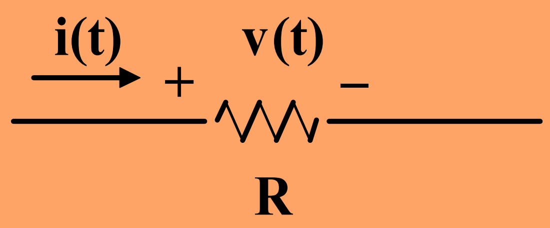
Basic Laws of Electric Cicuits

Ohms Law
Kirchhoff's Current Law

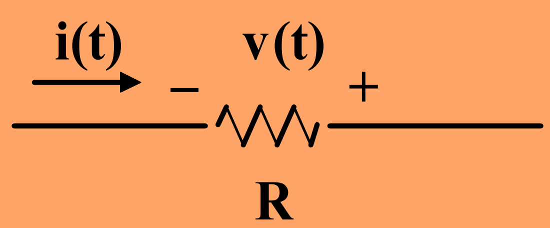
Basic Laws of Circuits

Ohm's Law:

The voltage across a resistor is directly proportional to the current moving through the resistor.



$$v(t) = Ri(t) \qquad (2.1)$$

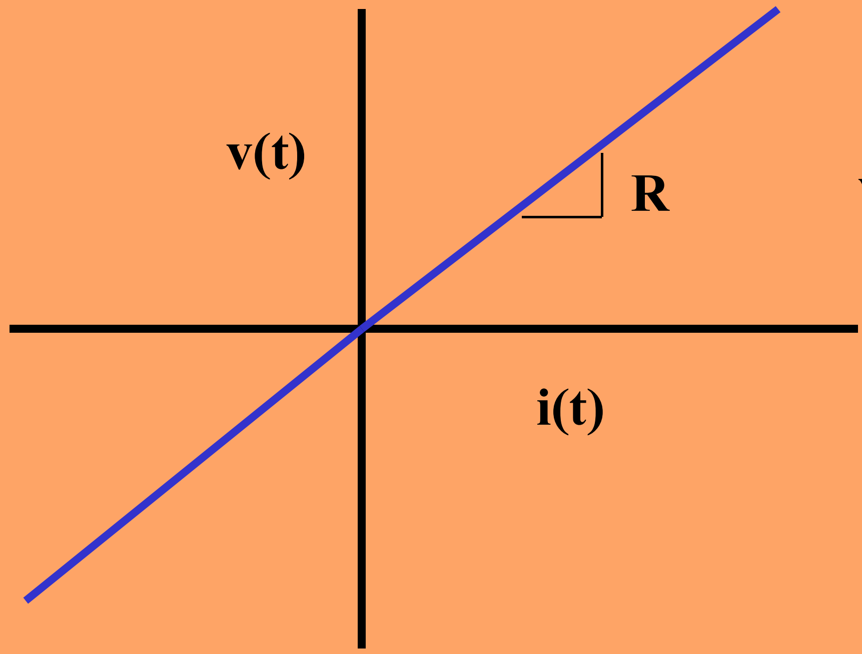


$$v(t) = -Ri(t) \qquad (2.2)$$

Basic Laws of Circuits

Ohm's Law:

Directly proportional means a straight line relationship.



$v(t) = Ri(t)$

The resistor is a model and will not produce a straight line for all conditions of operation.

Basic Laws of Circuits

Ohm's Law: About Resistors:

The unit of resistance is ohms(Ω).

A mathematical expression for resistance is

$$R = \rho \frac{l}{A} \qquad \textbf{(2.3)}$$

$l : The\ length\ of\ the\ conductor\ (meters)$

$A : The\ cross-sectional\ area\ (meters^2)$

$\rho : The\ resistivity\ (\Omega \cdot m)$

Basic Laws of Circuits

Ohm's Law: About Resistors:

We remember that resistance has units of ohms. The reciprocal of resistance is conductance. At one time, conductance commonly had units of mhos (resistance spelled backwards).

In recent years the units of conductance has been established as seimans (S).

