Couple of projects from summer camp, this time's topic: „How little is enough to make mathematician and physicist happy"

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The paper describes another year of the Young Physicists and Mathematicians Camp organized by the Faculty of Mathematics and Physics, Charles University in Prague, which took place at the Hořovice Cottage in Cholín. Attention is particularly given to three selected projects on which the participants worked.

Camp of 2019

Young Physicists and Mathematicians Camp is intended for students aged 14 to 19 years old that not only show interest in physics, mathematics and computer science but are also tempted to experience something new or to overcome their own limits. This year's camp took place at the Hořovice Cottage in Cholín a stone's throw away from the Slapy Reservoir. Amongst new challenges was not only (almost) traditional forest sleepover in one's own sleeping bag, but also a possibility to row a canoe across the Vltava River or dropping supplies of the bridge onto the heads of camp counsellors sailing under the bridge in ferryboats.

Non-specialized programme

An integral part of the camp is a so-called non-professional programme. On every single year is this programme connected to a certain legend and every afternoon, night or morning game is adjusted to fit into this legend. This year's participants were mapping an expedition to the North pole that was undertook by a Czech physicist František Běhounek back in 1928 (under the leadership of Italian captain Umberto Nobile onboard airship named *Italia*). All important milestones of this expedition (radiotelegraphing, shipwreck, tent building, rescue by a Soviet iceberg *Krasin*, …) were included into the games by the head of the non-specialized programme.

The aim of this part of the programme is to relax after spending (at minimum) three hours a day with physics, mathematics, and computer science, to "switch" to a different kind of entertainment and last but not least, to spend some time actively outside in the fresh air.

Everyone liked this year's topic (judging by traditional final feedback poll) and, with a few exceptions, all the participants were very enthusiastic about all the activities.

Non-professional programme culminated with traditional two-day "encryption game" as was expected by many participants. The culmination of this year's non-professional programme was designed to be experience-based so the participants could try out various new skills (independently cook dinner from received ingredients, a sport

activity, based on which breakfast ingredients were obtained, above mentioned crossing of Vltava on canoes…).

Specialized programme

A second vital part of the camp is a specialized program, this year covered by topic „How little is enough to make mathematician and physicist happy". This program traditionally starts with a so-called miniproject that is supposed to prepare participants for the days to come. For this year's miniproject, they were supposed to create a device that will measure 23 s using only given equipment. Their ideas were very interesting. This activity (as well as all the other activities during camp) does not have winners or losers – everyone participates in every prepared activity with enthusiasm, the only potential handicap being participant's age. Yet we are trying to compensate for that.

Another part of the specialized programme consists of everyday physics, mathematics (both in three levels) and computer science courses. Courses are taught by the camp counsellors – i.e., students of the Department of Physics Education, Charles University, Prague, or teachers from practice.

Furthermore, there are invited talks. This year's invited talks were Irena Dvořáková – *Mathematical Games*, Leoš Dvořák – workshop *Toying with magnets*, Mirko Rokyta – lecture *Prime numbers and RSA encryption* and Matěj Ryston – workshop *General theory of relativity*.

Main part of the specialized programme are projects that participants work on for approximately 10 days. Following projects were solved this year (those in bold letters are further described in more detail).

3D images

Euclidean and non-Euclidean geometry (models)

Euclidean and non-Euclidean geometry (GTR coursebook)

Cameras and microscopes

Pocket physics

Goniometry and trigonometry

Infinite cube

IR Zeppelin

Levitator

Mechanical binary calculator

Cloud chamber

Non-round wheels

Arc lamp

Perspective illusion

Sirens

Statistics

Thermocouple couple

Tesla turbine

Artificial intelligence

Waves and resonance

Description of individual projects in this paper are based upon documentation provided by participants who were involved in the project.

Pocket physics

The project, solved by Soňa Husáková, was focused on designing and creating simple physics experiments, which could "fit into a pocket". Author designed and produced an array of simple equipment that can demonstrate important physics phenomena and laws:

carts to demonstrate elastic and inelastic collision (see fig. 1);

a turntable demonstrating behaviour of bodies in a non-inertial frame of reference (including demonstrations of Coriolis and Euler forces) and certain optical illusions;

a device for drawing magnetic field lines (see fig. 2);

a piston Cartesian diver;

the principle of conservation of mechanical energy during rolling of two seemingly identical bodies from an inclined plane;

a drinking glass suitable for demonstrations of sound propagation, demonstration of existence of resistive forces (hence invalidity of the principle of conservation of mechanical energy in air), demonstrations of phenomena in gas and imaging with a cylindric lens.

