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ASSIGNMENT

Question 1

Using the concept of Newton's second law of motion, describe the magnitude and direction of the acceleration of an electron being shot horizontally into a closed space with a uniform field being directed upward.

Solution

The magnitude of the force on a charge q in an electric field is given by F = |qE|, where E is the magnitude of the field.

Newton's 2nd law relates the magnitudes of the force and acceleration: F = ma, so the acceleration of the electron has magnitude a = F/m

That's the magnitude of the electron's acceleration. Since the electron has a negative charge the direction of the force on the electron (and also the acceleration) is opposite the direction of the electric field.

Question 2

Describe electric field, magnetic field and electric current with respect to charges

Solution

Electric field

The electric field is defined mathematically as a vector field that associates to each point in space the (electrostatic or Coulomb) force per unit of charge exerted on an infinitesimal positive test charge at rest at that point. It can also be said/defined as below.

Electric field, an electric property associated with each point in space when charge is present in any form. The magnitude and direction of the electric field are expressed by the value of *E*, called electric field strength or electric field intensity or simply the electric field. Knowledge of the value of the electric field at a point, without any specific knowledge of what produced the field, is all that is needed to determine what will happen to electric charges close to that particular point.

Instead of considering the electric force as a direct interaction of two electric charges at a distance from each other, one charge is considered the source of an electric field that extends outward into the surrounding space, and the force exerted on a second charge in this space is considered as a direct interaction between the electric field and the second charge. The strength of an electric field E at any point may be defined as the electric, or Coulomb, force F exerted per unit positive electric charge q at that point, or simply $E = F/q$. If the second, or test, charge is twice as great, the resultant force is doubled; but their quotient, the measure of the electric field E, remains the same at any given point. The strength of the electric field depends on the source charge, not on the test charge. Strictly speaking, the introduction of a small test charge, which itself has an electric field, slightly modifies the existing field. The electric field may be thought of as the force per unit positive charge that would be exerted before the field is disturbed by the presence of the test charge.

The direction of the force that is exerted on a negative charge is opposite that which is exerted on a positive charge. Because an electric field has both magnitude and direction, the direction of the force on a positive charge is chosen arbitrarily as the direction of the electric field. Because positive charges repel each other, the electric field around an isolated positive charge is oriented radially outward. When they are represented by lines of force, or field lines, electric fields are depicted as starting on positive charges and terminating on negative charges. A line tangent to a field line indicates the direction of the electric field at that point. Where the field lines are close together, the electric field is stronger than where they are farther apart. The magnitude of the electric field around an electric charge, considered as source of the electric field, depends on how the charge is distributed in space. For a charge concentrated nearly at a point, the electric field is directly proportional to the amount of charge; it is inversely proportional to the square of the distance radially away from the center of the source charge and depends also upon the nature of the medium. The presence of a material medium always diminishes the electric field below the value it has in a vacuum.

Magnetic field

A **magnetic field** is a vector field that describes the magnetic influence on moving electric charges, electric currents, and magnetized materials. A charge that is moving in a magnetic field experiences a force perpendicular to its own velocity and to the magnetic field. The effects of magnetic fields are commonly seen in permanent magnets, which pull on magnetic materials such as iron, and attract or repel other magnets. In addition, a magnetic field that varies with location will exert a force on a range of non-magnetic materials by affecting the motion of their outer atomic electrons. Magnetic fields surround magnetized materials, and are created by electric currents such as those used in electromagnets, and by electric fields varying in time. Since both strength and direction of a magnetic field may vary with location, they are described as a map assigning a vector to each point of space or, more precisely—because of the way the magnetic field transforms under mirror reflection—as a field of pseudo vectors.

From this point of view, the magnetic force F on the second particle is proportional to its charge q_2, the magnitude of its velocity v_2, the magnitude of the magnetic field B_1 produced by the first moving charge, and the sine of the angle theta, ϑ, between the path of the second particle and the direction of the magnetic field; that is, $F = q_2B_1v_2 \sin \vartheta$. The force is zero if the second charge is travelling in the direction of the magnetic field and is greatest if it travels at right angles to the magnetic field.

The magnetic force on a moving charge is exerted in a direction at a right angle to the plane formed by the direction of its velocity and the direction of the surrounding magnetic field.

Electric current

An **electric current** is a stream of charged particles, such as electrons or ions, moving through an electrical conductor or space. It is measured as the net rate of flow of electric charge past a region.

The moving particles are called charge carriers, which may be one of several types of particles, depending on the conductor. In electric circuits the charge carriers are often electrons moving through a wire. In semiconductors they can be electrons or holes. In an electrolyte the charge carriers are ions, while in plasma, an ionized gas, electric current is formed by both electrons and ions.

The SI unit of electric current is the ampere, or *amp*, which is the flow of electric charge across a surface at the rate of one coulomb per second. The ampere (symbol: A) is an SI base unit. Electric current is measured using a device called an ammeter.

Electric current in a wire, where the charge carriers are electrons, is a measure of the quantity of charge passing any point of the wire per unit of time. In alternating current, the motion of the electric charges is periodically reversed; in direct current it is not. In many contexts the direction of the current in electric circuits is taken as the direction of positive charge flow, the direction opposite to the actual electron drift. When so defined the current is called conventional current.

Current is usually denoted by the symbol I. Ohm's law relates the current flowing through a conductor to the voltage V and resistance R; that is, $V = IR$. An alternative statement of Ohm's law is $I = V/R$.

Current in gases and liquids generally consists of a flow of positive ions in one direction together with a flow of negative ions in the opposite direction. To treat the overall effect of the current, its direction is usually taken to be that of the positive charge carrier. A current of negative charge moving in the opposite direction is equivalent to a positive charge of the same magnitude moving in the conventional direction and must be included as a contribution to the total current. Current in semiconductors consists of the motion of holes in the conventional direction and electrons in the opposite direction.

Electric current generates an accompanying magnetic field, as in electromagnets. When an electric current flows in an external magnetic field, it experiences a magnetic force, as in electric motors.
The heat loss, or energy dissipated, by electric current in a conductor is proportional to the square of the current.