Thus, we express the relationship between conductance and resistance as

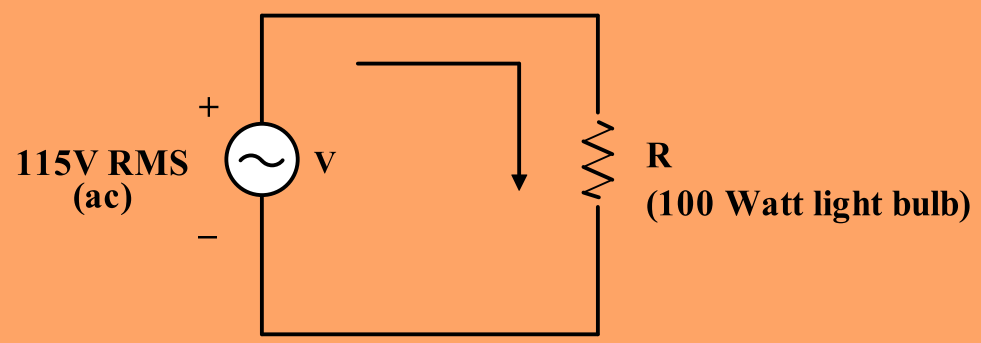
$$G = \frac{1}{R} \quad \text{(S)} \qquad (2.4)$$

We will see later than when resistors are in parallel, it is convenient to use Equation (2.4) to calculate the equivalent resistance.

Basic Laws of Circuits

Ohm's Law: **Ohm's Law: Example 2.1.**

Consider the following circuit.



Determine the resistance of the 100 Watt bulb.

$$P = VI = \frac{V^2}{R} = I^2 R \qquad \textbf{(2.5)}$$

$$R = \frac{V^2}{P} = \frac{115^2}{100} = 132.25\ ohms$$

A suggested assignment is to measure the resistance of a 100 watt light bulb with an ohmmeter.

Basic Laws of Circuits

Ohm's Law: **Property of Resistance:**

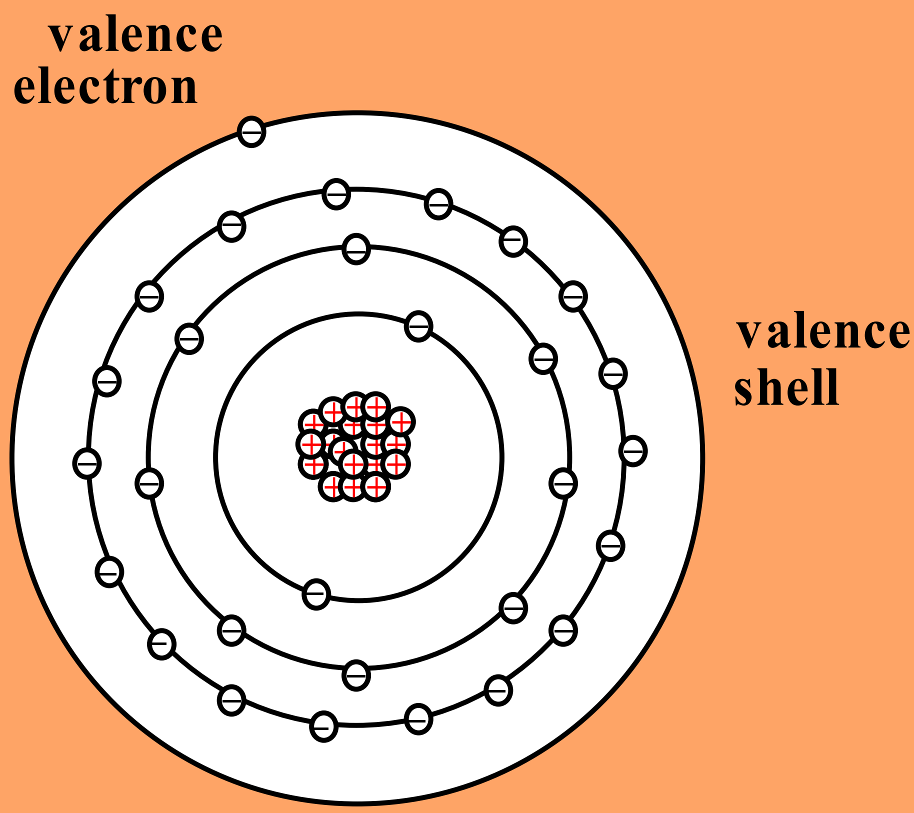
Resistivities of some basic materials

Material	Resistivity (ohm meters)	Common Use
silver	$1.6x10^{-8}$	conductor
copper	$1.7x10^{-8}$	conductor
aluminum	$2.8x10^{-8}$	conductor
gold	$2.5x10^{-8}$	conductor
carbon	$4.1x10^{-5}$	semiconductor
germanium	$47x10^{-2}$	semiconductor
silicon	$6.4x10^{2}$	semiconductor
paper	$1x10^{10}$	insulator
mica	$5x10^{11}$	insulator
glass	$1x10^{12}$	insulator
teflon	$3x10^{12}$	insulator

