Computer-based experiments as IBL-exercises

Katalin Kopasz[1,2], Károly Tóth[2], Imre Csiszár[2]

[1] Department of Optics and Quantum Electronics, University of Szeged

[2] Ságvári High School, University of Szeged, Hungary

INTRODUCTION

During our work we combined the IBL-method with the opportunities provided by computer-aided experimentation. Our hypothesis was that by linking methods popular among students we can increase the popularity of science subjects, develop time-efficient experiments that help teaching, and allow the students to have a direct experience of phenomena that we have only been able to show them on videos before.
The applied method strengthens the relationship between the school subjects of physics, information technology and mathematics, thus students with diverse interests may experience success during the measurements.

METHODS

The students used a self-developed software environment.
At the beginning they carried out a guided inquiry with detailed instructions, then the guided inquiry gradually turned into an open discovery activity.
Our primary aim was to see whether the system could be applied in a real educational environment, thus we tested our tasks with small groups.

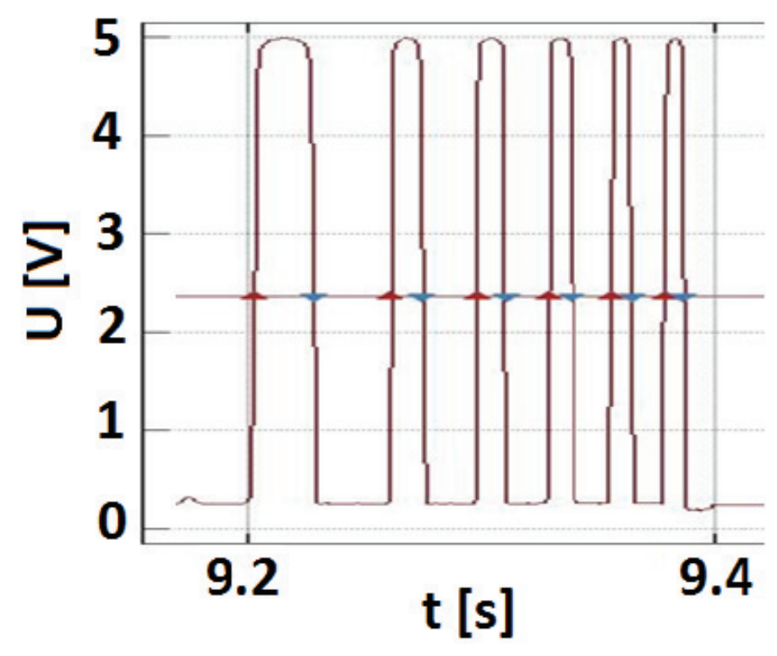
STUDENT EXPERIMENTS

Free falling bodies

Students' task:

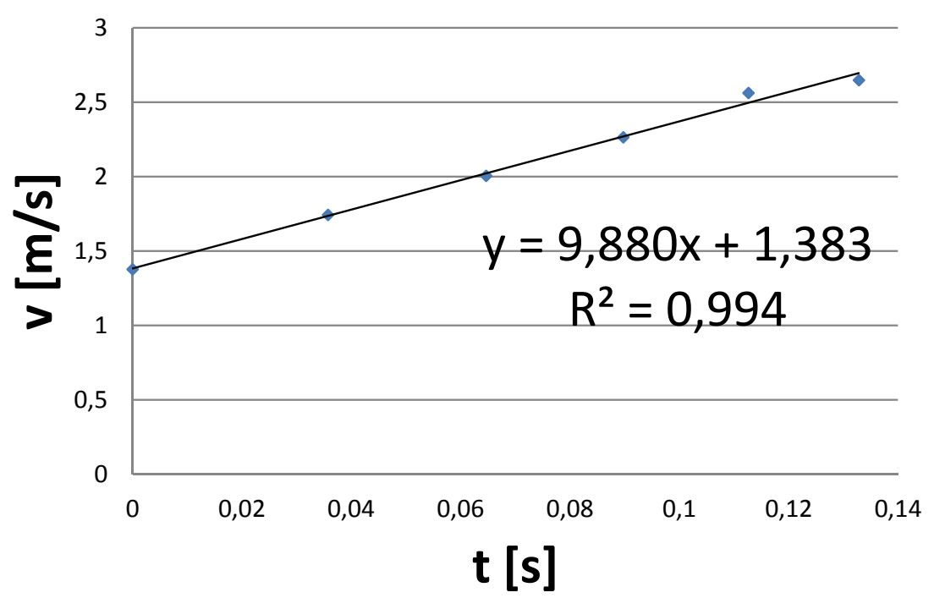
With the help of a ruler transformed into a picket fence and a photogate, students observe how the speed of the free falling body changes.
The students can determine how long it takes a black line to pass by the sensors of the gate. With the help of a built-in level crossing function they can also define the quasi-instantaneous speed. By exporting their measurement results into a spreadsheet program they can examine the distance vs. time and speed vs. time graphs.

