

## Hands- and Minds-on Physics for All

Leoš Dvořák

*Dept. of Physics Education, Faculty of Mathematics and Physics, Charles University,  
Ke Karlovu 3, 121 16 Prague 2, Czech Republic  
Leos.Dvorak@mff.cuni.cz*

### Abstract

*Selected activities aimed mainly at informal physics education of different age groups are described: physics ‘club’ for children, education of pupils of age 12-15, summer physics camps for age group 14-19, spring camps for future physics teachers and weekend seminars for physics teachers in practice. The common characteristic of these activities is an active work of all their participants. Mutual inspiration and a ‘synergic effect’ of these activities are shortly commented. Each activity is illustrated by at least one (sometimes nontraditional) simple experiment.*

### Introduction

Various activities concerning informal physics education we organize have one common point: the active work of all participants. We try to enable them really “to touch physics” – not only with their hands but also with their minds. (That’s why we speak about “hands- and minds-on physics”.)

Up to now the feedback has been encouraging – so maybe something from the following short presentation can be inspiring also to someone else.

### 1 Physics clubs for children

Physics “clubs” headed by university students are organized for children of various ages. They take place at schools, typically 2 hours per week. We have long-time experience with clubs for children 14-18 years old. But there is also a physics club for primary school pupils attended by children 8-10 years old, which has successfully evolved in last two years.

There are plenty of simple experiments that can be done in such a club. I would like to mention one or two that can be presented also to much older audience. They are variants of a known experiment with resonance of two tuning forks (after hitting one tuning fork the other one, tuned to the same frequency, also vibrates and sounds).

One possibility is to force vibrations of the tuning fork by singing into a wooden resonant box on which it is mounted. Second variant uses two tuning forks on their boxes. The vibrations of initially non-vibrating fork are detected by a small ball (initially just touching the fork)

hanging on a thread. Children like to observe that hitting one tuning fork at the distance of several meters can cause the ball at the second tuning fork bounce. (And older children, after being asked, can realize themselves that this experiment demonstrates that sound transfers energy.) You can also combine both experiments and cause the ball to bounce by singing into the resonant box of the tuning fork.

Note: These experiments are certainly not brand-new. But they surely attract attention of children and, according to our experience, they are not much known by teachers.

### 2 Education of pupils of age 12-15

How we try to improve physics education of pupils of age 12-15 (and older) is briefly described elsewhere (see [1]). Here we just illustrate it by experiments that can be also presented to older students.

A nice set of experiments demonstrating properties of traveling and standing waves can be done with an elastic “band” (with circular cross-section) used in anoraks etc. A piece of such elastic band 5 meters long can be used to show transversal traveling wave and to measure its speed. (A traveling pulse bounces at fixed ends. If we let it go back and forth 10 times, the total time is several seconds, long enough to be measured in a classroom.)

Standing waves can be generated either manually or by an electric drill or by a shaver. We can even more or less quantitatively verify the formula  $f = v / \lambda$  and use it to measure the frequency of vibrations of the shaver. (In fact, we can choose the level of our demonstrations from simple playing and showing nodes and antinodes through qualitative demonstrations to, e.g. discussion of wave equation at the university level. All these experiments and discussions can of course be done with the help of the whole class.)

### 3 Summer camps for age group 14-19

Summer math-phys camps for secondary school students are described in an accompanying article [2].

To illustrate how inspiring projects on the camps are I present a simple instrument, which developed from the results of one of projects. It is a model of an electrodynamic loudspeaker. You can use it for example for a non-traditional demonstration of Lorenz force.

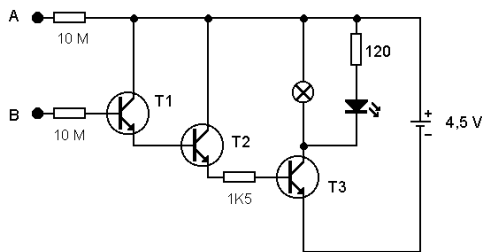
Take a piece of light plastic (Styrofoam), e.g. 7 x 7 cm, about 1-2 cm thick, and wind up a thin (0,2-0,3 mm) insulated copper wire around it. The wire goes along narrow sides of the plastic – to form a square coil. The number of turns (several tens) should be such that the total resistance of the coil is about 8  $\Omega$ . Connect the ends of a coil to bendy wires terminated by a suitable connector. And (an important point!) fix the wire to the plastic by wrapping it by a plastic tape.

