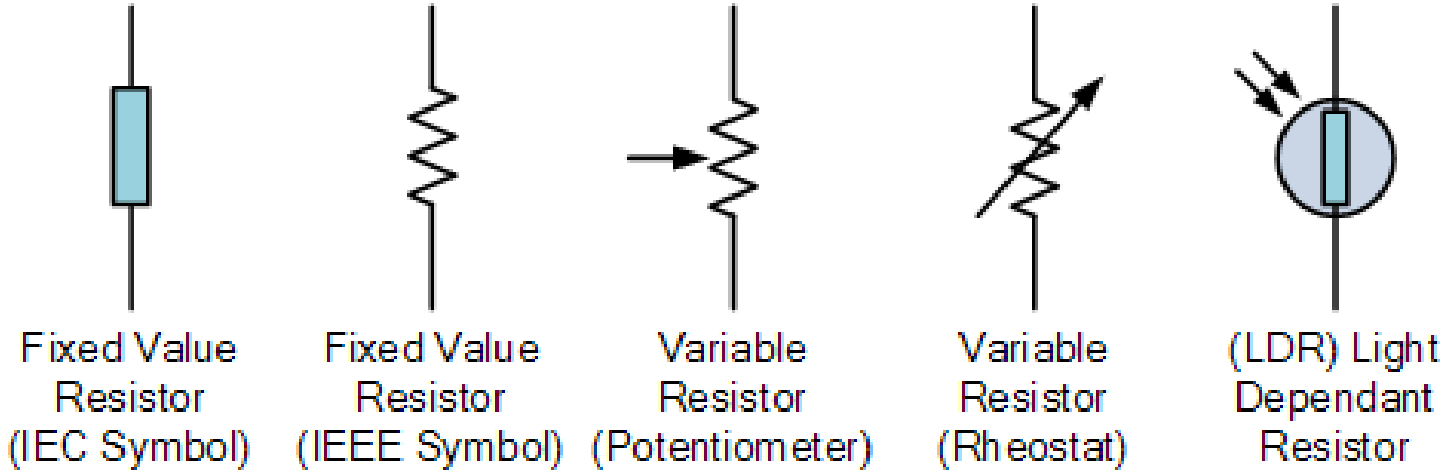
[R = V ÷ I] R (Ω) = V (volts) ÷ I (amps)

Construction

Devices having a more or less constant value of resistance over the widest possible range of operating conditions are called **resistors.**