Ruler transformed into a picket fence and a photogate

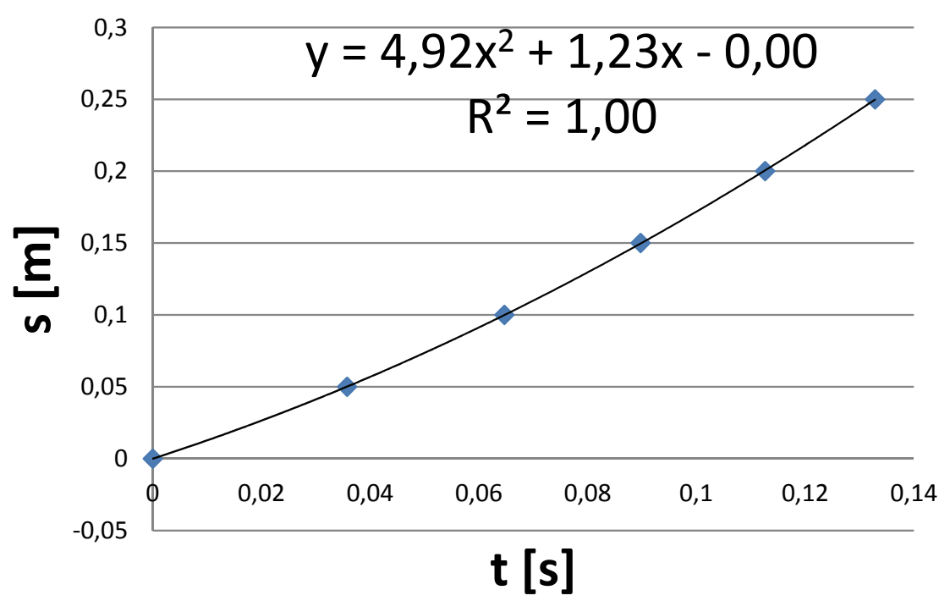


Voltage-time diagram of the photogate: built-in level crossing function for measuring speed

The line laid on the first graph shows that the value of g is 9.88m/s, which indicates a measurement with an error below 1%. The squared relationship between distance and time is clearly seen on the distance by time graph.



Quadratic displacement -time graph of a free falling body (measured by Jakab Mayer)



Velocity-time graph of a free falling body (measured by Jakab Mayer)

One of the advantages of the experiment is that students can turn their attention from drawing the graphs by hand to the observation of the phenomenon and the interpretation of the results.

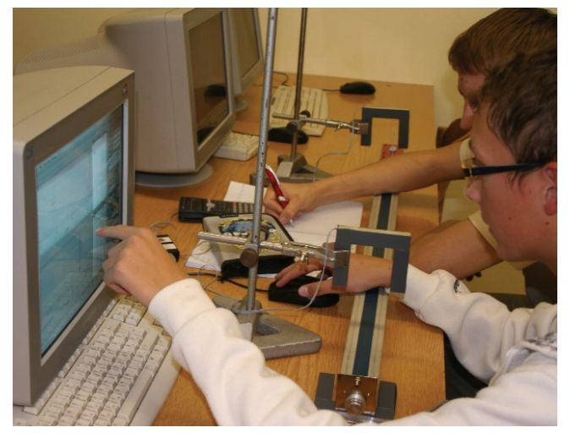
Collisions

Our ninth graders were not familiar with the concept of momentum when they started doing the work, therefore their task was a structured experiment (they knew the tools of the measurement and the process but they did not know the expected result). The teacher's aim is to make the students discover the notion of momentum and the law of conservation of momentum.

