VIVEKANAND EDUCATION SOCIETY'S POLYTECHNIC

Study Material

Program Code: All Program

Semester: First

Course Name: Basic Science (Physics)

Course Code: 22102

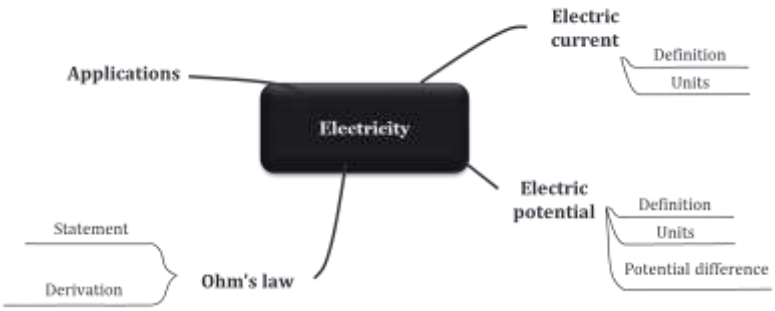
Topic Name: Electricity, Magnetism & Semiconductors

UO2d: Apply laws of series and parallel combination in the given electric circuits.

LO5: Student will be able to define electric current and state Ohm's law.

Course Expert: S. K. Rawat	**Date: 26/08/2020**

Concept Map:



Key words: electric charge, electric current, ampere, electric potential, potential difference, volt, ohm's law, resistance

Key Questions:

1. What is electric charge and electric current?
2. What is electric potential and potential difference?
3. State Ohm's law?

Key Definition:

1. Electric charge is a quantitative polarity of electrons & protons in an atom.
2. Electric current is the rate of flow of electric charges.
3. One ampere is defined as the current which flows through the conductor when one coulomb of charge flows through the conductor in one second.
4. The capacity of a charged body to do work is called Electric Potential.
5. The difference in potential's of two charged body is called Potential Difference.
6. If the amount of work done in moving a charge of one coulomb between the two points is equal to one joule, the points are said to have potential difference of one volt.
7. Ohm's law states that the potential difference (V), across the ends of a given metallic wire in an electric circuit is directly proportional to the current (I) flowing through it, provided its temperature remains the same.

Formula:

1. Electric current $I = \frac{Q}{t}$
2. Electric potential $V = \frac{W}{Q}$ or $V = IR$

Notes

Simple D.C. electric circuits

D.C electric circuit consists of a source of electricity (energy) and different components. Electricity is a controllable and convenient form of energy for a variety of uses in homes, schools, hospitals, industries and so on.
What constitutes electricity? How does it flow in a D. C. electric circuit? What are the factors that control or regulate the current through D. C. electric circuit? In this Chapter, we shall attempt to answer such questions and also study concept of Wheatstone bridge, potentiometer and condenser.

Electric charge

An Atom consists of protons, neutrons & electrons. Atom becomes positively charged when electron is taken away from it. Electric charge is a quantitative polarity of electrons & protons in an atom. A quantity of charge should always be identified with a positive or a negative sign.

The unit of electric charge is the coulomb (C).

Electric current

Electric current is expressed by the amount of charge flowing through a particular area in unit time. In other words, it is the rate of flow of electric charges. Electric current was considered to be the flow of positive charges and the direction of flow of positive charges was taken to be the direction of electric current. Conventionally, in D. C. electric circuit the direction of electric current is taken as opposite to the direction of the flow of electrons, which are negative charges.

Definition: The electric current flowing through a conductor is the rate of flow of charge through any cross section of a conductor.

Mathematical form: If a charge of Q unit passes through any cross-section of a conductor in time t second, then the current I flowing through the cross-section of the conductor is $I = \frac{Q}{t}$

Current is denoted by symbol I.

The electric current is expressed by a unit called ampere (A). Small quantities of current are expressed in milliampere (1 mA = 10–3 A) or in microampere (1 μA = 10–6 A).