Basic Laws of Circuits

Ohm's Law: Property of Resistance

Why are some materials better conductors than others? Consider copper.

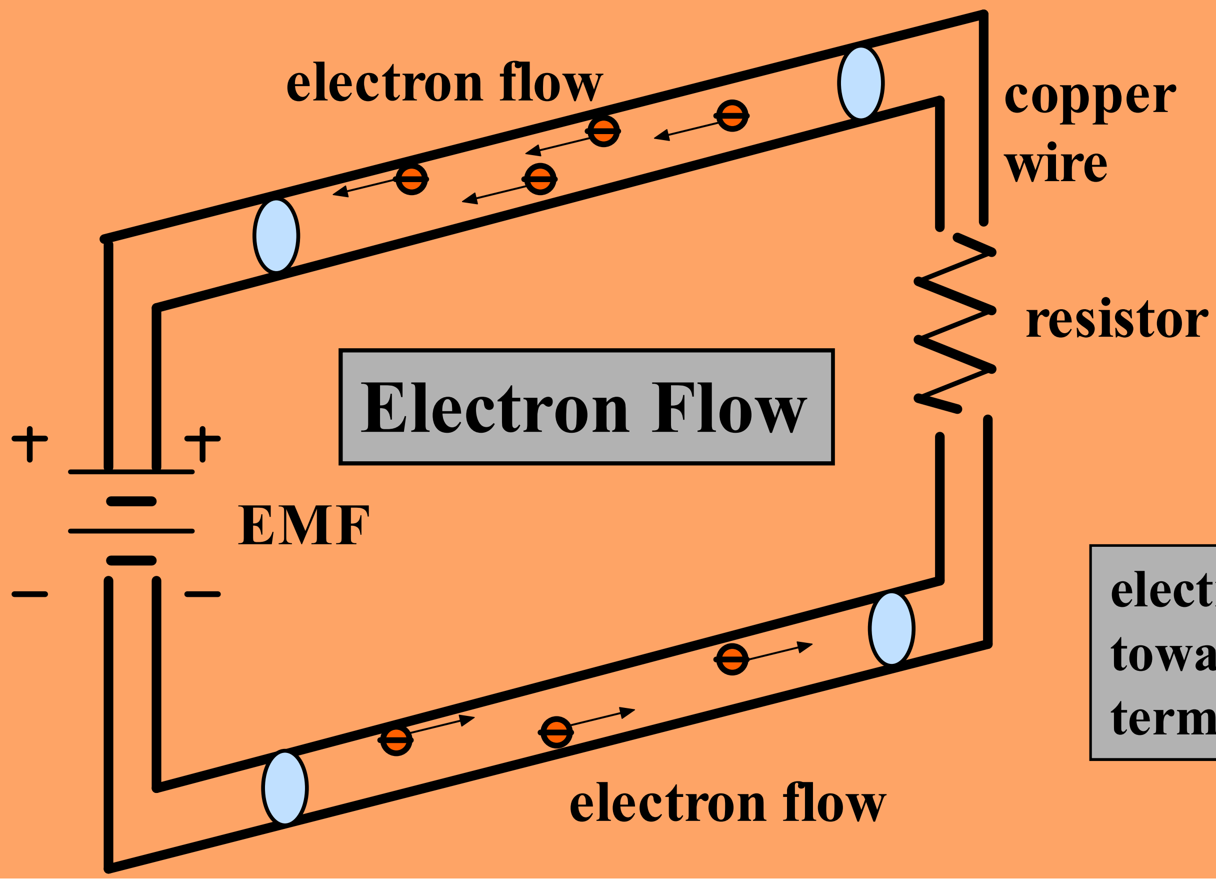


Copper Atom

Basic Laws of Circuits

Ohm's Law: Current

Under the influence of an electromotive force, the one valence electron of each copper atom is pulled from the outer orbit and moves through the copper space toward a positive potential.

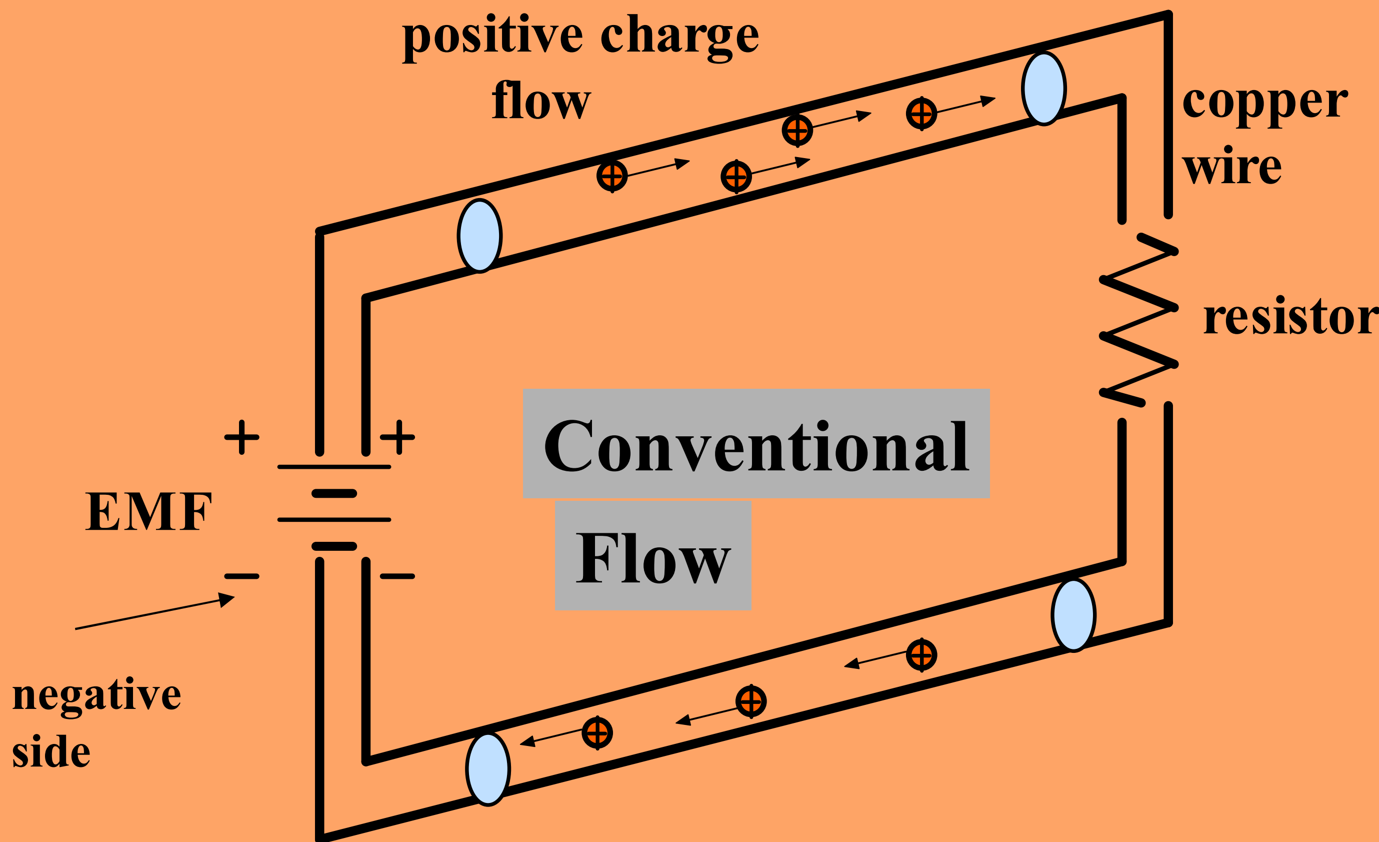


electrons move toward the positive terminal of the EMF

Basic Laws of Circuits

Ohm's Law: Current

Conventional current flow assumes positive charges move toward the negative side of the circuit EMF.