Students' task:

With the help of the available aluminum rail, cars, weights and photogates students observe the collisions. They prepare a plan of the implementation of the experiment and also carry it out.

Besides the photo taken during the measurement we show the result of a series of measurements below.



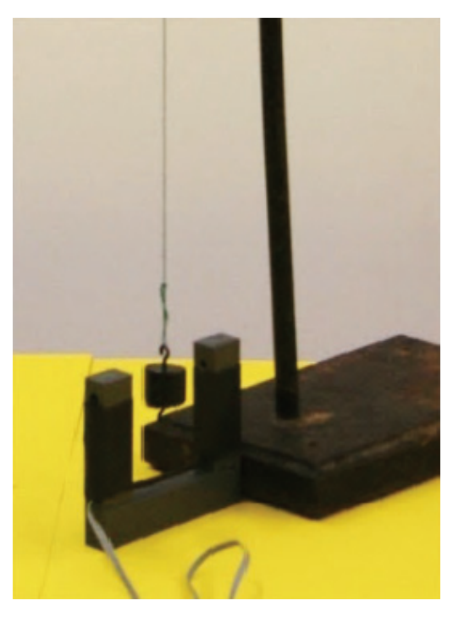
	1. car					2. car					
	m [*]	v_b $\left[\frac{m}{s}\right]$	v_a $\left[\frac{m}{s}\right]$	Δv $\left[\frac{m}{s}\right]$	Δp [**]	m [*]	v_b $\left[\frac{m}{s}\right]$	v_a $\left[\frac{m}{s}\right]$	Δv $\left[\frac{m}{s}\right]$	Δp [**]	$\Sigma\Delta p$ [**]
inelastic collisions	m	0.896	0.374	-0.522	-0.522	m	0	0.374	0.374	0.374	-0.148
	m	1.216	0.472	-0.744	-0.744	m	0	0.472	0.472	0.472	-0.272
	m	0.827	0.508	-0.319	-0.319	m	0	0.508	0.508	0.508	0.189
	2m	0.9	0.497	-0.403	-0.806	m	0	0.497	0.497	0.497	-0.309
	2m	0.902	0.477	-0.425	-0.85	m	0	0.477	0.477	0.477	-0.373
	2m	0.901	0.549	-0.352	-0.704	m	0	0.549	0.549	0.549	-0.16

In the first series the masses of the stationary and the moving cars were the same, while in the second series the mass of the moving car was the double of that of the stationary car. (*, **: The mass of the cars was taken to be a unit, i.e., the mass is to be understood as having an arbitrary unit, while momentum in mass-unit multiplied by meter/second.) (measured by Ágnes Nemes)