Now connect your loudspeaker to the output of some amplifier and put a musical signal into it. Silence? Of course, it is necessary to put a magnet close to the coil. Now you can feel the plastic to vibrate and you can hear the sound – in surprisingly good quality.

#### 4 Spring camps and other activities for future physics teachers

The activities at summer camps for secondary school students had been so successful that about 7 years ago we decided to organize smaller but similar “spring camp” for future physics teachers ([3], [4]). These camps, together with other special seminars and other activities, proved to be very good for development of informal contacts with students, their practical skills and creativity – and the work there also results in nice experiments and instruments.

An interesting example is an indicator with 2-3 bipolar transistors (e.g. BC337) developed to demonstrate the conductivity of human body etc. It occurred that with 3 transistors it is so sensitive that it reacts to changes of electrostatic field.



We can construct the indicator on a small wooden plate by soldering the component legs to small brass nails. The whole scheme (see the picture) is then clearly visible. You can use this or similar “instrument” for demonstration of a function of transistors – or to various electrostatic experiments. The indicator also provides a nice opportunity to discuss *why* it works (why the light bulb shines if we bring positive charge closer to the point B, what should we do with negative charge to make the indicator shine etc.). It also works as an indicator of small currents of the order of 1 nA. (Unscrewing the light bulb and watching the LED increases the sensitivity.)

#### 5 Weekend seminars for teachers in practice

Weekend seminars for physics teachers are one of major parts of an informal project Heureka [5]. The experiments and their discussions play a vital role also in these activities. As a simple yet attractive example we can mention blowing bubbles when being charged by a school van de Graaf generator. The bubbles are also charged, are repelled from the person who blew them, and their motion can be controlled by a charged rod. Variants of this experiment offer a nice possibility to show various electrostatic phenomena. And they can also inspire the invention of a new variant of an old experiment with “electrostatic pendulum” (a light conductive ball bouncing between two oppositely charged electrodes): the electrodes can be hands of two people.

#### 6 How it fits together

All these activities are not isolated. They affect and inspire each other and people involved in it form one broad cooperating group.

Physics club and summer camps date back to 1980s. (At that time, however, the club was for older students only and the summer camps were rather theoretically oriented.) Then in the first half of 1990s Heureka came and became a source of inspiration which resulted into more experimentally and then project-oriented camps. And all this gradually started to influence a pre-service training of future physics teachers at our university. Now we invite university students to seminars for teachers and teachers to spring camps for students – and it seems that the synergy of all these activities works quite well.

#### Conclusions

What to add? Perhaps our favourite slogan:  
*To teach physics well is not an easy job. But it's a joy for the whole life!*

#### References

- [1] KOUDELKOVÁ I., DVOŘÁK L.: Heureka: Hands- and Minds-on Physics at School. *In: this proceedings.*
- [2] DVOŘÁK L., JÍLEK M., KOUPIJ J.: Projects at Students' Physics Camps - Never Ending Inspiration. *In: this proceedings.*
- [3] DVOŘÁK L.: On the Road To Hradstice Tables. *In: Proceedings of IOSTE Symposium Science and Technology Education in New Millenium*, Prague 2000, p.238-242
- [4] DVOŘÁK L.: „By One's Own Hands and Head: - Physics Summer Camps for Secondary School Students and for Future Teachers of Physics. *In: Focus On Teachers. Physics On Stage 2 Project Summaries.* (SP-504) ESTEC-ESA, 2002, p.61-63
- [5] KOUDELKOVÁ I., DVOŘÁK L.: Heureka Project – for both Pupils and Teachers. *In: this proceedings.*