Practical Course on School Experiments for Future Physics teachers

V Koudelkova and S Gottwald
Charles University, Prague, Czech Republic
vera.koudelkova@mff.cuni.cz

Abstract. One of the important skills of physics teachers is proficiency in performing physics experiments and using them during lessons. For this purpose, future physics teachers at our faculty attend a cycle of seminars named Practical Course on School Experiments. The paper describes the second one, which is focused on electricity and magnetism. Uncommon experiments we use in the seminar are presented; our experience and students’ feedback is discussed too.

1. Introduction
Practical course on school experiments for future physics teachers is a cycle of seminars at our faculty. The seminars are focused on both demonstrative and pupils experiments which can teacher use during lessons. There are two obligatory seminars in the cycle – the first is focused on mechanics, oscillations and optics, the second one is focused on electricity and magnetism. The following three seminars are optional. Following information concern mainly the second seminar but main ideas are the same for all seminars in the cycle.

2. About the seminar
There are a few goals of the seminar. The main goal is to give students an opportunity to gain proficiency in using and performing demonstrative experiments and familiarize themselves with common school teaching aids. In the topic of electricity and magnetism, it is important for students to gain some “technical experience” in connecting circuits, using tools etc.

The seminar is divided into eight topics – Electrostatics, Electric current in metals, liquids and gasses, Semiconductors, Magnetic field, Electromagnetic induction, Alternating circuits, Generators, motors and transformers, Electromagnetic oscillations and waves. Students work in pairs and have about three hours for each topic. In each topic there are variety of different types and different levels of experiments – these are both low-cost and high-tech experiments, demonstrative experiments, experiments suitable as IBSE or laboratory work etc. In addition, students have the opportunity to familiarize themselves with common misconceptions in electricity and magnetism, and with experiments which can be used to overcome them – we added to the seminar some new experiments which were developed (not only) for this purpose and were verified during high school lessons. Discussions about how to use particular experiments in classes are a natural part of the seminar.

All materials for the seminar are freely available in an electronic form ([1], but only in Czech), so students gain access to a database of school experiments which they can use in their own future teaching.

3. Examples of experiments
3.1. **Charge on a plastic tube**

The goal of this experiment is to show students, that polarity of a charge on a plastic tube depends on both materials – material of the tube and what we use for rubbing.

It is well known that if we use some cloth, we will get negative charge on the tube. But, if we use a Teflon foil for rubbing the tube, we will get positive charge on the tube (and negative on the Teflon) – see Figure 1. We use Coulombmeter to measure the polarity of a charge.

![Figure 1. Plastic tube charged with cloth (left) and with Teflon foil (right).](image)

3.2. **Current-voltage characteristic of a bulb**

This experiment can be used as a problem task. First, students measure current-voltage characteristic of a resistor (or resistance wire). Then, they repeat the same measurement, but with bulb. They are often surprise, that although there is only a wire in the bulb, the characteristic is non-linear. As a third step they discussed hypothesis, why it is not linear and then they check their hypothesis by experiment.

Natural hypothesis is that the resistance of the wire depends on temperature and there is not constant temperature in the bulb. Because we want to verify this, we use a big bulb (230 V) – it is possible to break the glass. If we put the wire alone into some cold water, we get constant temperature of the wire (see Figure 2).

![Figure 2. Detail of the bulb without glass (left) and wire of a bulb with socket in water.](image)

Result of the measurement can be seen in Figure 3.
3.3. **LED in a saline solution**
This experiment can be used as a motivation at the beginning of topic electric current in liquid. We use LEDs with spread ends, which are put on small polystyrene plates (see Figure 4).

These LEDs are put to water with salt and with two electrodes (is it possible to use for example aluminium foil). Power supply should be up to 30 V. If we switch on the power supply, there will be enough potential difference at both ends of the LED to let it shine. It is possible to discuss how intensity of light depends on orientation of LED’s end.