Pendulum motion

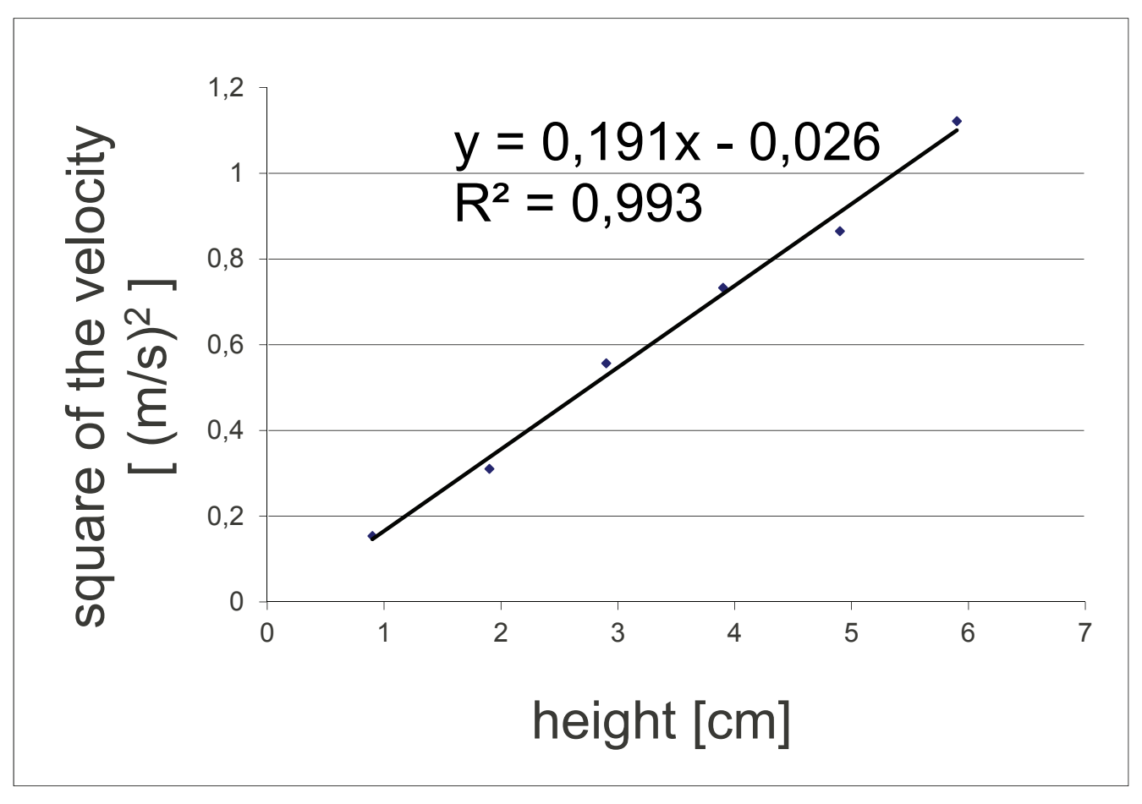
Students' task:

When we first discussed the pendulum in our study circle our ninth graders were already familiar with the concept of energy, but of the periodical movements they had only met rotary motion. Besides the already known measurement instrument the students neither got any instructions on how to explore the behavior of the unknown tool, nor did they know what result to expect at the end of their experiments.



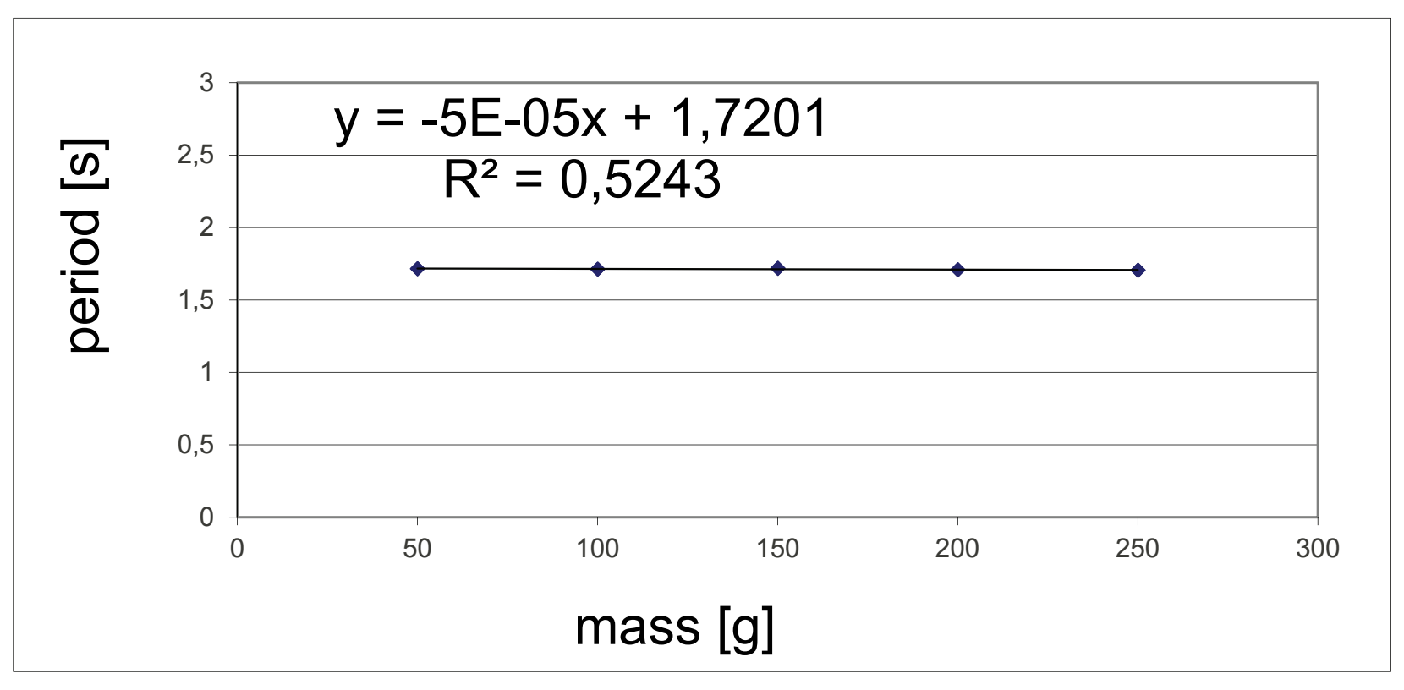
It was a typical open-ended inquiry situation, a higher level realization of IBL: besides the measurement program a photogate, a stand, strings and a set of weights were available to the students. Their task was to explore the movement of the pendulum as thoroughly as possible.