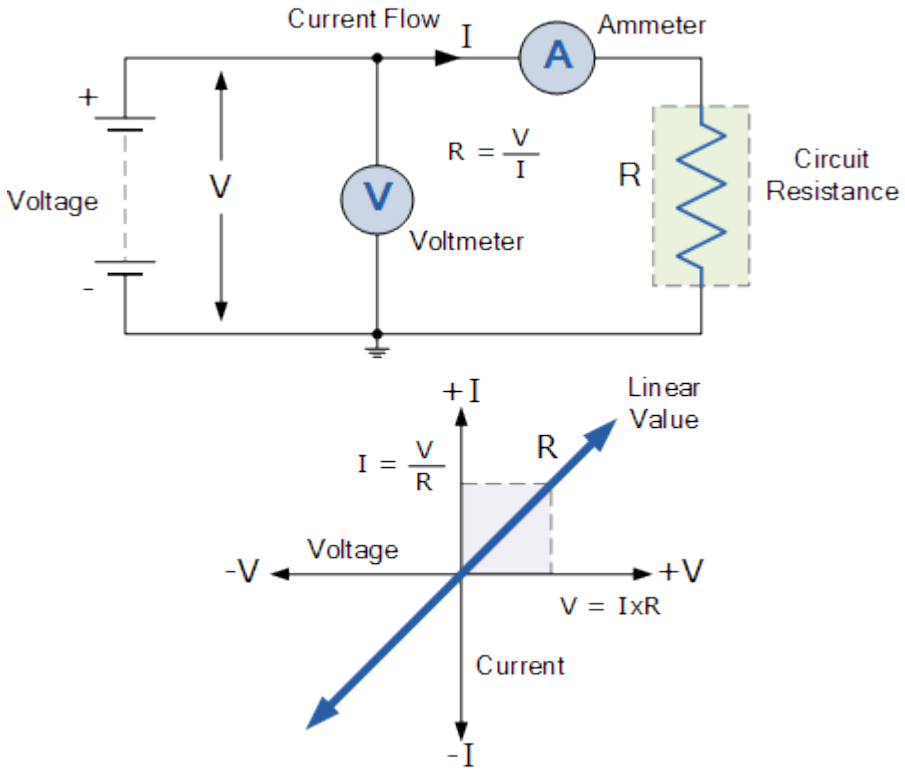


Resistor Symbols



A “good conductor” – low resistance,
a “bad conductor” – high resistance

Volt-Ampere Characteristic

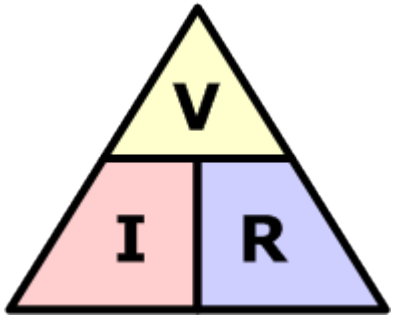


A voltage/current graph for a resistor that would be a straight line through the origin, where the slope of the line is the resistance.

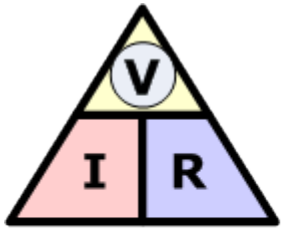
Ohms Law Relationship

$$Current,(I) = \frac{Voltage,(V)}{Resistance,(R)} \; in \; Amperes,(A)$$

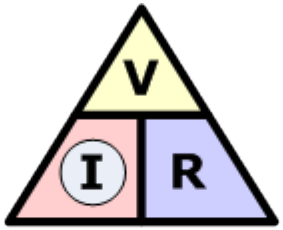
Ohms Law Triangle:



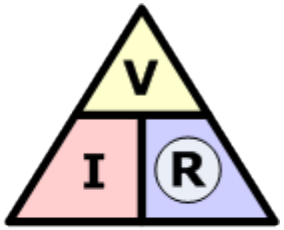
By knowing any two values of the Voltage, Current or Resistance quantities we can use Ohms Law to find the third missing value:



$V = I \times R$



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



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

Conductance

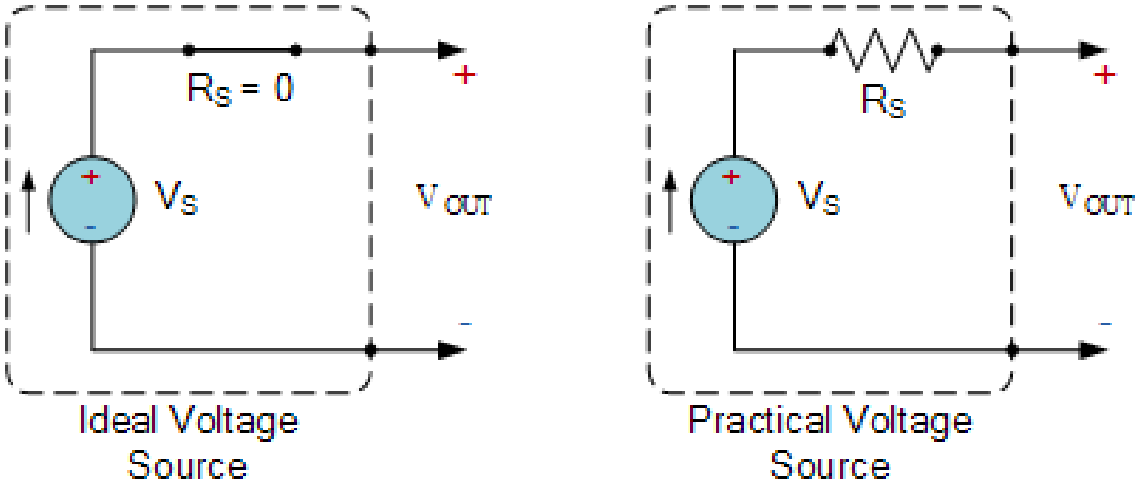
The ratio *I*/*V* is called the **conductance** of the circuit, symbol *G*:

