E. ELECTRIC CIRCUITS

Reference: Heinemann Physics 11 Units 1 & 2 4th Edition
Chapters 3 & 4 Page 87 – 165

E.1 Electric Charge

- The unit of charge is the coulomb (C)
- 1 coulomb = 6.25 x 10^{18} electronic charges (the charge on an electron)
- The charge on 1 electron = 1.60 x 10^{-19} C.
- There are two types of charge. Positive and Negative.
- Objects can become charged when rubbed. This does not create charges, but separates the charges already there. This is referred to a static electricity as the charges do not move around.
- Like charges repel.
- Unlike charges attract.
- The closer the charges are the stronger the force.
- Objects that allow charges to move along them are called conductors.
- Objects that do not allow charges to flow are called insulators.

Example

a It has been stated that the charge on a rubbed pen would involve many billions of electrons. What is the charge in coulomb carried by 10 billion electrons?

$$10{,}000{,}000{,}000 \times 1.60 \times 10^{-19} = 1.6 \times 10^{-9}\ C$$

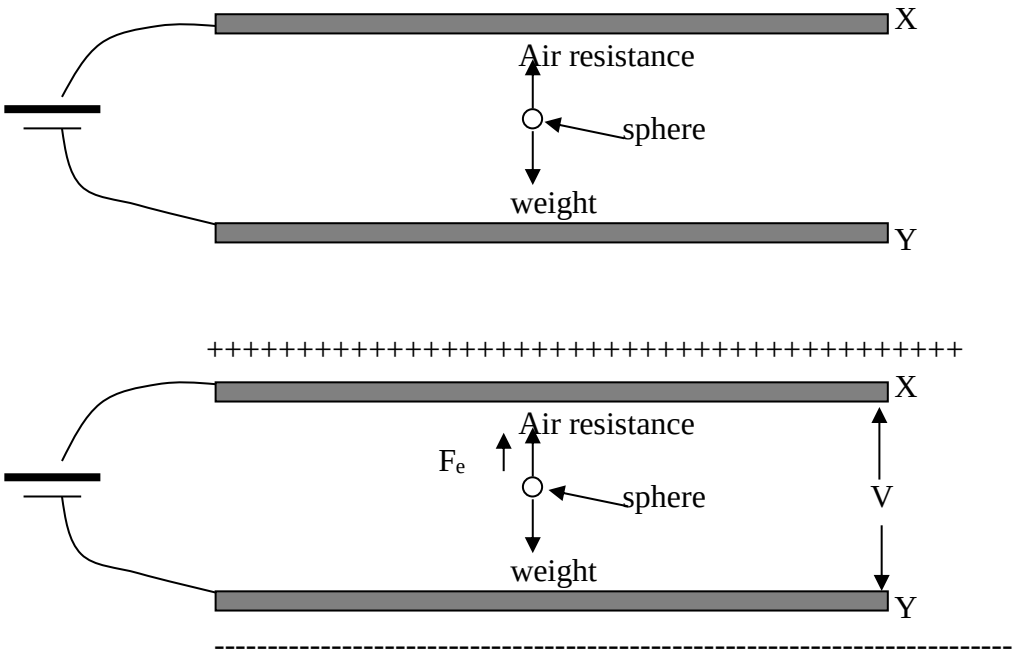
b The charge on a school Van de Graaff generator might be around −3.0 μC (1 μC = 1 microcoulomb = 10^{-6} C). How many extra electrons are on the dome?

$$\frac{3.0 \times 10^{-6}}{1.9 \times 10^{-19}} = 1.57 \times 10^{13}\ electrons$$

E.1.1 MILLIKANS EXPERIMENT

Video: Millikan's Oil Drop

In 1907 Robert Millikan set out to show that electric charge came in fundamental units (called the elementary unit). He set up two plates X and Y, which were charged by battery (B) to 8000V. He used small identical oil drops and observed their motion under a microscope.
The small spheres fell due to the force of gravity. An opposing upward force due to air resistance increases as the velocity of the spheres increases. In a short time the two forces equalised, this allowed him to calculate the weight from the measurements of their speed. When the plates were charged by the battery, the speed changed as a result of the added electric force on the drops. Some drops fell even faster, others almost stopped or even rose. As the speed at which the drops fell was directly related to the total force on them, he was able to calculate the strength of the electric force. From this he was able to calculate the electric charge on the drop.



The direction of F_e depends on the charge on the sphere. Millikan found that the charge on the oil drop was always a multiple of a particular value. I.e. the charge on the oil drop is given by: q = ne, where n is a whole number, and e was 1.6×10^{-19}C. Millikan suggested that 'e' is the charge on an electron. Millikan argued that an oil drop got its charge by gaining or losing electrons, hence the 'e' charge on the drop had to be a whole number times the charge on one electron.

In 1909 Millikan determined that

Mass of electron = 9.1×10^{-31} kg
Charge of electron e = -1.6×10^{-19} C

Problem Set #1: Text Section 3.1 Page 94 Questions 1, 2, 3, 4