Mobile laboratories of the „Academy of Young Explorers”

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As part of the “Academy of Young Explorers” project, new experiments have been developed that can be presented in lower- and upper-secondary schools, as well as during classes with children. We would like to present the ideas and solutions that we use. The aim of these experiments is to broaden the pupils’ knowledge of physics and to convince them that physics is a useful field of science that has much to do with engineering and the world surrounding us.

“Academy of Young Explorers” Centre

The “Academy of Young Explorers” Centre (http://www.amo.pwr.edu.pl) runs a series of popular science lectures and laboratory classes for children and the youth. Our aim is to raise interest in exact sciences among children and young people.

This year, the “Academy of Young Explorers” Centre organized for the first time a series of laboratory classes addressed to students of senior high schools. Tools for carrying out laboratory exercises have been designed especially for them.

The exercises designed reflected the tasks included in high school graduation exams, obligatory exercises from the core curriculum, but also some extra exercises related to the students’ interests (e.g. determining liquid viscosity, examining the surface tension of a liquid or the step voltage effect). The aim of the classes was to teach the young people to measure physical quantities and process them. Hence, the task of the students was to carry out the experiment on their own, correctly write the collected data in the table, calculate the required quantities and estimate measurement uncertainties. The groups that took part in the classes, were made up of 15 to 30 students, while the laboratory teams were composed of 2-3 people.

The laboratory classes are a pilot project. It was conducted at selected schools (the schools signed up themselves for the project) in four cities of the Dolnośląskie Province: Jelenia Góra, Zgorzelec, Brzeg Dolny, and Duszniki-Zdrój. Most of the classes were held at the Wrocław University of Technology Branch in Jelenia Góra (about 10 meetings). The topics of the classes were agreed on with the participants or sometimes were even chosen based on their requests to satisfy their curiosity, complete their knowledge of physics or prepare them better for the high school graduation exams.

Participation in the project was free of charge, it was financed by Wrocław University of Technology and Boeing Company. The project will be continued in the 2015/2016 school year.

Completing the experiment sets for the students was a great organizational challenge. They had to meet the following criteria:

- each exercise had to be prepared to be conducted for at least 7 times,
- the experiment sets had to fit into a passenger car and take up as little space as possible,
- they had to have modular structure – one set could be made of modules used in another experiment,
- the sets had to be safe for the user,
- the carrying out of the experiments had to be feasible in classroom conditions,
- the sets had to be durable and not too expensive,
- due to financial restrictions, the quantities measured had to be measurable with sufficient accuracy using simple and cheap tools.

The complexity of the sets had to be adjusted to the skills of an average student (in many cases, the students came across such measuring tools as multimeter for the first time). Also, the complexity of calculations had to be taken into consideration, so that the students could quickly calculate the required values. As the differential and integral calculus has been withdrawn from the curriculum of most high schools, it could not be used. During laboratory classes, the participants were taught to pay attention to the estimation of uncertainty measurements and their reasons.

Over 30 laboratory exercises from various areas of physics were designed for the project. The experiment sets addressed issues relating to electricity, thermodynamics, geometric and wave optics, mechanics, and nanotechnology.

In the remaining part of the article, the authors confine themselves to describe a number of examples of experiments that are included in the sets:

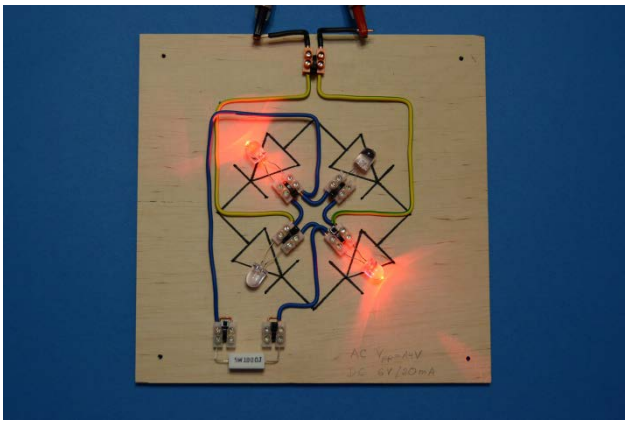
1) examination of semiconductor diodes (rectifier diodes and LEDs),
2) measurement of temperature-dependence of electrical resistance in a semiconductor and in metal,
3) determining the focal length of lenses,
4) verifying Kirchhoff's laws.

Examination of semiconductor diodes (rectifier diodes and LEDs)

Current and voltage characteristics of diodes is an issue often present in high school graduation exams. During our classes, the students:

- measured the current and voltage characteristics of rectifier diodes, carried out at two different temperatures (a rectifier diode, simple electrical meters and a thermos mug filled with hot water were used in the experiment),
- measured the current and voltage characteristics of LEDs emitting light of known wavelength, and calculated the Planck constant on its basis,
- assembled a Graetz circuit and learned about its functioning.

Assembling of the Graetz circuit attracted the most interest. The students were given 4 LEDs and a screwdriver. The application of LEDs allowed them to check quickly if the circuit is built correctly and determine which diodes are conducting electricity at a given moment.