One ampere

The unit of current 'ampere' is defined as the current which flows through the conductor when one coulomb of charge flows through the conductor in one second.

$$1\,\text{ampere} = \frac{1\,\text{coulomb}}{1\,\text{second}}$$

Electric Potential

The capacity of a charged body to do work is called Electric Potential. Electric Potential at a point is also defined as the amount of work done in bringing a unit positive charge from infinity to that point.

$$V = \frac{W}{Q}$$

Potential Difference

The difference in potential's of two charged body is called Potential Difference. If two bodies at different are connected together then current flows from higher potential to lower potential.

Electric potential or potential difference is denoted by symbol V.

The electric potential or potential difference is measured in volt (V).

One volt

If the amount of work done in moving a charge of one coulomb between the two points is equal to one joule, the points are said to have potential difference of one volt.

$$1\,\text{volt} = \frac{1\,\text{joule}}{1\,\text{coulomb}}$$

Ohm's law:

In 1827, a German physicist Georg Simon Ohm discovered relationship between the current I, flowing in a metallic wire and the potential difference V across its terminals.

Statement: Ohm's law states that "the potential difference (V), across the ends of a given metallic wire in an electric circuit is directly proportional to the current (I) flowing through it, provided its temperature remains the same."

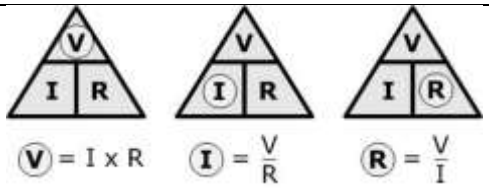
Mathematical expression

According to Ohm's law

$$V \propto I$$

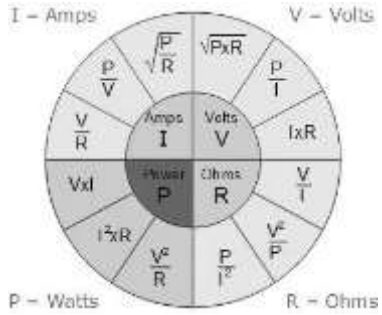
$$\text{or} \quad V/I = \text{constant} \quad \text{or} \quad V/I = R \quad \text{or} \quad V = IR$$

where R is called resistance and is constant for the given metallic wire at a given temperature.



Ohm's law Pie Chart

Figure shows the relation between current (I), voltage (V), resistance (R) and power (P)



Resistance

It is the property of a conductor to resist the flow of charges across it. Or The opposition offered to flow of current by the conductor.

According to Ohm's law, $R = \frac{V}{I}$

One Ohm

If the potential difference across the two ends of a conductor is 1 V and the current through it is 1 A, then the resistance R, of the conductor is 1 Ω. i.e.,

Its SI unit is ohm, represented by the Greek letter Ω.

Applications

Entertainment

Today, the modern sources of entertainment starting from listening to music from MP3 players, watching Television, playing movies in DVDs or VCDs or VCRs runs on electricity.

Healthcare

We can see the use of electricity for operating modern technologies every day. These surgical operations won't even start without electricity. For example, the doctors need a powerful light during an operation on a patient and without electricity, the light won't function, and operation can prove fatal.

Engineering

Constructions of buildings and structures for the convenience of people require electricity in every step. Building houses, installing gates and windows, welding of materials require current electricity to operate the machines.

Transport and Communication

Reaching places or communicating from a different corner of the world is only possible because of electricity. A power cut during airline travel can be dangerous.

Outdoors

The street lights on the road use electricity to function, even the pool requires electricity to heat the water in colder regions. The lawnmower, which is used to cut grass uses electricity to operate. The water sprinkler for the grass on the lawn uses electricity as well.

Household

Starting from toaster to refrigerator, microwave, washing machine, dishwasher, electrical chimney, and many more appliances which are simple to use and made for the convenience of day to day activities use electricity to function.

Commercial purposes

For the production of various materials, the factory uses heavy machinery which always runs on electricity. Even the magnets which are of a giant like structures require electricity to keep it charged for lifting heavy metals.

Offices

We go to work in offices in which most things run on electricity. The lights, lifts, AC, coffee machine, ID card reader, biometric scanners and everything else require electricity.

