

## introduction

Conducting experiments in physics by usage of modern measuring techniques, particularly computers are much often more attractive to students than conventional ways of experiments. SCLPX - Sound Card Laser Pointer eXperiments deals with experiments in physics under which such equipment as a computer sound card as a measuring device and other available physical devices such as a laser pointer, photodiode or solar cell, electrets microphone, pendulum, paper comb, skewer, etc. are being used. The work presents alternative experiments in physics that can be used directly as demonstration experiments in classes of physics or as students' attempts in a laboratory work. The most important advantage of the proposed experiments is a relevant low cost of the basic equipment and the fact that all of the proposed experiments could be repeatedly conducted at home individually. The price of all our basic components is about 15 euro. On the other hand, the price of a professional laboratory school kits as Vernier, IP Coach, ISES, etc. is in the range 800 – 1600 euro per one student workplace.

Detailed work procedures and laboratory protocols for individual experiments will be published step by step on <http://www.sclpx.eu>.

At present we have prepared and tested 25 experiments in the field of mechanics and sound waves. Another 30 experiments dealing with the properties of solids and liquids, electricity and magnetism or quantum physics are in the process of screening. All the experiments have been tested at the Nový Bydžov High school (<http://www.gnb.cz/nweb2/>).

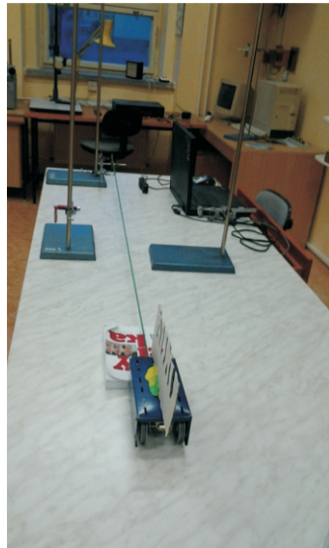


Fig. 2 Dynamic mass measurement

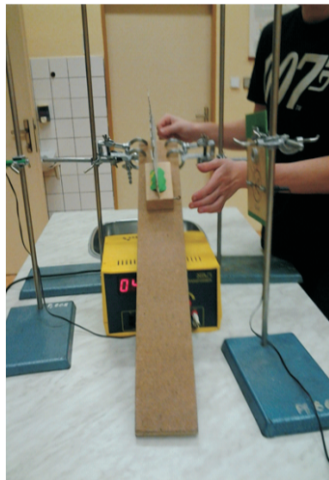


Fig. 3 Determine the coefficient of friction

## new school physics experiments

In the experiments, we continuously used the following tools: notebook or PC, photodiode or solar cell, laser pointer, pendulum and paper comb with wide teeth well cut out of cardboard. Photodiode must have the ability to receive frequency in the visible region. Solar cell has a larger surface than photodiode and therefore it is easier to work with. All experiments can also be performed using a tablet.

List of some realised experiments: dynamic mass measurement (Fig. 2), determination of a coefficient of friction (Fig. 3), free fall of paper comb (Fig. 4), induced voltage (Fig. 5), acoustic beats by Visual Analyser (Fig. 6), dynamic measurements with spring or pendulum, frequency of pipes or strings and many other.

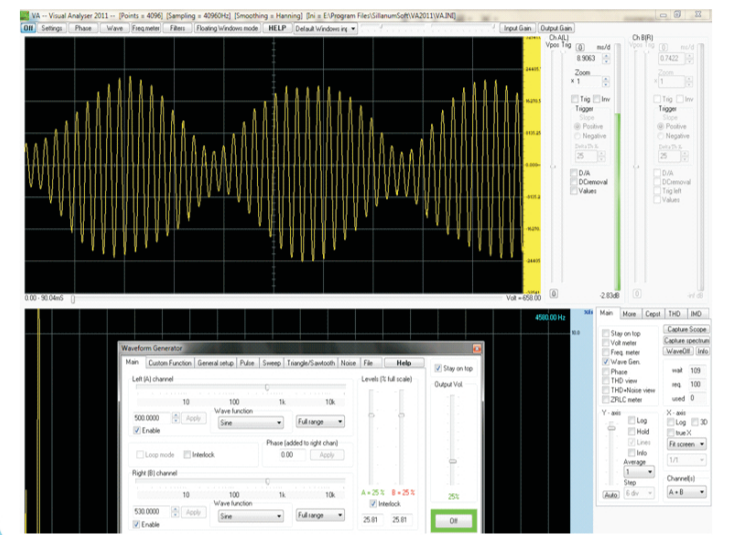


Fig. 6 Demonstration of acoustic beats by Visual Analyser

# SCLPX – A New Approach to Experiments in Physics at School

## how does the experiment work?

All experiments using a simple optical gate, which is composed of a laser pointer and a photodiode or solar cell, from which the signal is connected by cable to the microphone input of the sound card by 3.5 jack connector. The principle of optical gate is then obvious: the interruption of the laser beam changes the output voltage of the photodiode or solar cell and the output pulse corresponds to the course during the transient process, as shown in Fig. 1.

In this way, we can then measure the length, so even for very short periods of the order of 10<sup>-4</sup> to 10<sup>-6</sup> seconds. This can be used e.g. for measuring of the time sequences of the free fall, an acceleration of a body, a pendulum motion or we can measure the speed of sound using a microphone instead of the photodiode.