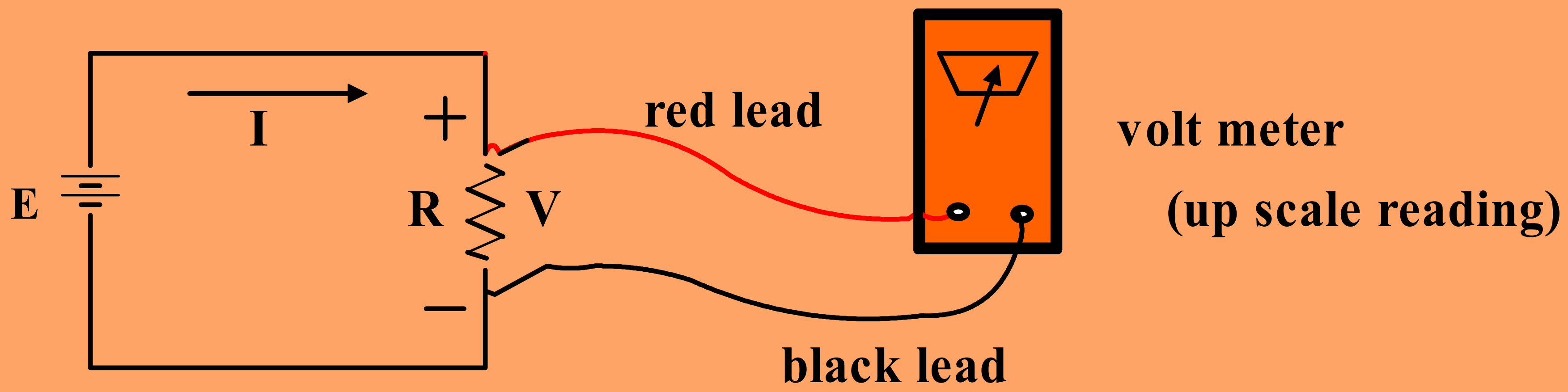


Basic Laws of Circuits

Ohm's Law: Current

We assume conventional current flow (positive charge movement) although we know this is not the case.

Assuming conventional current flow does not change the answer(s) to an electric circuit solution.



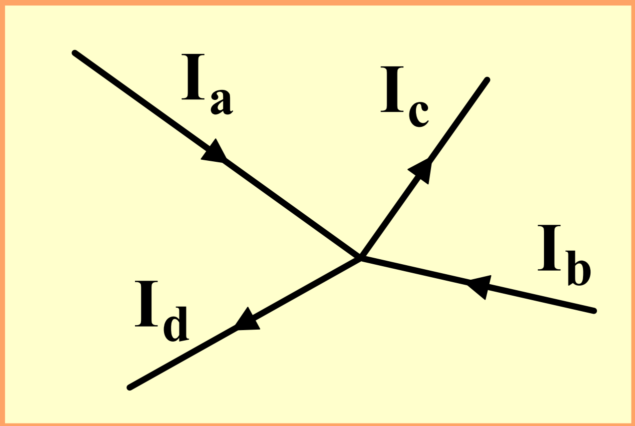
$$E = V = +IR$$

Basic Laws of Circuits

Kirchhoff's Current Law

As a consequence of the Law of the conservation of charge, we have:

- **The sum of the current entering a node (junction point) equal to the sum of the currents leaving.**



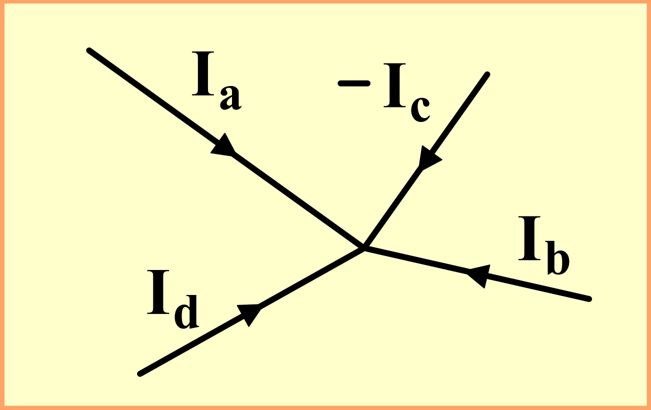
$$I_a + I_b = I_c + I_d$$

I_a, I_b, I_c, and I_d can each be either a positive or negative number.

