W12.02

Applied Electric Fields

1. In the Millikan oil drop experiment, an atomizer (a sprayer with a fine nozzle) is used to introduce many tiny droplets of oil between two oppositely charged parallel metal plates. Some of the droplets pick up one or more excess electrons. The charge on the plates is adjusted so that the electric force on the excess electrons exactly balances the weight of the droplet. The idea is to look for a droplet that has the smallest electric force and assume that it has only one excess electron. This lets the observer measure the charge on the electron.

   Suppose we are using an electric field of 3×10^{4} N/C. The charge on one electron is about 1.6×10^{-19} C. Find the radius of an oil drop for which its weight could be balanced by the electric force of this field on one electron. Use a density of 900 kg/m^3 for oil.

2. Linear accelerator are used in a variety of devices from mass spectrometers used for chemical analysis, to medical imaging and therapy systems, to accelerators used in particle physics research. They work by sending electrons, protons, or ionized particles through an electric field. Some of the most powerful of these accelerators generate speeds close to the speed of light using very large field strengths.

   Suppose that we are using a potential difference of 5 MV to accelerate a proton (m = 1.67×10^{-27} kg) along a 3-m tube.
   a. What is the electric field (assumed constant) along the axis of the tube?
   b. What is the speed of the proton as it exits the tube?

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1. $r=5x10^{-7}m$
2. $E=1.67x10^{6}$ V/m, $v=3.1x10^{7}$ m/s