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Electric current, flow of electric charges in a metallic conductor, drift velocity

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 03
CHAPTER NAME : CURRENT ELECTRICITY

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LEARNING OUTCOME

After this lesson, students will be able to :

- Define electric current, ampere, and drift velocity
- Describe the direction of charge flow in conventional current.
- Use drift velocity to calculate current and vice versa.

Slide 2

1 @Format for content and slide heading is missing? Just like you have mentioned in DOC., We need to specify, for each slide's heading and text content, what will be the font style +amanrouniyar@odmegroup.org
Assigned to you
-Swoyan Satyendu
, 6/17/2020

REVIEW

1. What is electric current?
2. What is the expression for force due to electric field??
3. What is direct current ?
4. What is the essential condition for flow of electric current ?

Electric Current:

The electric current is defined as the charge flowing through any section of the conductor in one second.

$I = q / t$ (if the rate of flow of charge is steady)

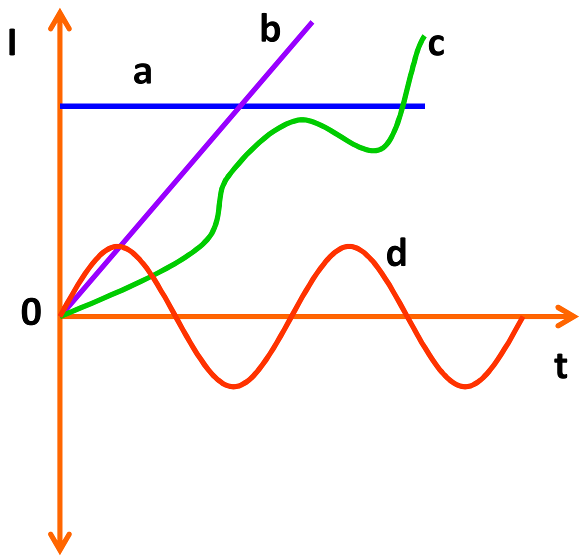
$I = dq / dt$ (if the rate of flow of charge varies with time)

Different types of current:

a) Steady current which does not vary with time

b) & c) Varying current whose magnitude varies with time

d) Alternating current whose magnitude varies continuously and direction changes periodically



ELECTRIC CURRENT

- The strength of the electric current in a conductor is defined as the rate of flow of charge across any cross-section of the conductor.

  Average current flowing through a cross-section in an interval is $I_{av} = \frac{\Delta q}{\Delta t}$

- Where Δq = the charge flowing through a cross-section in time Δt

  The current flowing through a cross-section at an instant t is ; $I = \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$

- Where dq is the small amount of charge flowing in the conductor in a small-time dt
- So total charge flowing through a cross-section in a time t is; $q = \int_0^t I dt$
- For steady current ; $q = It$

Units of Electric Current: In S.I. system the unit of current is **ampere (A)**.

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

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Numerical

Question: The amount of charge passed in time t through the cross-section of a wire is

$$Q(t) = At^2 + Bt + C.$$

a) Write the dimensional formulae for A, B, and C

b) If the numerical values of A, B and C are 5, 3 and 1 respectively in SI units,

   i. Find the value of the current at t = 5 s.

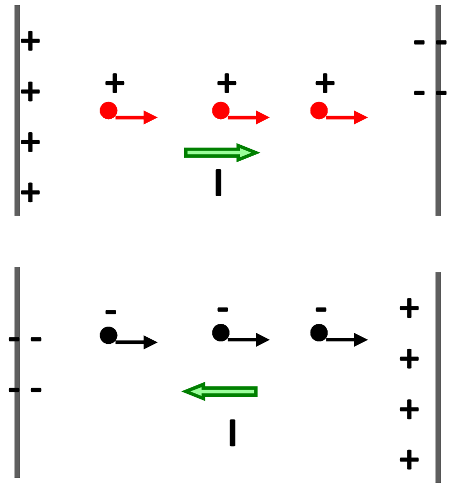
   ii. Find the average current flowing through the cross-section in the interval 0 to 5 s

ELECTRIC CURRENT - Charge Carriers

- In conductors, the current is carried by some particles called as charge carriers.
- For metals, charge carriers are free electrons.
- For semiconductors, charge carriers are free electrons and holes.
- For electrolytes +ve and -ve ions are charge carriers.

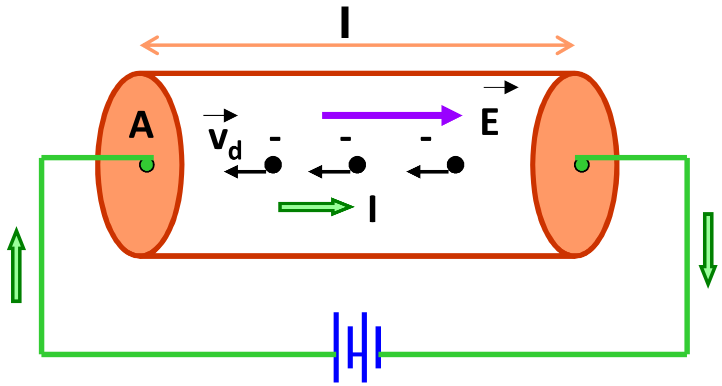
CONVENTIONAL CURRENT :

Conventional current is the current whose direction is along the direction of the motion of positive charge under the action of electric field.



Drift Velocity and Current:

$\vec{v}_d = \vec{a}\,\tau$	$\vec{v}_d = -\,(e\vec{E}\,/\,m)\,\tau$	$I = neA\,\vec{v}_d$



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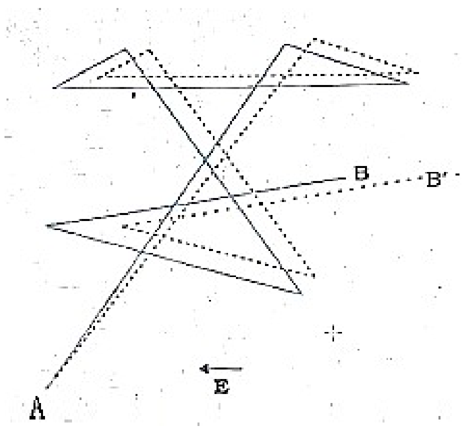
DRIFT VELOCITY

The velocity with which free electrons in a conductor are drifted from lower potential to higher potential (i.e. towards +ve terminal) under the action of the applied electric field is called drift velocity.



NOTE

- The value of v_d is very small in the order of 1mm/s.
- The relaxation time for the free electron in a metal depends upon its nature and its physical conditions like temperature.
- With the rise in temperature, as average relaxation time decreases hence drift speed of free electrons also decreases.
- The drift velocity of the electrons should not be confused with the velocity with which electricity is conducted. Drift velocity of electrons is of the order of a few mm per second while the conduction of electricity, which is in the form of a wave-motion, takes with the velocity of light.

NUMERICAL

Question:

a) The electron drift speed is estimated to be only a few mm/s for currents in the range of few amperes. How then the current established almost the instant a circuit is closed?

b) The electron drift arises due to the force experienced by electrons in the electric field inside the conductor. But force should cause acceleration. Why then do the electrons acquire a steady average drift speed?

c) If electron drift speed is so small and the electron’s charge is small, how can we still obtain a large amount of current in a conductor?

d) When electrons drift in metal from lower to higher potential, does it mean that all the free electrons of the metal are moving in the same direction?

e) Are the paths of electrons straight lines between successive collisions (with positive ions of the metal) in the (i) Absence of electric field, (ii) Presence of electric field.

HOME ASSIGNMENT

1. How is the drift velocity in a conductor affected with the rise in temperature?
2. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area $1.0 \text{ x } 10^{-7} \text{ m}^2$ carrying conduction electrons to be $9 \text{ x } 10^{28} \text{ m}^{-3}$.
3. Find the relation between drift velocity and relaxation time of charge carriers in a conductor. A conductor of length L is connected to a DC source of emf E. If the length of the conductor is tripled by stretching it, keeping E constant, explain how its drift velocity would be affected.

THANKING YOU

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