Fuel

Electrical energy comes under renewable energy, and we can produce it using most of the natural resources available to us. Today, things which were running on fossil fuels such as cars and bikes, are now made in such a way that it runs on electricity (like solar-powered), which will be more convenient in the future.

Space

The satellites and probes which are sent from the earth for space expeditions run on electricity. The electricity is generated with the help of a generator or is battery powered. The Apollo mission for the landing of humans on the moon, would not have been possible without the use of electricity.

Link to YouTube/ OER/ video/e-book:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
2. https://learn.sparkfun.com/tutorials/what-is-electricity/all
3. https://www.studyrankers.com/2017/08/notes-of-ch-12-electricity-class-10th.html
4. https://byjus.com/physics/uses-of-electricity/

Key Take away:

1. Difference between electric potential and potential difference.
2. Concept of Ohm's law.

Formative Assessments

<22102> : <All Program> : < All Program >: <Electricity, Magnetism & Semiconductors>: <UO2c> : <LO5> : <Assessments> : <Formative>

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Assessment Type: Formative Assessments: Embedded questions in video/ PPT

Set 1		
Question No 1	Question No 2	Question No 3
Which of the following correctly represents the relation among Charge (Q), Potential difference (V) and Work done (W)	The Potential Difference between two terminals can be measured by _____	On which of the following no "plus" or "minus" sign is marked
Remembering	Understanding	Applications
a) V = W × Q	a) an ammeter	a) a battery
a) W = V / Q	b) a voltmeter	b) an ammeter
b) V = Q / W	c) an ohm-meter	c) a voltmeter
c) V = W / Q	d) a rheostat	d) a resistor
Ans: < V = W / Q >	Ans: < a voltmeter >	Ans: < a resistor >

Set 2		
Question No 1	Question No 2	Question No 3
According to Ohm's law,	Two charged bodies having equal potential are connected through a conducting wire, in this case	What will be the potential of a body, if work done to move a charge of 25 C is 1600 J.
Understanding	Understanding	Application
a) The resistance increases with the increases in current.	a) current will flow	a) 15.6 mV
b) The resistance increases with the increases in voltage.	b) current will not flow	b) 40 kV
c) The current increases with the increases in voltage.	c) cannot say	c) 64 V
d) The resistance and current both increases with the increases in voltage.	d) current flows only if resistor connected	d) 6.4 V
Ans: <The current increases with the increases in voltage >	Ans: <current will not flow >	Ans: < 64 V >

Practice Worksheets

<22102> : <All Program> : < All Program >: <Electricity, Magnetism & Semiconductors>: <UO2d> : <LO5> : <Assessments> : <Formative>

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A. When one coulomb of electric charge continuously passes a given point every second, the electric current is said to a) 1 μA b) 1 mA c) 1 A d) 10 A	B. One ampere is equal to _____ electrons per second. a) 1×10^{18} b) 1×10^{19} c) 6.25×10^{18} d) 6.25×10^{19}
Ans A:	Ans B:
C. If 1 joule of work is done in bringing a charge of 1 coulomb from infinity to any point against the electric field, then the potential is said to be _____. a) 1 coulomb b) 1 volt c) 1 ampere d) 1 watt	D. The amount of work done in bringing a unit positive charge from one point to another point inside electric field is called _____. a) charge b) potential difference c) potential gradient d) absolute potential
Ans C:	Ans D:
E. The electric potential at a point in air due to a charge is 21 V. If the air is replaced by a medium of relative permittivity of 3, then electric potential at that point will be a) 63 V b) 21 V c) 7 V d) 42 V	F. Ohm's law is valid only when the temperature of conductor remains _____ a) zero b) constant c) infinity d) variable
Ans E:	Ans F:
G. The rate of flow of charge is called electric _____. a) current b) voltage c) power d) resistance	H. The amount of work done in bringing a unit positive charge from one point to another point inside electric field is called _____. a) charge b) potential difference c) potential gradient d) absolute potential
Ans G:	Ans H: