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THE VERNIER SYSTEM AT THE FACULTY OF AERONAUTICS

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Abstract: This article describes an educational challenge which was prepared for students at the faculty of Aeronautics, Technical University of Košice. Our goal is to improve the mathods of the practical training by introducing modern automation and information technologies to the experiments and to the processing of acquired data. We have updated our physics laboratory with this system and have automated respective experiments.

Key words: engineering education, physics laboratory, Vernier system, LabQuest 2

1. Introduction

Physics is a subject which belongs to the theoretical basis at colleges of technical education. It aims to give students an overview of those parts of physics which are important for them in terms of professional studies. Students will use them during their studies of professional disciplines and during their engineering practice, too. The subject Physics is divide in lectures and numerical exercises at the faculty of Aeronautics.

One challenge in reorganizing education at the faculty is to tie the theoretical university training more closely with the development af the students' practical skills. This can be achieved by students' experiments in the laboratory.

Many Physics experiments which are important for teaching physics should be evaluated not only qualitatively but also quantitatively in terms of data sampling. High frequence sampling helps students to better observe measurement changes and gain better understanding for the overall process of experimentation. Sometimes it's hard to find a suitable device which can help teachers because it is not suitable for educational use. There are several systems that meet these requirements for example Leybold system [4], phywe (set TESS) [5] etc. We have choosen the Vernier system because it was recommended by members of the faculty of Electrical Engineering and Informatics. They successfully implemented it into the teaching process. The Vernier system was developed for educational enstitutions but its quality gous beyond high-school level. The Vernier system is described in [1] by Böhm and Jermář. The interface Labquest 2 is portable and enables students to perform many experiments and measurements not only in the laboratory. It can process the measured data directly in LabQuest 2 or in a computer by software Vernier Logger Lite/Logger Pro or in a spreadsheet editor.

2. Description of the Vernier system

The basis of the measurement system are sensors. The basic setup can be extended with more than 60 sensors. Some sensors can be used alone; some can be connected to the computer via USB. But mostly it needs to wire sensors to an interface. Simple interfaces like Go! Link or LabQuest Mini serve only to connect sensors with computer. A more sophisticated interface is LabQuest 2. It has a very simple, intuitive operation using a color touch screen and it is also capable of fully independent operation and evaluation of experiments and data without the support of a computer. For evaluating data on a computer one can use the software Logger pro of Logger Lite. Or one can transfer data via an operating system to s spreadsheet editor and continue to make additional assessments. More about this system one can see in [3].

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3. Experiments

There exist lots of experiments, which can be dome by the Vernier system. In this paper we describe some of them, more can be found in [2].

Demonstrated experiments:

- Freezing and Melting of Water.
- Gas Pressure and Volume.
- Velocity and acceleration.

Students' experiments in the laboratory:

- The magnetic field exploration.
- Determination of kinematic viscosity.
- The physical pendulum period.
- The free fall acceleration.

Freezing and Melting of Water

Freezing temperature is the temperature at which a substance turns from a liquid to a solid. Melting temperature is the temperature at which a substance turns from a solid to a liquid. Freezing temperature and melting temperature are characteristic properties of a pure substance. In thes experiment students determine and compare the freezing and melting temperatures of water.

Figure 2 shows, how the experiment on freezing temperature it set up such that it works properly with a minimum of hard craft. Cold water with ice is put to the external beaker. A distiller water with Vernier Temperature Probe see Figure 1 connected to LabQuest 2 is put in to the beaker. Then salt is sprinkled into the external beaker. There is an endothermic reaction which causes that water temperature decreases. The temperature is measured by LabQuest 2, while water is freezing and, in the second part of the experiment, while water is melting.

Figure 1. *Vernier temperature probe*

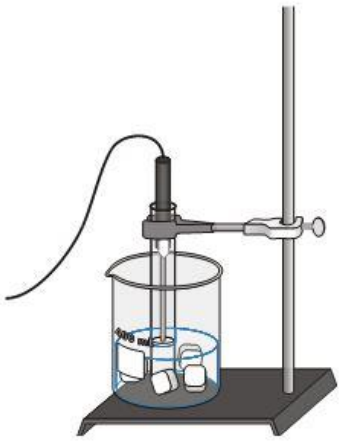

Figure 2. *The set for demonstration of freezing and melting temperature*

The graph of temperature for freezing water and for melting ice during the interpretation and discussion with students is in Figure 3.

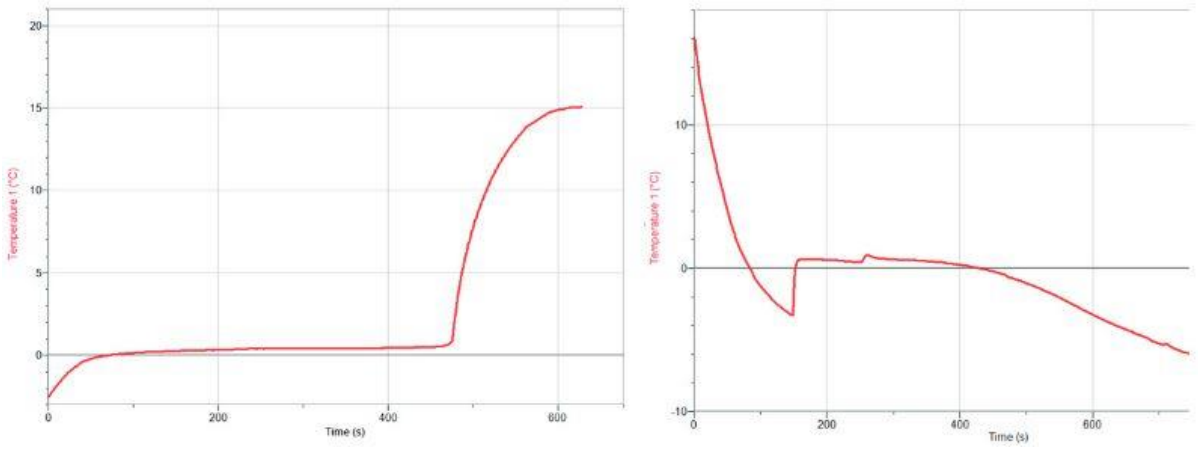

Figure 3. *Graph of temperature vs. time of melting and freezing [6]*

Gas Pressure and Volume

In this simple experiment, we use a pressure Sensor and gas syringe (see Figure 4) to study the relationship between gas pressure and volume. Temperature and amount of gas are kept constant. The results are expressed in a table with a graph, and with a mathematical equation. These are four mathods commonly used by scientists to communicate information.

Figure 4. *A Pressure sensor and a gas syringe*

This experiment is a similar as the first done by Robert Boyle in 1662-without the use of a calculator, of course. The relationship we will discover is know as Boyle's law.

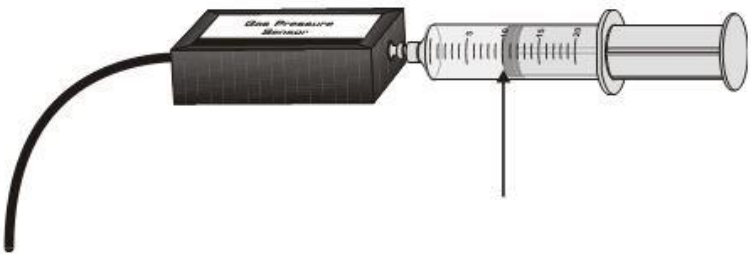

Figure 5. *The tool set for investigating gas pressure and volume*

The measurement is organized as seen in Figure 5. Boyle's law can be checked by measuring the pressure depending on the volume of a syringe, which is connected to the gas pressure sensor. One student slowly pushes the plunger of the syringe at the selected volume value. The second student presses a button to record levels. LabQuest 2 records values of volume and pressure values. Volume is read from the scale on the syringe and entered by hand. After completing the measurements LabQuest 2 draws a graph of pressure vs. volume.

Velocity and acceleration

Velocity is rate that tells how much distance is covered in a unit of time. It can be expressed by the formula

$$v=d/t$$

where v is velocity or speed (in *m/s*), d is distance traveled (in meters), and t is time (in sec). In this activity, the velocity of a car is studied after it is released from different points on a ramp. A Motion detector in Figure 6 will be used to measure velocity.

Figure 6. ***Motion Detector***

Figure 7 shows, how the experiment on velocity and acceleration is set up such that it works properly with a minimum of hard craft. A ramp serves as a mean to accelerate a car. The height of the ramp is 45*cm*, the length between 1.5*m* and 2*m*. A meter stick serves foe measurement as well as a quide rail for the car. The bottom ends with the end of the ramp, at the upper and is a (heavy) book, which provides the distance to the motion detector required to make LabQuest 2 work properly, if attached to the detector.

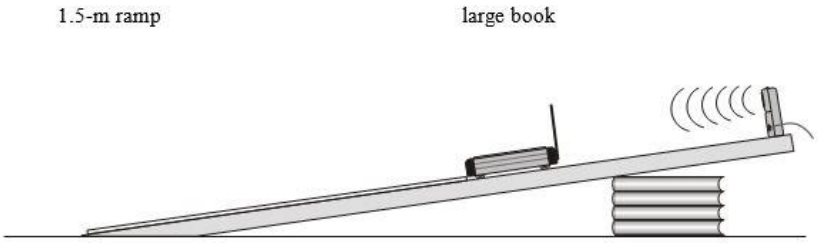

Figure 7. *The set of demonstration a ramp on books*

Students' experiments with Vernier in laboratory:

- The physical pendulum period;
- the fall acceleration;
- the marnetic field exploration;
- determination of kinematic viscosity;

Figure 8. *Determination of kinematic viscosity and the physical pendulum period*

4. Future of the Vernier system at the faculty of Aeronautics

The first laboratory in which we have introduced this system is the physics laboratory. The aim of our work is to analyze and to put into practice all options which have not been used at the faculty of Aeronautics before. For example, communication with a computer, tablet and a mobile phone. Nowadays students are equipped with such devices. We would like to use this system at all stages of experiments: the preparation of experiments (download the detailed instructions for measurement from e-learning system Moodle), the actual measurement and the measurement evaluation (in the form of tables, graphs, etc.). They can transfer data from LabQuest 2 via Wifi network to other devices.

Evaluation in terms of didactics in technical education is planned, as soon the equipment is accessible for large number of students. The physics laboratory is still under construction, so it isn't available to

all students who attend the subject Physics. It is available only for students who are enthusiasts of physics or are working on students' project or writing diploma or bachelor thesis on physics.

5. Conclusion

The setup of various experiments described in article showed, that the Vernier system is

- flexibly usable to set up various experiments,
- helpful to understand basic as well as advanced physical phenomena,
- motivating for students,
- robuts enough to withstand unexperienced users.

The preliminary findings were confirmed by demonstrations in several lectures and by watching several dozens of students at work.

This equipment meets the requirements for enhancing engineering education at the faculty of Aeronautics with hogh-tech tools. We recommend the Vernier system for analogous faculties at other universities.

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