For the recording and signal evaluation we used a freeware program for audio editing Free Audio Editor. The advantage is clear and easy in manipulation. The program can also edit the recorded signal, so we can make the selection as part of the signal and the program evaluates its length (window called Length) or weak signal can be increased. Before measuring just only set the input type (mono or stereo), as the input device we select the microphone, level signal (Input Level), set so that the signal from the photodiode does not exceed 100%, and then you run your own measurements (sound recording) by Record button. After running the experiment (usually just 10 s to 15 s) we finish the measurement by button Keep. Monitor shows recorded signal, which we can then further handle with the mouse. Recording can of course also be saved in WAV format audio file, so we can experiment data at any time to reload. For some experiments, particularly with sound, we used freeware program Visual Analyser.

Finally, recall the important fact that using the sound card can only be measured AC voltage to 1.5 V (output of the photodiode is of the order of 100 mV, so do not be afraid of destroying the sound card when directly connected to the output diode microphone input via 3.5 mm jack connector). DC voltage due to buffer capacitor of the soundcard can't be recorded. The advantage of using a sound card over other systems is a high sampling frequency (44,1 kHz standard, but nowadays you can go up to values of the order of MHz).

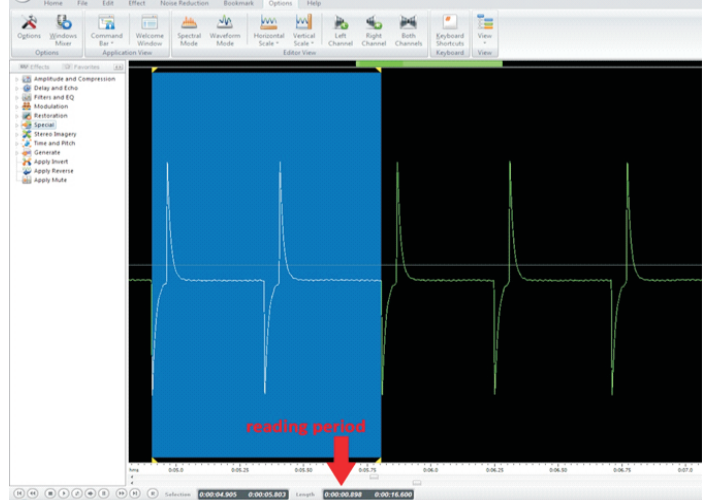


Fig. 1 Output signal from photodiode or solar cell with reading of the period in Free Audio Editor



Fig. 4 Free fall of paper comb

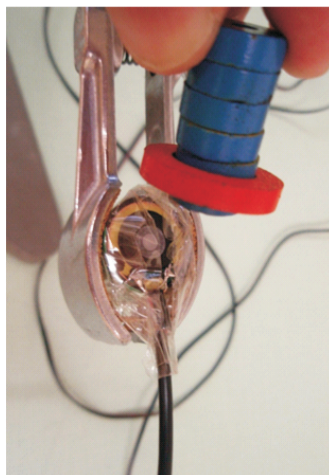


Fig. 5 Measurement of induced voltage

## results and conclusions

During our work with optical gate constructed of laser pointer and a solar cell, we didn't meet any major obstacles to the realization of our experiments. The results of the measurements are in correspondence with the tabular values and compared with conventional methods without the use of computer or notebook we have achieved much more accurate results.

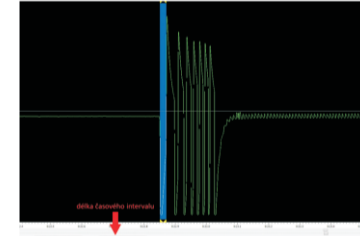


Fig. 7 Free fall of the paper comb by Free Audio Editor

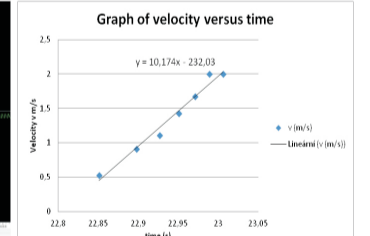


Fig. 8 Velocity of falling paper comb with linear regression

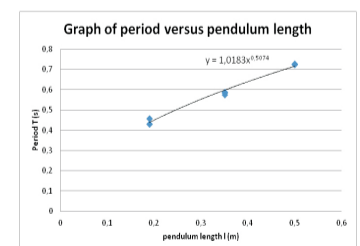


Fig. 9 Time period versus pendulum length with square root regression

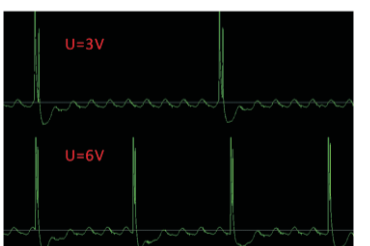


Fig. 10 Uniform circular motion - different angular velocity at the constant distance by Free Audio Editor

In our experiments with sound card we have verified in several experiments from the field of mechanics and the theory of oscillations that the optical gate consisting of a photodiode and laser pointer allows you to make measurements comparable with experiments undertaken using professional kits as ISES, Vernier or Coach. The advantage is the ability to carry out experiments not only as a demonstration, but also as student's laboratory exercises. The next advantage is affordability of used equipment, which may for a variety of primary and secondary schools represent an interesting alternative to the very expensive professional headsets.

Experiments with a sound card can be extended to other areas of physics: experiments with sound (speed, frequency), demonstration of acoustic beats, the law of conservation of mechanical energy, litters, heart rate, power measurements with alternating current (RLC), modulus of elasticity determined from the torsional vibration, measuring of temperature and many others.

## acknowledgments

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