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MOTION OF CHARGED PARTICLES IN ELECTRIC FIELD

Makhmudov Yusup Ganievich
Professor, Department of Physics, Termiz State University, Doctor of Pedagogical Sciences.

Kosimov Asroridin Sadievich
Head of the Department of Physics, Termiz State University, Candidate of Physics and Mathematics, Associate Professor

Mamadraimov Sardor Sobirjonovich
student of Termiz State University

ANNOTATION
This article discusses the capabilities and significance of the movement of charged particles in an electric field.
KEY WORDS AND CONCEPTS: *motion, particle, field, charge, electron, proton, ion, force, voltage, speed, mass.*

DISCUSSION

It is advisable to study the movement of charged particles in an electric field in the topic "Electric charges and electric field", and then repeat when studying the topic "Electronic phenomena in a vacuum."

When studying the electric field, the teacher often uses the concept of free charge. As examples of the behavior of free charges in a field, we can speak of the behavior of electrons, protons, and ions in it. Here, when studying the field, it is convenient to consider the question of particle acceleration using the field.

In an inhomogeneous electric field, the motion of charged particles will occur with a variable acceleration, in a uniform - acceleration is constant. In all cases, in the absence of resistance forces, the energy acquired by a particle is equal to the potential difference of the initial and final points of its path, multiplied by the particle's charge (work done by field forces):

$$\frac{mv^2}{2} = eU.$$

It is convenient to enter a unit of energy measurement here - 1 electron-volt.

At the end of the topic, we should consider the motion of charged particles in the field of a plane capacitor. In this case, the teacher uses the well-known student formulas of kinematics and dynamics, as well as the concept of curvilinear motion, which allows students to draw their own conclusions on the topic. Therefore, this lesson is useful in the form of a conversation.

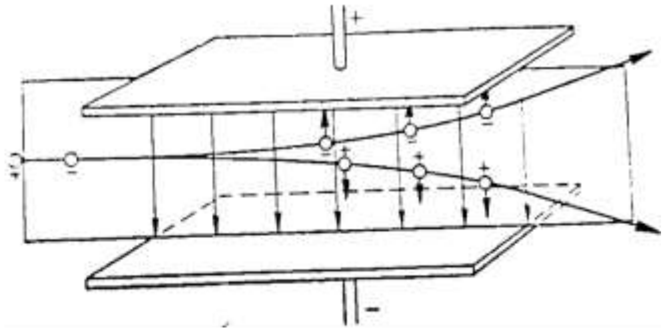

Fig. 1. The movement of charged particles in an electric field.

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Let us consider the case of a charged particle moving in a uniform electric field with intensity E for the case when the initial particle velocity v is perpendicular to the field lines of force (Fig. 1).

Together with the students, we establish what the shape of the particle's trajectory will be (by analogy with the motion of a body thrown horizontally in the gravitational field) and the reasons for the particle to deviate from the horizontal direction.

The magnitude of the deflection of the particle along the lines of force is determined by the formula:

$$S_e = \frac{1}{2}\frac{eEi^2}{mv^2}.$$

We analyze the formula and find out that the magnitude of the deviation se depends both on the external parameters l and E, and on the property of a given particle — its mass m and charge e.

When analyzing the formula, in order to show the dependence of the deviation only on the particle's charge under other identical conditions, one can use as example ions having the same masses but different charges (once and twice ionized).

If you need to analyze the dependence of the deviation from the mass, you can use as an example the deviation of the electron and proton, the absolute values, the charges of which are the same, and the masses are different.

By requiring students to explain the dependence of the magnitude of the deviation of the particle from the charge and mass using Newton's second law, this law can be repeated. So, for example, if two ions with the same mass but different charges are moving in the field, then a large force $F = eE$ will act on the ion with a large charge, a, therefore, the acceleration of its motion along the lines of force and the deviation of se will more.

By converting the formula:

$$s_e = \frac{1}{2}\frac{eEi^2}{mv^2} = \frac{1}{4}\frac{eEl^2}{E_k}.$$

where $E_к$ – kinetic energy of the particle, we are convinced that the deviation is inversely proportional to the kinetic energy of the particle, that is, the higher this energy, the closer the path of the particle to the rectilinear.

It is important to emphasize that, by studying the motion of a particle in an electric field, it is easy to measure the deviation se, which is not difficult to measure, to determine the ratio of the particle's charge to its mass, i.e. one of the most important characteristics of a particle.

A demonstration of particle deflection and its dependence on the field strength is carried out using an instrument proposed by I. M. Rumyantsev (see Ch. 4, § 3).

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