Basic Laws of Circuits

Kirchhoff's Current Law

- **The algebraic sum of the currents entering a node equal to zero.**



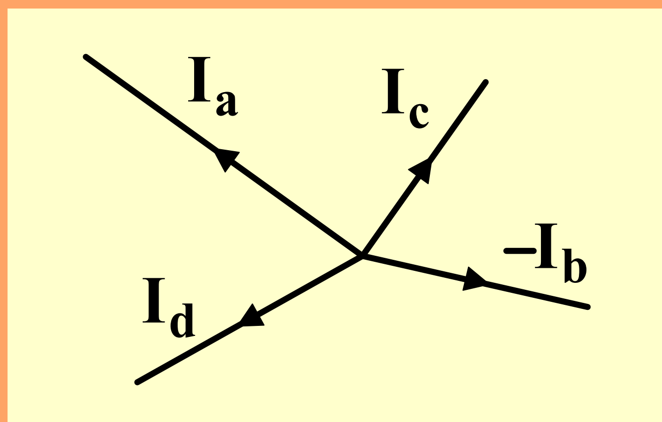
$$I_a + I_b - I_c + I_d = 0$$

I_a, I_b, I_c, and I_d can each be either a positive or negative number.

Basic Laws of Circuits

Kirchhoff's Current Law

- **The algebraic sum of the currents leaving a node equal to zero.**



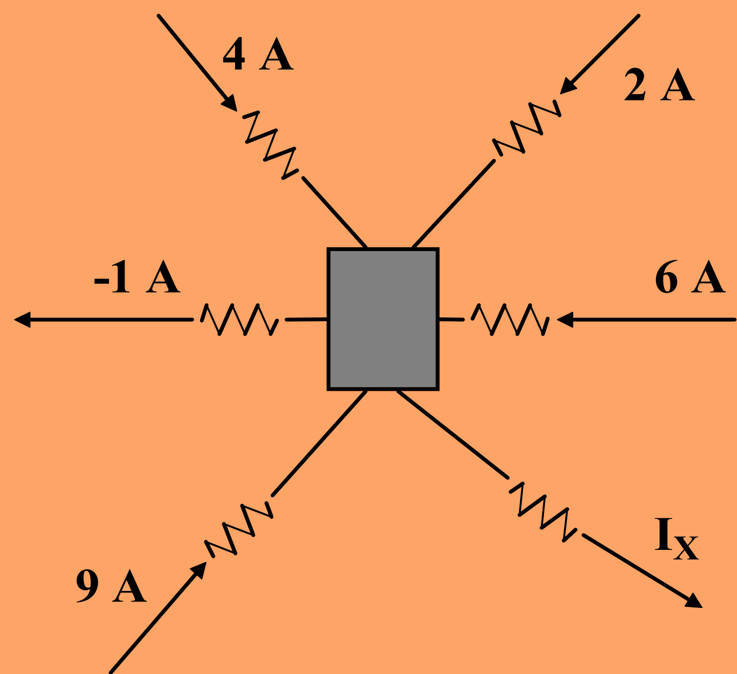
$$I_a - I_b + I_c + I_d = 0$$

I_a, I_b, I_c, and I_d can each be either a positive or negative number.

Basic Laws of Circuits

Kirchhoff's Current Law: Example 2.2.

Find the current I_x.



