ELECTRICAL QUANTITIES

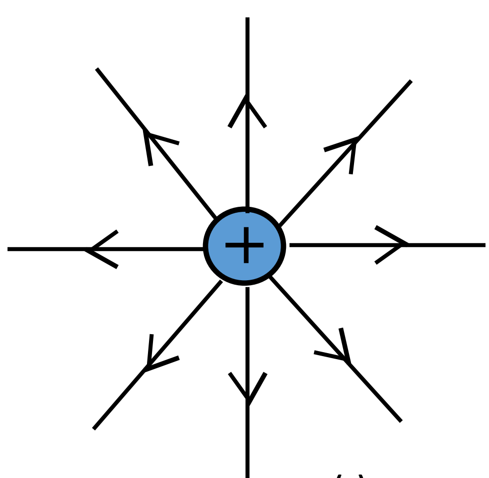
LEARNING OUTCOMES:

At the end of this lesson, you are expected to do the following

- Define electrical terms and their units
- Draw simple circuits and show measuring instruments connections
- Connect components and instruments with the correct polarity

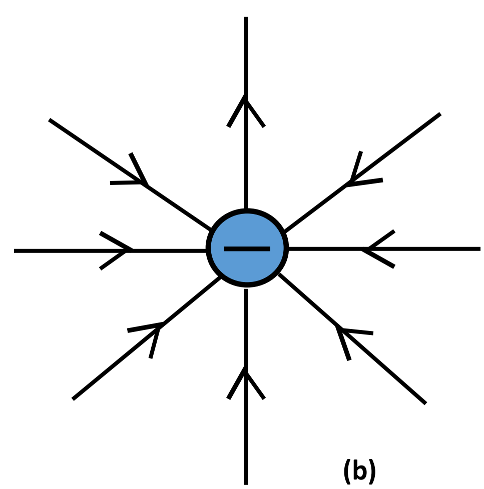
CHARGE

A charge is a unit electrical particle that has the ability to exert a repulsive or attractive effect on another electrical body placed close to it. The charge is said to possess an electric field which allows it to have an electric force (repulsive or attractive) effect on an electric body placed close to it. Hence, two like charges placed close to each other exhibits a repulsive force on each other, and two unlike charges exhibits attractive forces on each other. Fig 1 (a) and (b) shows the single charge and their resulting magnetic fields. Fig 2 (a) and (b) shows the resultant field of charges placed close to each other.



(a)

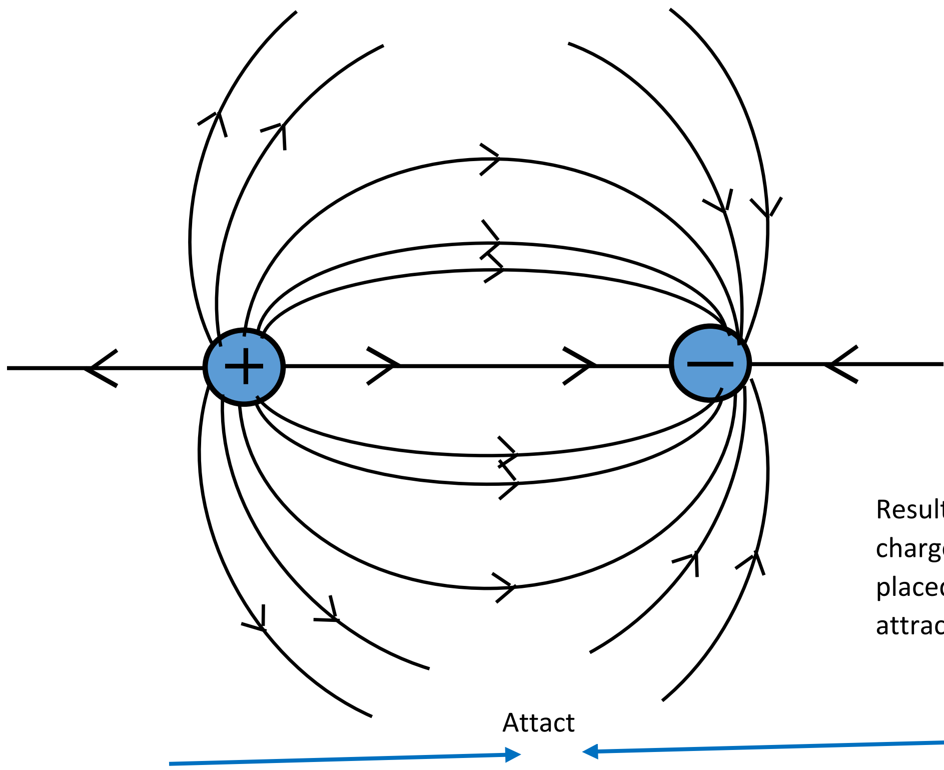
Positive electric charge and field pointing radially outwards



(b)

negative electric charge and field pointing radially inward

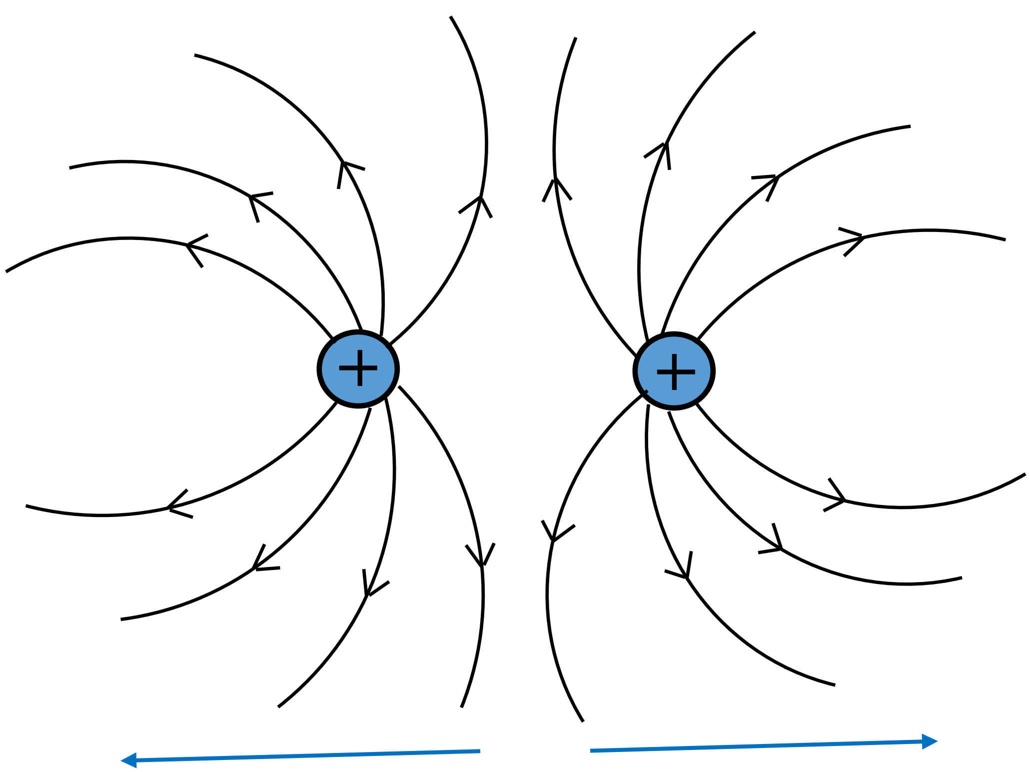
Fig 1.



Resultant field of two unlike charges. Two unlike charges placed close to each other attract

Fig 2

(a)



(b)

Resultant field of two like charges. Two like charges placed close to each other repel

The measurement of the charge or charge effect (*repulsive or attractive strength*) is quantized in a unit called the Coulomb (C), symbol (Q). One electron, has a charge of 1.6 x 10^{-19} Coulombs. 6.25 x 10^{18} electrons have a charge of one coulomb. Charge or the coulomb is also defined in terms of quantity or amount of charge particles present.

TEST YOUR KNOWLEDGE

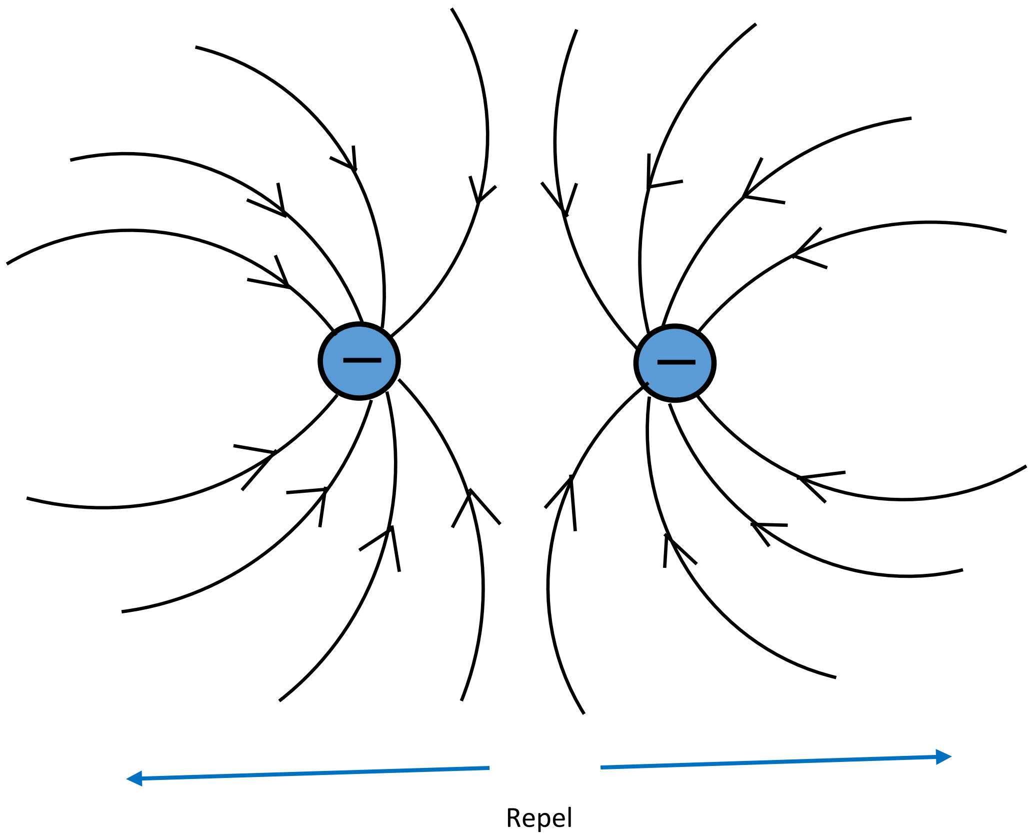
QUIZZ 1.

Fig 3

Fig 3 above shows two negative charges placed close to each other. Re-draw the diagram and complete the following:

(a) draw the resultant magnetic field.
(b) Indicate if the charge effect is attractive or repulsive.

ANSWER TO *QUIZZ 1.*



CURRENT: The Ampere

Current is defined as the flow of charged particles in a specified direction. The unit measurement for current is the Ampere (A); symbol, (I). The ampere is also expressed as the amount of charge flow per second, Coulombs/second.

Note that Coulombs measure the quantity of charge flow in a circuit while the ampere really measures the rate at which this charge flows in Coulombs/second (this unit is expressed as the Ampere). Current $I = Q/T$, where Q, is the charge in Coulombs and T is the time in seconds.

This formula can be written to express charge as $Q = I \times T$.

The instrument used to measure current is the ammeter. This instrument is attached to the current path in the circuit. The connection is shown in Fig 4 below.

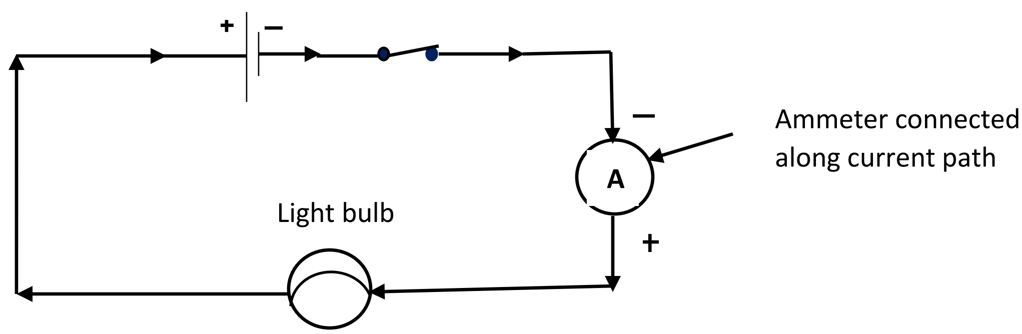


Fig 4.

RESISTANCE

Resistance is the opposition to current flow in a circuit. Resistance is caused in a circuit because of the bonding arrangement of atoms in the material and because of the bombardment or collision of electrons when they flow through a material as an electric current.

The measurement for resistance is the ohm, symbol; Ω. The average resistance of an electric iron heating element is about 22Ω.

Resistance in a circuit normally leads to the generation of heat in a circuit due to the bombardment of electrons when they drift through the circuit. Heat energy is given off as a result of this bombardment. A resistance in a circuit is also referred to as a load, hence the lamp in fig 4. is a load.

Materials with low resistance to current flow are referred to as conductors, example, metals. Insulators are materials that offer a high resistance to current flow. It is quite difficult for current drift through these materials. Some examples of Insulators are plastic, wood and rubber.

ELECTROMOTIVE FORCE (EMF)

An electromotive force (EMF) is defined as that driving energy that produces a current flow (***please note that EMF is an energy term***). The unit for EMF is the volt. An EMF is the result of energy transfer from one form of energy to electrical energy. A battery therefore is a source of EMF. It converts chemical energy to electrical energy in a circuit. In other words, there is a transfer of energy from chemical energy to electrical energy

Another definition of EMF, is the total energy of an electrical source (battery, generator, etc..) per coulomb of electric charge it delivers round a circuit joined to it. The EMF across the battery causes a current flow because of the difference in electric charge across its terminals. The current flow, which is a movement of negative electrons through the circuit is pushed by the negative terminal of the battery and the positive terminal attract the negative electrons which creates the current flow.

Many of the early theories developed on electricity by scientist at the time was of the belief that current was a flow of positive charges. This idea of positive charged current flow is known as **conventional** current flow. The negatively charged electron flow concept, proven and adopted today is known as the **electrons flow** concept. When theories on electricity are explained however, the both concepts can be utilized to explain the theory.

POTENTIAL DIFFERENCE (P.D)

The potential difference is the ability or potential between two (2) points in a circuit to produce work. The unit for potential difference is the volt. When the term potential difference is used it is usually to express the voltage across a load (e.g. lamp, resistor, motor, heating element). Potential difference in its strictest sense arises from an energy transfer from electrical energy to some other form of energy. A lamp will therefore dissipate heat and light energy when electrical energy flows through the lamp, electrical energy through a motor is converted to mechanical and sound energy. The potential difference or voltage measured across a load is also referred to as a voltage drop. When a current flow through a load a voltage is dropped across the load, which is a measure of the work done by the load or the energy dissipated by the load.

DEFINITION OF THE VOLT

One (1) volt is the potential difference between two points in a circuit when one (1) joule of energy or work is obtained as one (1) coulomb of electric charge moves between the two points.

The measuring device used to measure voltage is the voltmeter. The voltmeter is always connected across the device being measured. Fig 5 illustrates this idea.

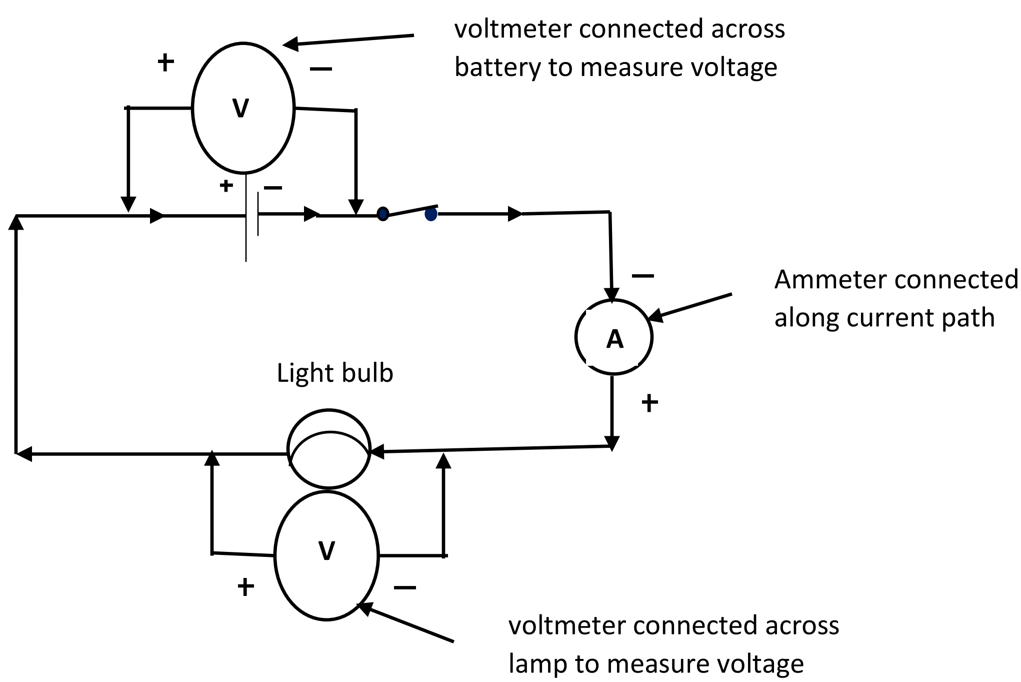


Fig 5

VOLTAGE POLARITIES ACROSS RESISTANCE LOADS WHEN CONNECTED IN CIRCUIT

Whenever a current flow through a resistance, there is a potential difference or voltage that exist across it. It should be noted however, that if there is no current flow through the resistance, no p.d. or voltage drop exist across the resistance. The polarities of the voltage drop across the lamps are illustrated in Fig 6.

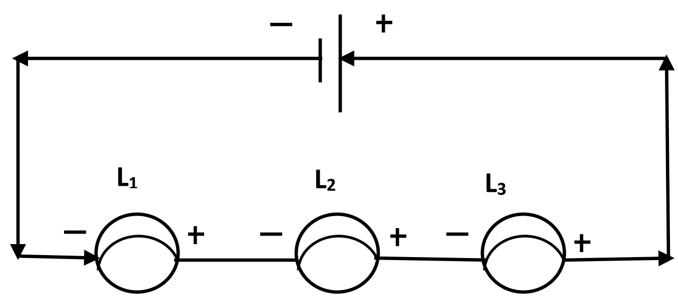


Fig 6

1. The ends of the L1 and L3 close to the battery terminals take the polarities of the battery terminal
2. Every subsequent terminal is assigned opposite polarities.

TEST YOUR KNOWLEDGE

QUIZZ 2.

1. Copper is an example of a material with a <u>high/low</u> resistance to current flow

2. Glass is an example of a material with a <u>high/low</u> resistance to current flow

3.

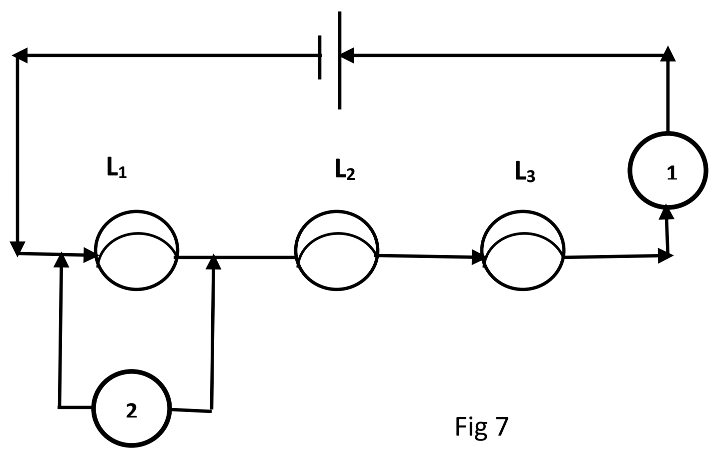


Fig 7

Re-draw the diagram in fig 7 and on the diagram complete the following:

(a) Name the instruments 1 and 2
(b) Complete the polarities on all components and instruments on the diagram.

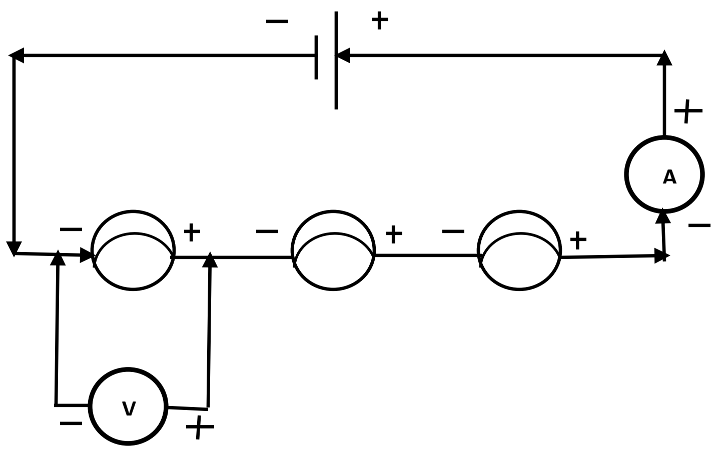
4. The type of current drift in Fig 7 is <u>conventional/electron</u> current flow

ANSWER TO *QUIZZ 2.*

1. Copper is an example of a material with a **LOW** resistance to current flow

2. Glass is an example of a material with a **HIGH** resistance to current flow

3.



4. The type of current drift in Fig 7 is **electron** current flow