Hands-on Science

Education Activities. Challenges and Opportunities of Distant and Online Teaching and Learning

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The Experimental and Historical Foundations of Electricity

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Abstract. In this talk we make 4 experiments: (a) The rotation of a versorium by an electrified straw (instrument due to William Gilbert in 1600); (b) the Attraction/Contact/Repulsion of an electric pendulum made of a paper disc suspended by a silk thread (instrument due to Stephen Gray in 1720 and ACR mechanism due to Du Fay in 1733); (c) the levitation of a dandelion seed with an electrified straw (experiment due to Guericke in 1672); (d) charging and discharging an electroscope (made of cardboard, a thin paper strip, and supported by a plastic straw) in order to distinguish conductors and insulators.

We present some aspects related to the history of electricity which can be constructively explored in physics teaching. In particular, we discuss the amber effect, the attraction of a thin water stream by an electrified straw, the electric attraction and repulsion, the mechanism of attraction/contact/repulsion, conductors and insulators together with some of their main properties. We show how to build cheap instruments like the versorium, the electric pendulum and the electroscope. They are simple devices but very sensitive and extremely important in the history of electricity. We compare the low-cost electroscope with the gold leaf electroscope.

We present the usual explanation for the amber effect (attraction of light objects like bits of paper by an electrified straw) and for the deflection of a thin stream of water by an electrified straw. We emphasize that we do not agree with the explanations of these two phenomena which are given in the textbooks.

We call attention that some of the main discoveries in electricity happened very late in the history of science. Isaac Newton (1642-1727), for instance, did not know the distinction between insulators and conductors of electricity. This discovery was made by Stephen Gray in 1731. Moreover, Newton did not know about the existence of positive and negative charges. The discovery of two kinds of electricity was made by Du Fay in 1733.

Finally, we discuss 3 mysteries related to the amber effect which have not yet been completely solved, although this is the oldest experiment of electricity with some 2500 years. For instance, we know Coulomb's law q1q2/r^2 which explains the attraction of charges of opposite sign. 1st mystery: (a) What is the origin of the force which SEPARATES opposite charges during the friction of two bodies? What is the law satisfied by this unknown force? Textbooks mention that there is a transfer of electrons during frictional electrification. 2nd mystery: (b) Is frictional electrification really due to a transfer of electrons? What are the experiments which support this assumption? 3rd mystery: (c) What is the origin of the force which prevents the explosion of a positively charged sphere or the disintegration of a positively charged straw? What is the law satisfied by this unknown force?

This talk in based on the 2 volumes of the book "The Experimental and Historical Foundations of Electricity", [1] and [2]. A similar approach to mechanics was presented in the book "Archimedes, the Center of Gravity and the First Law of Mechanics: The Law of the Lever", [3]. These books are based on hands-on experiments made with simple material. These experiments are combined with historical discussions of the subject and many quotes from original sources. These 3 books are freely available in PDF format in English, Portuguese, Italian and Russian, [4].

Keywords. Controversies, Electricity, Hands-on Experiments, History of Physics.

References

[1] Assis AKT. The Experimental and Historical Foundations of Electricity, Volume 1, Montreal: Apeiron, 2010.

[2] Assis AKT, The Experimental and Historical Foundations of Electricity, Volume 2, Montreal: Apeiron, 2018.

[3] Assis AKT, Archimedes, the Center of Gravity, and the First Law of Mechanics: The Law of the Lever, Montreal: Apeiron, 2nd edition, 2010.

[4] https://www.ifi.unicamp.br/~assis