$$G = \frac{I}{V}$$

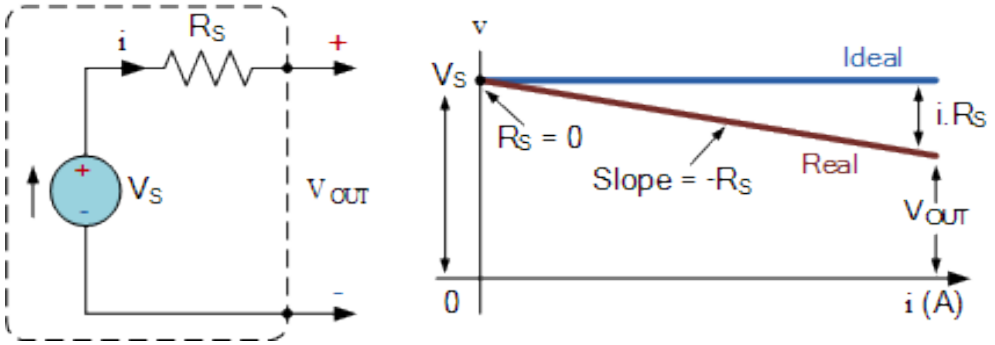
The conductance unit is the **siemens** (symbol *S*).
A resistor whose conductance is 1 S, through which a current of l A is flowing, has 1 V potential difference across it.

$$G = \frac{1}{R}$$

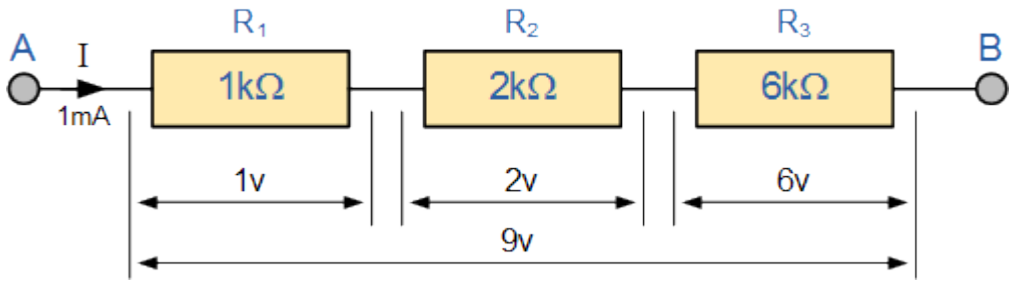
Internal Resistance of an E.M.F. Source



Practical Voltage Source Characteristics



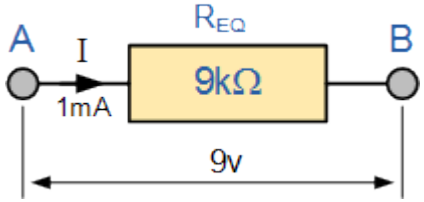
Resistors in Series



As the resistors are connected together in series the same current passes through each resistor in the chain and the total resistance, R_T of the circuit must be equal to the sum of all the individual resistors added together.

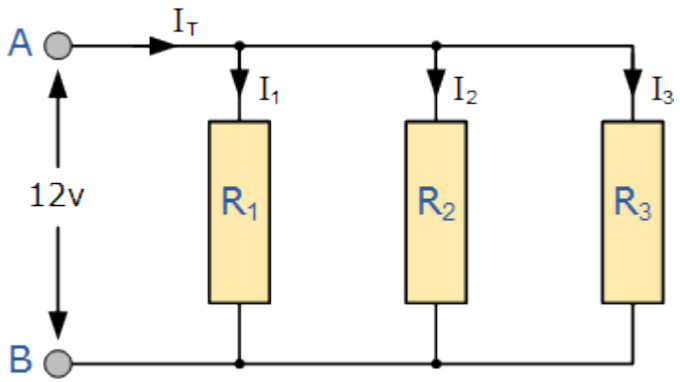
$$R_T = R_1 + R_2 + R_3$$

we can replace all three individual resistors above with just one single “equivalent” resistor:



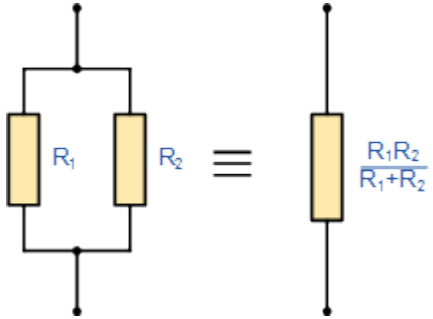
- This is the simple one*!!!*
- Resistors *must* carry the same current*!!!*
- L’s is series and C’s in parallel have same form.