Video of this experiment is available at Collection of physics experiments [2].

![Figure 4. LED prepared for the experiment.](image)

3.4. **Diamagnetism and paramagnetism using scales**
Force between diamagnetic or paramagnetic material and magnet is very small, so it is difficult to measure (or demonstrate) it. One possibility is using scales with precision of at least 0.01 g. As a diamagnetic material we use bismuth. Paramagnetic material is for example chromium, we use a collarbone replacement.

Materials are put on some stand (to put some distance between the magnet and the scales) on scales and scales are reset to zero. If we put the magnet near the sample, the scales will display the “force” – diamagnetic material is slightly repelled from the magnet, so the value on the display is positive. On the contrary, chromium is slightly attracted, so the value is negative.
More detailed description of this experiment including video is available at the Collection of Physics Experiments [2].

3.5. Levitating pencil lead
As a more attractive demonstration of diamagnetism one can show diamagnetic levitation. This experiment is very simple and a low-cost arrangement of diamagnetic levitation – we use pencil lead which levitates in the track made from common neodymium magnets.

![Figure 5. Arrangement of the experiment.](image)

Arrangement of the track can be seen in Figure 5 – there is an iron L-profile inside which magnets are placed with their poles alternating (one magnet is tucked inside the profile, second one is touching it). North pole of each magnet is marked. Optimal diameter of magnets is 8 mm; pencil lead should not contain iron.

The lead levitates about 0.5 mm above magnets.

The experiment was published in Physics Education [3], so it is possible to find more detailed description there.

3.6. Induction charger and heater
Concerning application of electromagnetic induction, students may know we use induction heater and charger. If we put a coil with approximately 30 turns and LED connected to the ends of the coil, the LED will shine (see figure 6). In our case the LED blinks in intervals about 0.5 s, it depends on the charger.

![Figure 6. Coil with LED at induction charger.](image)

The power of induction heater is much bigger. Therefore, it is possible to demonstrate that the electromagnetic field is present a few centimetres above the heater – you can boil water in the air. Also,
it is possible to put a few pieces of paper between the heater and the pot. Similarly as with the induction charger, you can put one turn of wire with a bulb (simple electric circuit without any battery) around the pot and the bulb will shine (see fig. 7). The power of heater can be demonstrated using aluminium foil – if you put it on the heater and hold it, the foil will burn (see figure 7). Lenz’s law can be demonstrated too – if you only put the aluminium foil on the heater and not hold it, the foil will rise.

Figure 7. Induction heater with a bulb (left) and burning aluminium foil (right).

4. Students’ feedback
Students appreciate that they can try experiments and discuss them and, if they want, they can try experiments not only from prepared texts. Students often mention, that seminar help them to overcome their fear from electricity and magnetism. And, they appreciate that there are wide range of different type of experiments including new and unknown.

For instance, we quote three examples of written feedbacks:

- I have always been scared of electricity and magnetism. This seminar helps me with understanding electricity and helps me not to fear it. I tried many experiments which I didn’t know before. I will use them in the future.
- I liked the topic magnetic field because there are plenty of relatively simple experiments which are surprising and which I didn’t know before.
- At the beginning I feared using Vernier software but then I learn it and thanks to it many experiments much more impressed me.

5. Conclusion
Materials for students are available online ([1]) but only in Czech. Some experiments are published in the Collection of Experiments in Physics mostly in Czech, but they are being translated to English [2]. Experiments in this collection are supported by photos and videos too.

If you will be interested in any described experiment or want to know more about our experience, do not hesitate to ask authors.
6. References

[1] Practical Course in school experiment – webpage of the seminar:
   https://kdf.mff.cuni.cz/vyuka/psp2/doku.php (only in Czech)

[2] Collection of experiments in physics. Available online: http://fyzikalnipokusy.cz/en

[3] Koudelková, V 2016 *Phys.Educ.* **51** 014001