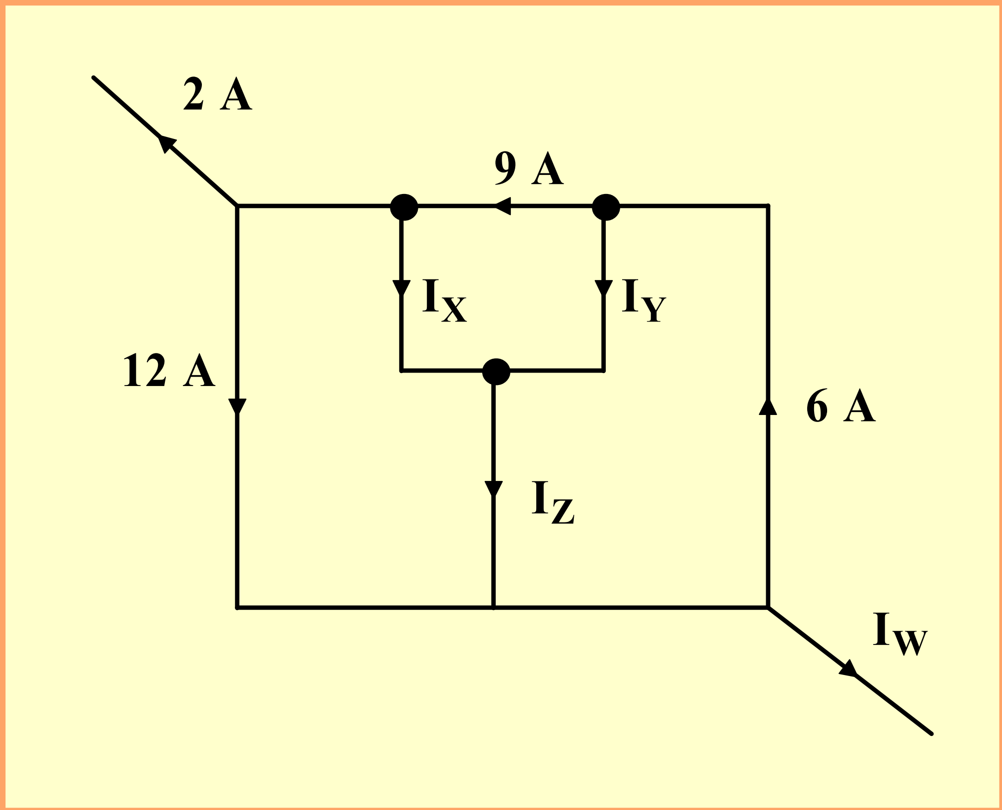
Ans: I_X =

Highlight the box then use bring to front to see answer.

Basic Laws of Circuits

Kirchhoff's Current Law: Example 2.3

Find the currents I_W, I_X, I_Y, I_Z.



I_W =

I_X =

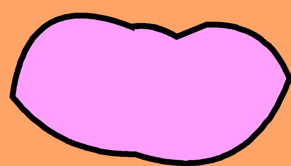
I_Y =

I_Z =

Basic Laws of Circuits

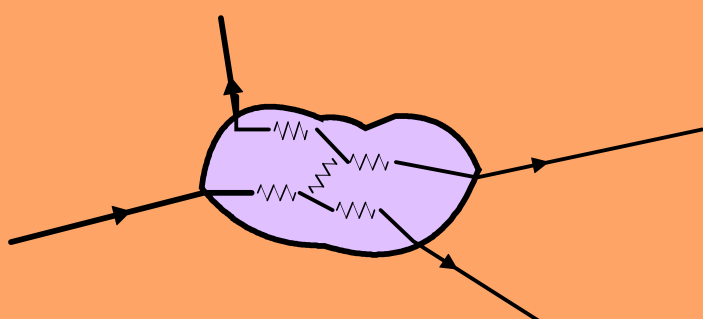
Kirchhoff's Current Law

Kirchhoff's current law can be generalized to include a surface. We assume the elements within the surface are interconnected.



A closed 3D surface

We can now apply Kirchhoff's current law in the 3 forms we discussed with a node. The appearance might be as follows:

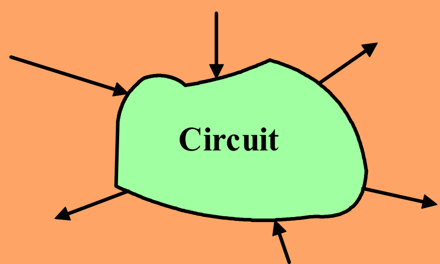


Currents entering and leaving a closed surface that contains interconnected circuit elements