Resistors in Parallel

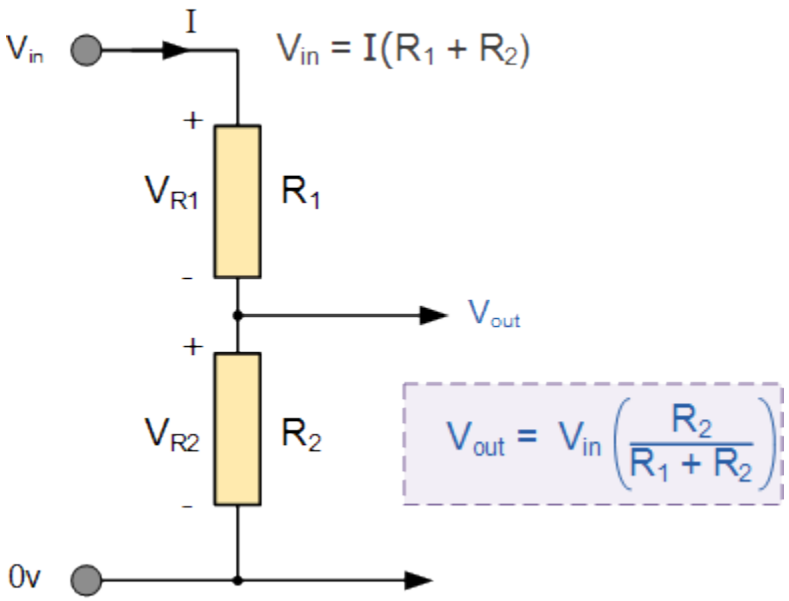


$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots + \frac{1}{R_n} \text{ etc}$$

If however, there are only two individual resistors in parallel then we can use a much simpler and quicker formula to find the total or equivalent resistance value, R_T

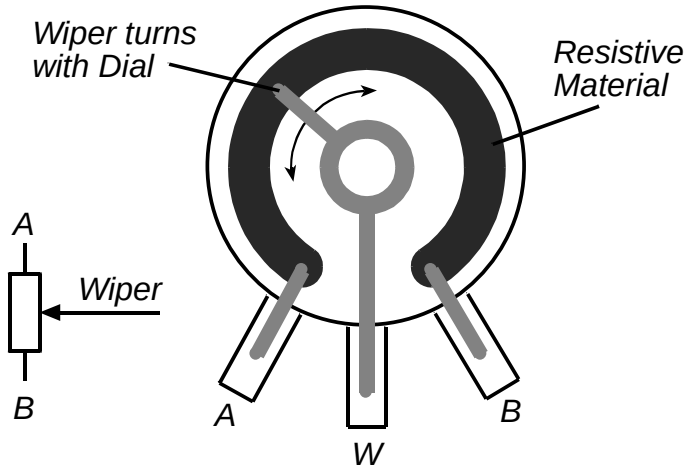


Voltage Divider Network



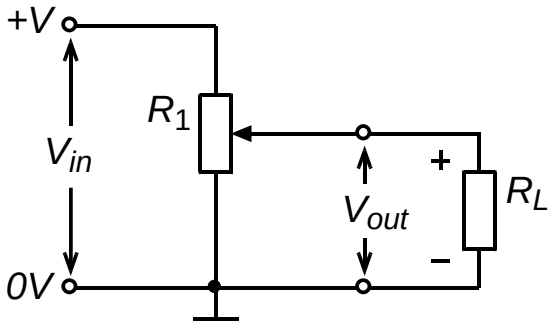
The circuit consists of two resistors, R_1 and R_2 connected together in series across the supply voltage V_{in}. One side of the power supply voltage is connected to resistor, R_1, and the voltage output, V_{out} is taken from across resistor R_2.

The Variable Potential Divider



Rotary potentiometer construction

The output voltage can be varied from zero to the input voltage level by adjusting the position of the wiper contact:



Kirchhoff's Laws

In 1845, a German physicist, **Gustav Kirchhoff** developed a pair or set of rules or laws which deal with the conservation of current and energy within electrical circuits.