The more unusual results of the experiments:



The verification of the conservation of mechanical energy in the case of the pendulum: the square of the speed measured at the lowest point of the pendulum as a function of the starting height.
(The trend line tends towards the pole. The direct proportionality among the examined quantities is clear, i.e.. h~v².)

We made it possible for the students to examine the relationship between the duration of the swing and the mass of the pendulum.

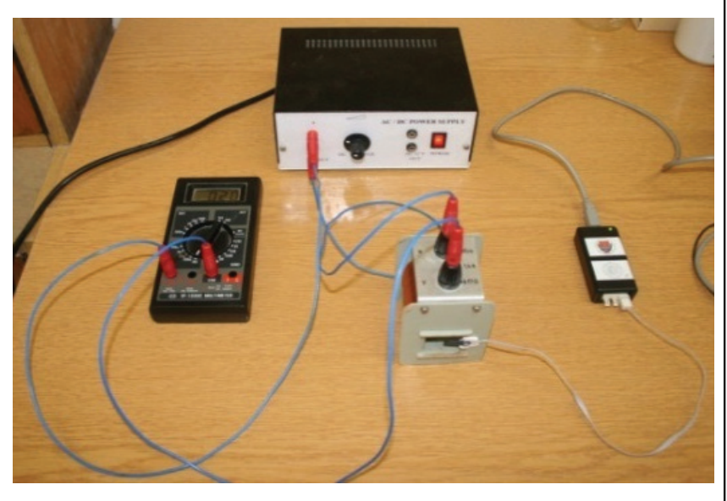


The figure shows that - in line with our expectations - the students did not manage to find the relationship between the examined quantities.

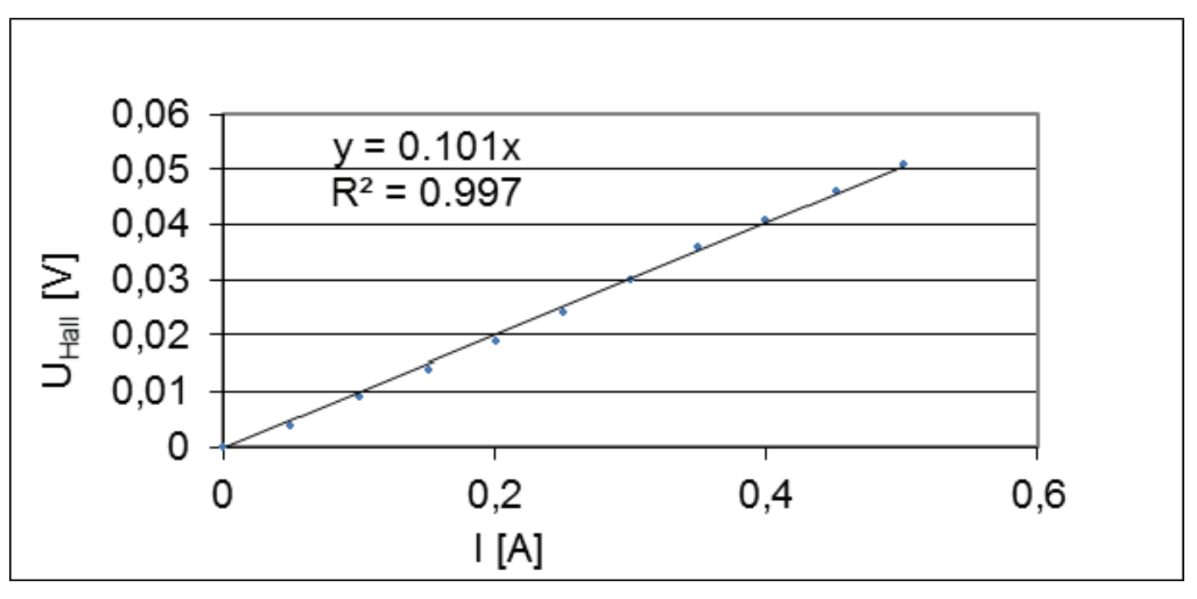
Hall of voltage

Using an ammeter we introduced variable direct current into a 1200-turn coil. Using plasticine as adhesive, we attached a Hall-sensor to the end of the coil. The table shows the Hall voltage as a function of the current intensity in the coil.

I [A]	0	0,05	0,1	0,15	0,2	0,25	0,3	0,35	0,4	0,45	0,5
U [V]	2,504	2,5	2,495	2,49	2,485	2,48	2,474	2,468	2,463	2,458	2,453



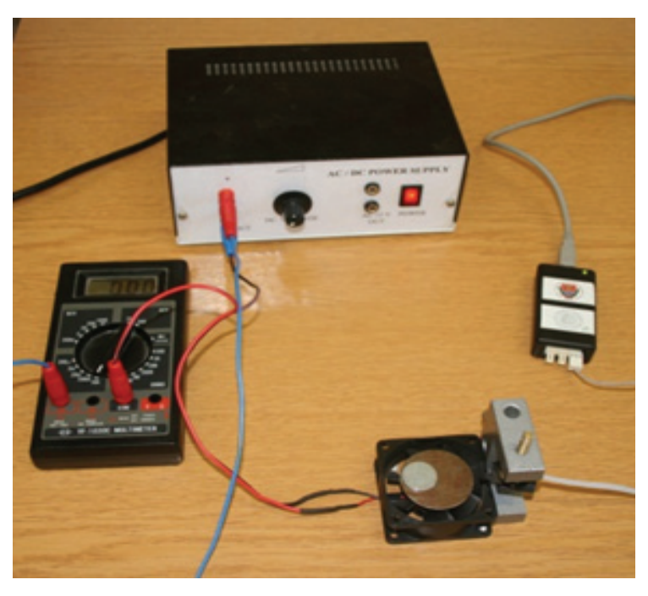
Testing the magnetic field of the coil.



Hall voltage as a function of the electricity of the coil.

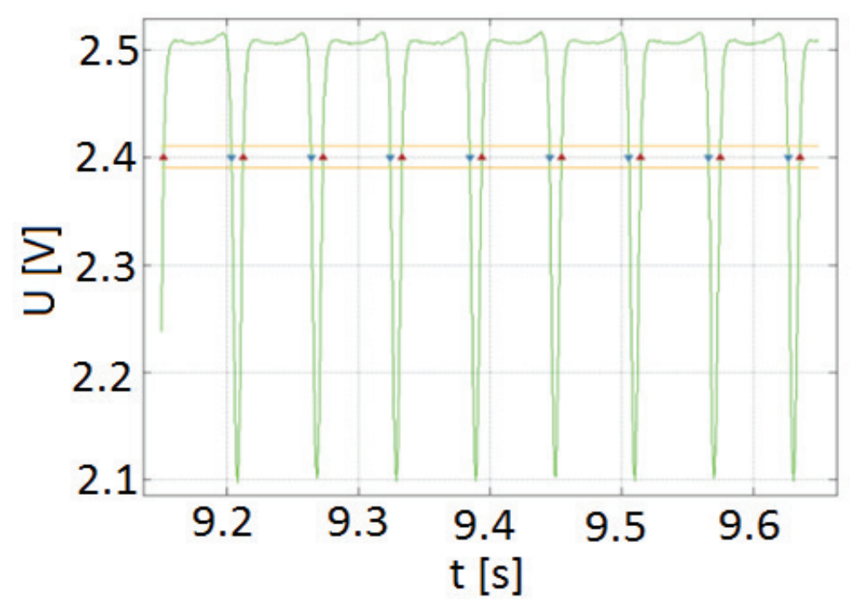
The measurement data corroborate the hypothesis that the intensity of the induction of the solenoid magnet is directly proportional to its current intensity. Without the computerized measurements this relationship could not be demonstrated in a secondary school.