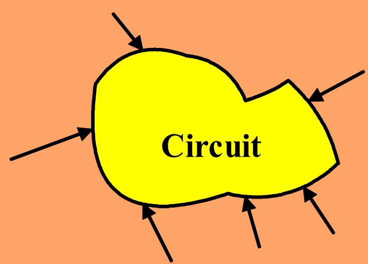
Basic Laws of Circuits

Kirchhoff's Current Law

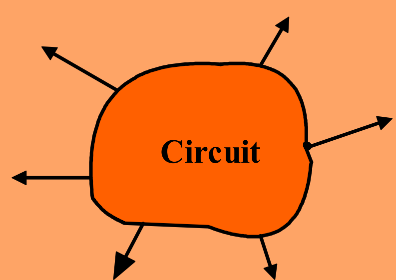
As a consequence of the Law of the conservation of charge, we have:



$$\sum_{j=1}^{j=N} i_j = \sum_{k=1}^{k=M} i_k$$



$$\sum_{r=1}^{r=Q} i_r = 0$$

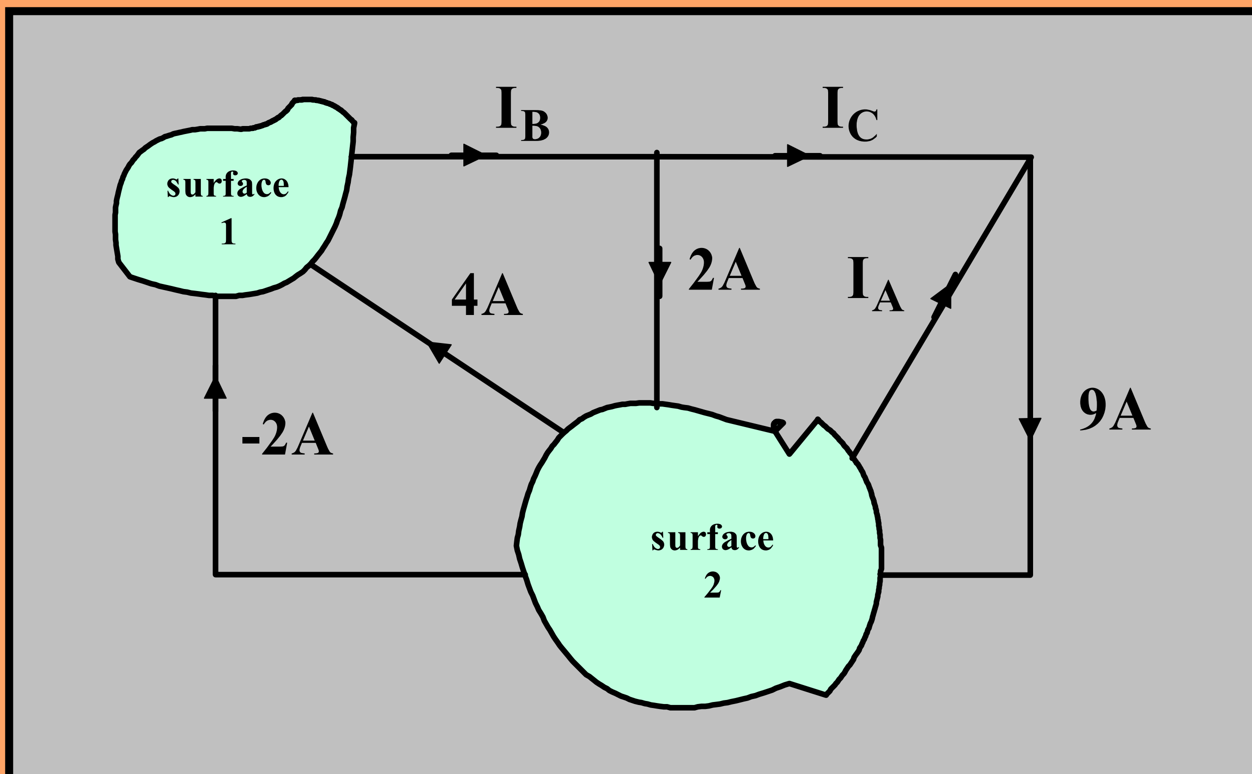


$$\sum_{m=1}^{m=Q} i_m = 0$$

Basic Laws of Circuits

Kirchhoff's Current Law: Example 2.4

Find the currents I_A, I_B, and I_C in the circuit below.



Basic Laws of Circuits

Kirchhoff's Current Law: Solution for Example 2.4

At surface 1: $I_B = 2A$: At node 1, $I_c = 0A$: At node 2, $I_A = 9A$