These two rules are commonly known as: *Kirchhoffs Circuit Laws* with one of Kirchhoffs laws dealing with the current flowing around a closed circuit,

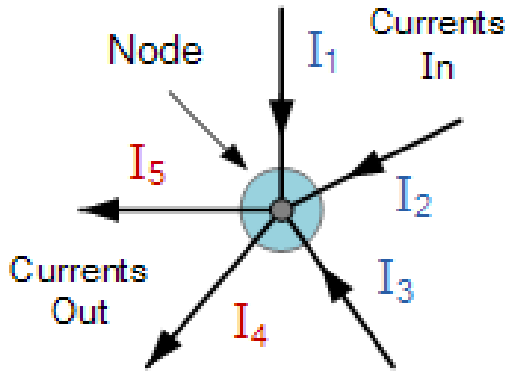
Kirchhoffs Current Law, (KCL)

while the other law deals with the voltage sources present in a closed circuit,

Kirchhoffs Voltage Law, (KVL).

Kirchhoffs First Law – The Current Law, (KCL)

Currents Entering the Node
Equals
Currents Leaving the Node



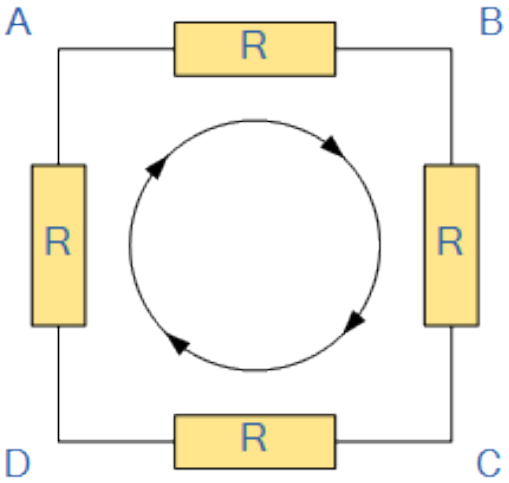
$$I_1 + I_2 + I_3 + (-I_4 + -I_5) = 0$$

"*Total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node*".

The term **Node** in an electrical circuit generally refers to a connection or junction of two or more current carrying paths or elements such as cables and components.

Kirchhoffs Second Law – The Voltage Law, (KVL)

The sum of all the Voltage Drops around the loop is equal to Zero

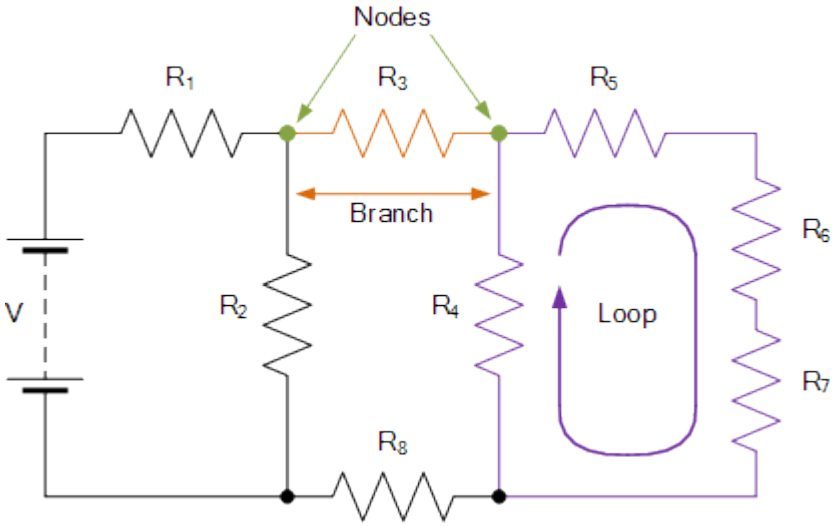


$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

"*In any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop*" which is also equal to zero.

A Typical DC Circuit

Common DC Circuit Theory Terms:



• Circuit – a circuit is a closed loop conducting path in which an electrical current flows.

• Path – a single line of connecting elements or sources.

• Node – a node is a junction, connection or terminal within a circuit were two or more circuit elements are connected or joined together giving a connection point between two or more branches. A node is indicated by a dot.

• Branch – a branch is a single or group of components such as resistors or a source which are connected between two nodes.

• Loop – a loop is a simple closed path in a circuit in which no circuit element or node is encountered more than once.

• Mesh – a mesh is a single open loop that does not have a closed path. There are no components inside a mesh.

Thank you for
your attention!