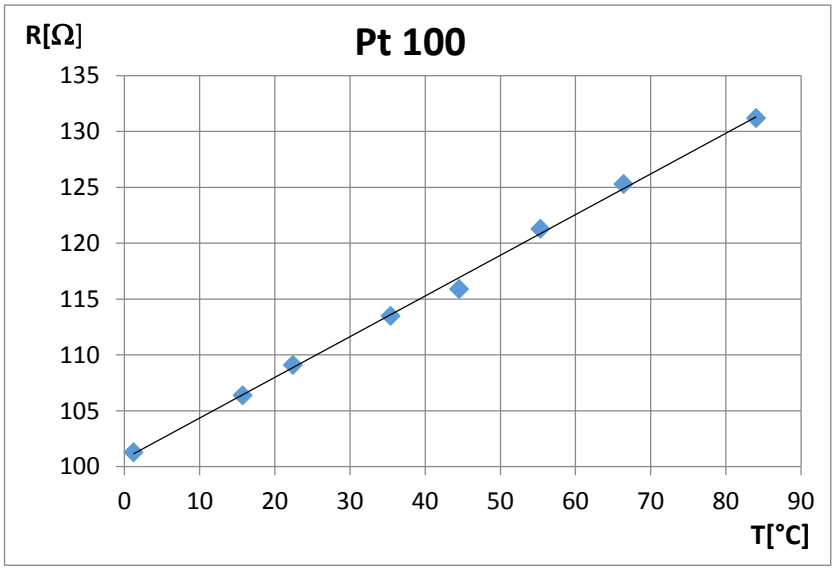


The students' task was to connect the elements of the circuit in a correct way and verify its functioning by connecting it first to a DC power supply and reversing the direction of current by switching the poles. In the second step, the circuit was connected to a variable frequency generator. By observing the sequence of diode lighting, the students checked if the circuit is correctly assembled. In their own opinion, this experiment helped them greatly in understanding the functioning of diodes.

Measurement of temperature-dependence of electrical resistance in a semiconductor and in metal

This is a typical experiment, compulsory in senior high schools. It is conducted with the use of Pt-100 thermocouple, NTC thermistor, and a simple ohmmeter. The temperature of the elements was changed by putting them, in a sequence, into 10 thermos mugs filled with water, each with a higher temperature, measured by the students.

a)



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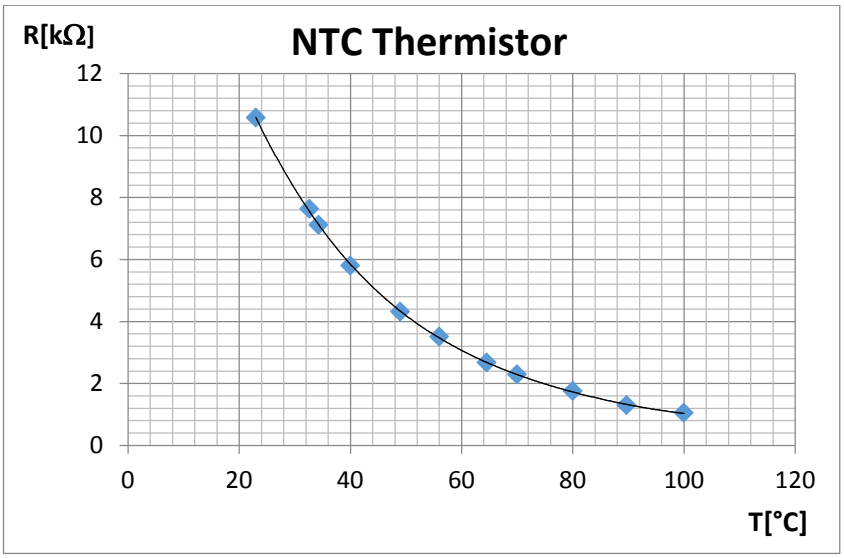
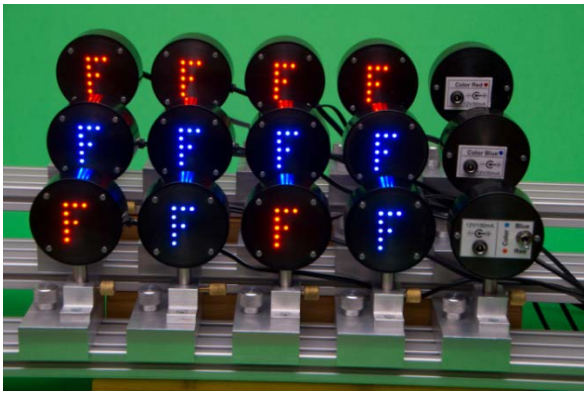


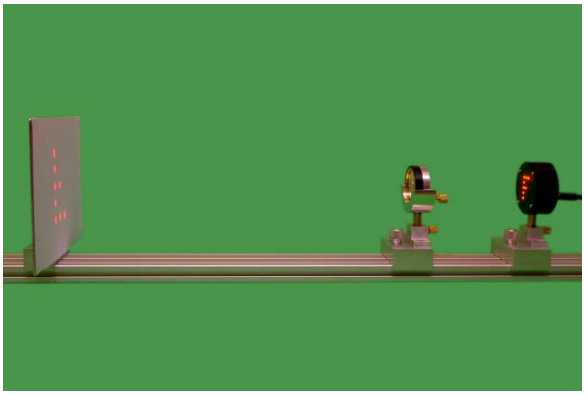
Fig. Measurement of temperature-dependence of electrical resistance in a semiconductor and in metal: a) Pt-100 Thermocouple, b) NTC Thermistor.

Determining the focal length of lenses

Ihis is also a very popular experiment that makes use of an optical table, light source, screen, and the examined lens.

As an extra element, the light source was designed in such a way to allow changing the wavelength of the emitted light from blue to red. In this way, the students had an opportunity to observe optical aberrations in the lens.





Verifying Kirchhoff's laws

The students checked the Kirchhoff's first and second law, using a circuit presented in the photo. With the use of potentiometers, one can alter the current intensity in the individual paths, causing voltage drops on the resistors. It is possible to match the current settings in such a way that no current is flowing through the central path. Using multimeters, the students measure the current intensity and voltage at selected points.