

# Lecture 1 : Charge, Current, Voltage

## Learning Objectives:

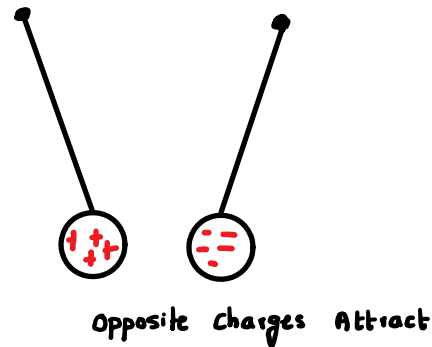
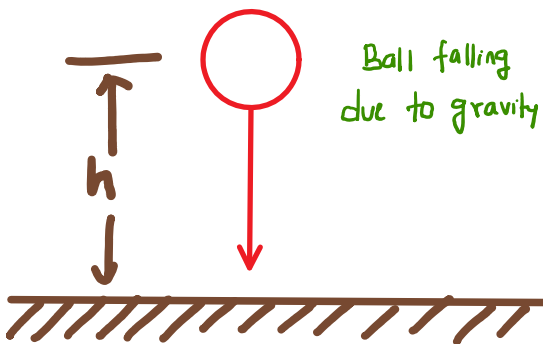
1. Intuitively define charge and current
2. Use fluid flow analogy to identify current magnitude and direction
3. Identify three electrical elements and sketch circuit schematic

### 1. Charge:

Charge is an intrinsic property of matter. Analogous to a ball experiencing gravitational force, the presence of charge in a material results in the material experiencing force in an electromagnetic field.

While gravitational force is always attractive, the force experienced by charged material can be of two types - attractive or repulsive. This indicates that charge can be of two types:

- ◆ Positive
- ◆ Negative



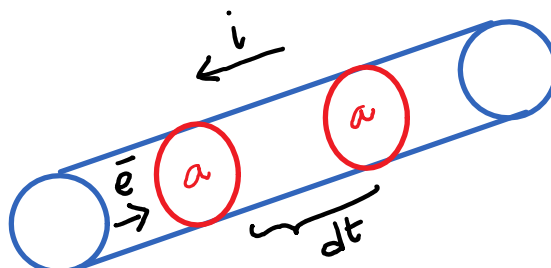
Recall that matter is made up of atoms. Atoms have:

- ◆ Electrons- Negative charge
- ◆ Electrons - Positive Charge (magnitude same as charge on electron)
- ◆ Neutrons - Neutral or no charge

**Unit of Charge:** The fundamental unit of charge is called Coulomb ( C ). A charge of one Coulomb (1C) represents the combined charge of  $6.24 \times 10^{18}$  electrons. Hence the charge of one electron:

$$1e^{-1} = -1.6 \times 10^{-19}$$

### 2. Current:

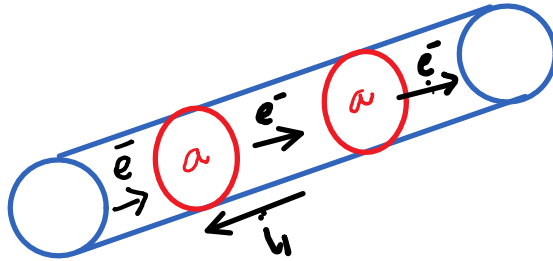


Charge in motion represents current. More precisely current is defined as the rate of flow of charge through an area "a" as shown in figure above,

$$i = \frac{dq}{dt}$$

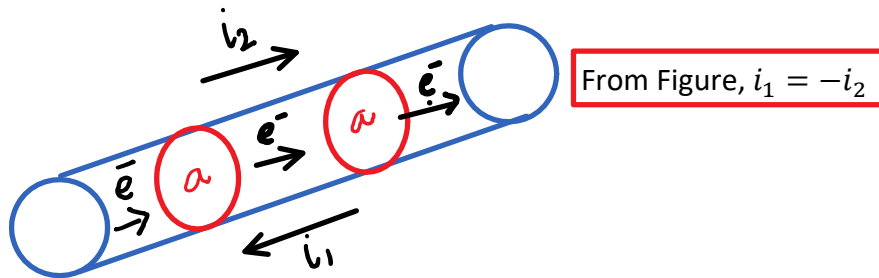
**Unit of current:** The unit of current is Amperes (A). A current of  $1 A = 1 C/s$ .

Current in a conductor has both **magnitude and direction** associated with it. Direction of conventional current is taken to be opposite to the flow of electrons.



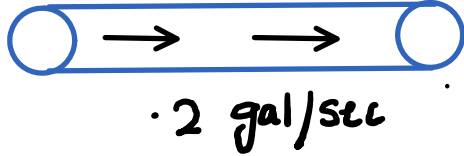
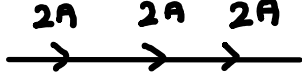
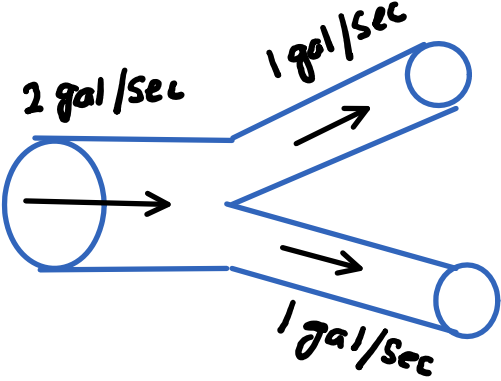
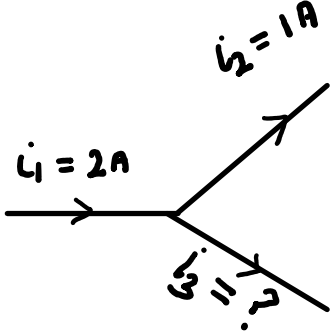
For the direction of flow of electrons shown in the figure above, current  $i_1$  is taken as positive.

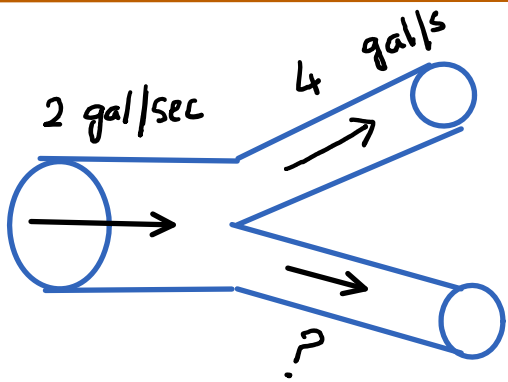
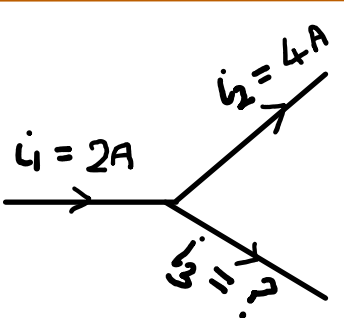
**Example:**



### 3. Fluid Analogy:

We can visualize current flowing in a conductor by comparing it to fluid flowing in a pipe as shown below:

PIPE	CONDUCTOR
 <p>• 2 gal/sec</p>	
	

PIPE	CONDUCTOR
	

#### 4. Electric Circuit, Elements, and Schematics:

An electrical circuit is an interconnection of electrical elements through which current can flow. Electrical elements can be seen as a model or an abstraction of electrical devices. For example, let us say we would like to light up an LED using a battery. We may sketch a physical arrangement of this set-up as shown below.

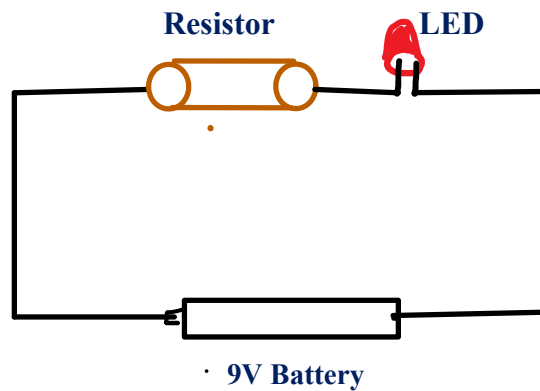

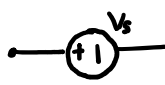
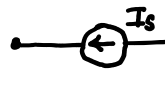
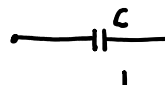
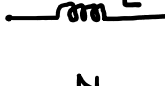


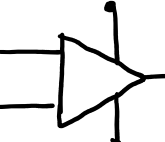


Fig. A physical circuit

A circuit schematic is a representation of the above physical circuit using standard circuit element representations. The circuit elements we will see in this class are shown below.

1. Resistor 
2. Voltage Source 
3. Current Source 
4. Capacitor 
5. Inductor 
6. Diode 
7. BJT 
8. OpAmps 

The figure below shows the circuit schematic for the physical circuit shown earlier.