Measuring rotational speed with Hall-sensor

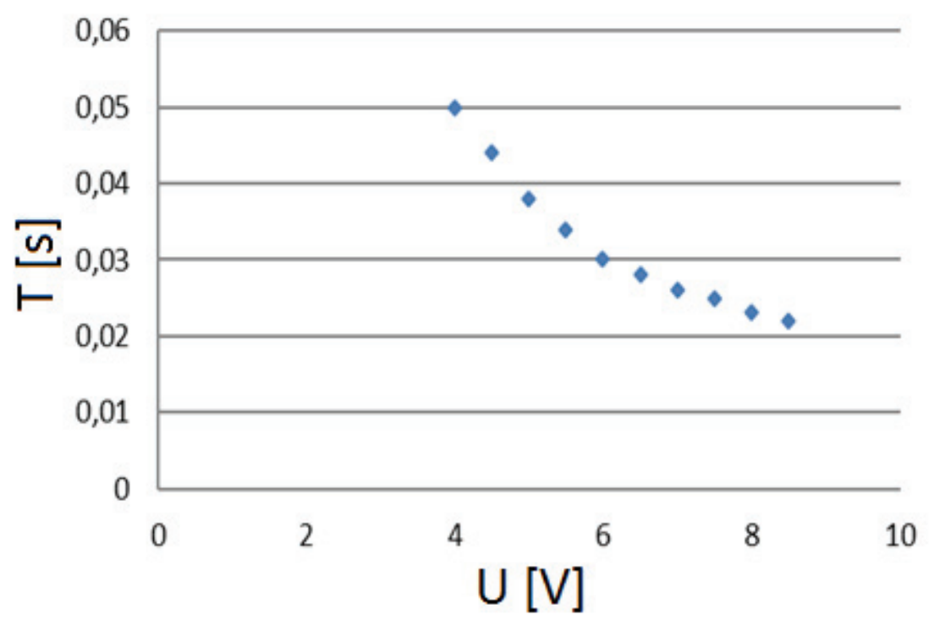


Hall-sensor for measuring rotational speed

The practical applications of the Hall-sensor include the measurement of distances, detection of position and the measurement of rotational speed. The working of the latter can be modelled by an easily arranged setting: we can measure the rotational speed of a direct current motor as a function of voltage.



Changes in Hall voltage at a given motor voltage – using the level crossing function, we can determine cycle time



Cycle time of direct current motor as a function of motor voltage (data by Moric Kiraly, 9th grade)

In addition to putting together the experimental equipment, it was also the student's task to plan and implement the measurement. The ninth grader's observation about motors, – that beyond the minimal voltage necessary for the start the rotational speed can be controlled by changing the voltage - may come useful later, during the planning phase. The processing of the data helped the student to improving his data processing skills and his ability to interpret the results.

CONCLUSIOINS

Our measurement practices combine the IBL-method with the application of computerized measurements. Several experiments that – in the absence of suitable equipment - could not even be demonstrated at school before have now become measurement practice exercises for students. Our students gladly work with these tasks, many of them have chosen research careers, and take part in independent experimental projects as secondary school students.

REFERENCES

Kopasz, K., Makra, P., Gingl, Z. (2013). Student Experiments and Teacher Tests Using Edaq530. Acta Didactica Napocensia, 6(1), http://adn.teaching.ro/

Kopasz, K., Makra, P. & Gingl, Z. (2011). Edaq530: a transparent open-end and open-source measurement solution in natural science education. *European Journal of Physics, 32*(2), 491-504.

Questions? Comments?
Please let me know!
Ms. Katalin Kopasz, University of Szeged (Hungary)
kopaszka@titan.physx.u-szeged.hu

SAILS Strategies for Assessment of Inquiry Learning in Science

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 289085