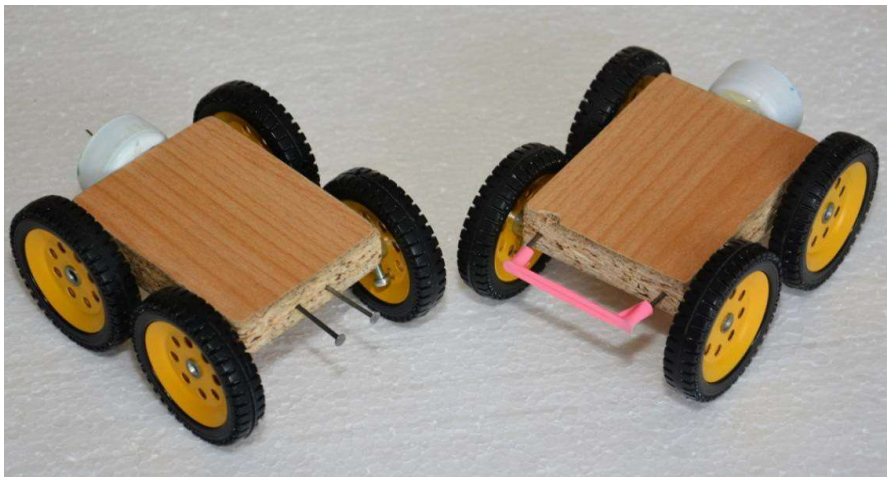


Fig. 1 – Carts to demonstrate collisions (photo taken from the side intended to demonstrate elastic collisions)

Fig. 2 - The device for drawing magnetic field lines

Every experiment was presented and explained by the author at the closing conference.

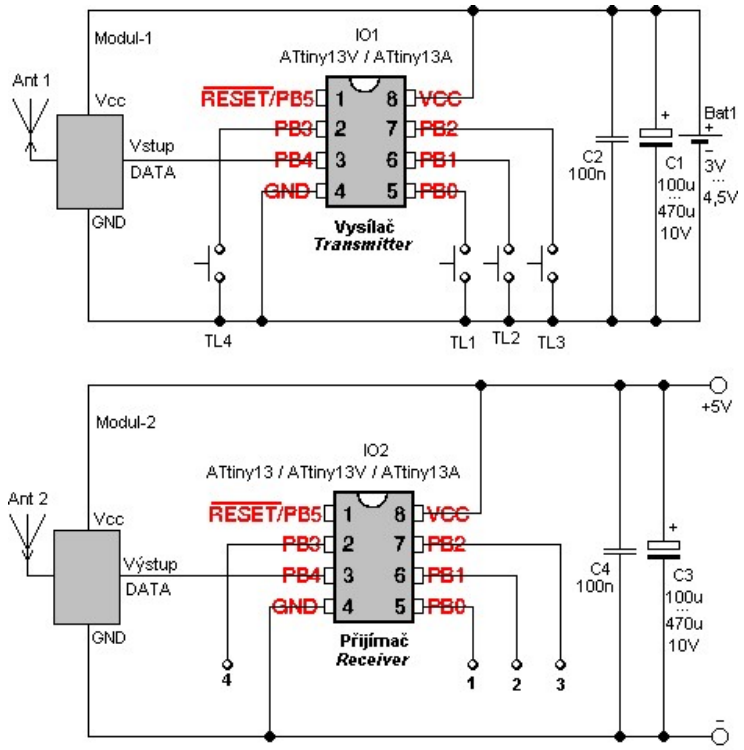
IR Zeppelin

This project with rather mysterious name was worked on by Tomáš Janovský, Kateřina Charvátová and Petr Kalina. Its aim was to build an airship lifted by helium filled balloons (a blimp), that could be steered using remote controller radiating infrared electromagnetic waves.

To propel the airship, 13-gram model engines controlled by a four-channel remote control were used (see diagram in fig. 3). After button press on a controller a signal is modulated by a microchip and transmitted via infrared diode. The signal is demodulated by another microchip inside the receiver on the airship's gondola. Current floating into the engine is triggered by a transistor. Engines are parallelly connected to a diode which serves as a filter for the current induced when the motors are being switched off. Capacitors are used as current cut-offs in the circuit, to protect it from current spikes.

The original plans to build a balsa gondola were reconsidered due to the low load capacity of the balloons. Thus, the gondola composes of two parallel skewers, to which two motors are attached. By appropriately tilting these motors, the airship can be steered both horizontally and vertically (see fig. 4).

Transmitter's operating voltage is 3V, receiver with motors is powered by a 3,7 V rechargeable battery with a 220 mAh capacity.



Radio remote on-off control with 4 channels

Fig. 3 – Circuit diagram of the four-channel remote controller

Fig. 4 – Testing of the finished airship

Mechanical binary calculator

Matěj Dvořák, who was constructing the mechanical binary calculator, first had to figure out how to convert logic gates AND, OR, …. (commonly used in digital technology) into a mechanical form. The calculator was built on a polystyrene plate and summed numbers were represented by small balls released from the top of the device. The author built the guiding borders for the balls out of cardboard. The gates were made using cardboard balances that tipped after the balls landed on them. Numbers consisting of 3 bits in binary system (i.e., numbers in range 1 to 7) were represented by a maximum of 3 balls that were dropped into appropriate slots of the device. Once the balls representing the first bit had been dropped, the balls representing the second bit followed with proper time separation, followed by the balls representing the third bit. Proper time separation is necessary, so the balls don't bump into each other between guiding borders and so the gates are readied (by changing their position) for the arrival of the next ball.

By successive simplification of the relevant "circuit", the author arrived at the circuit shown in fig. 5. Thanks to the author's inventiveness, the gates are multifunctional: if two consecutive moving balls pass through them, the gates behave differently for each ball - either as OR or AND.

The finished device is shown in fig. 6. The author has also conceived variations how to modify the calculator so that subtraction can be implemented as well.

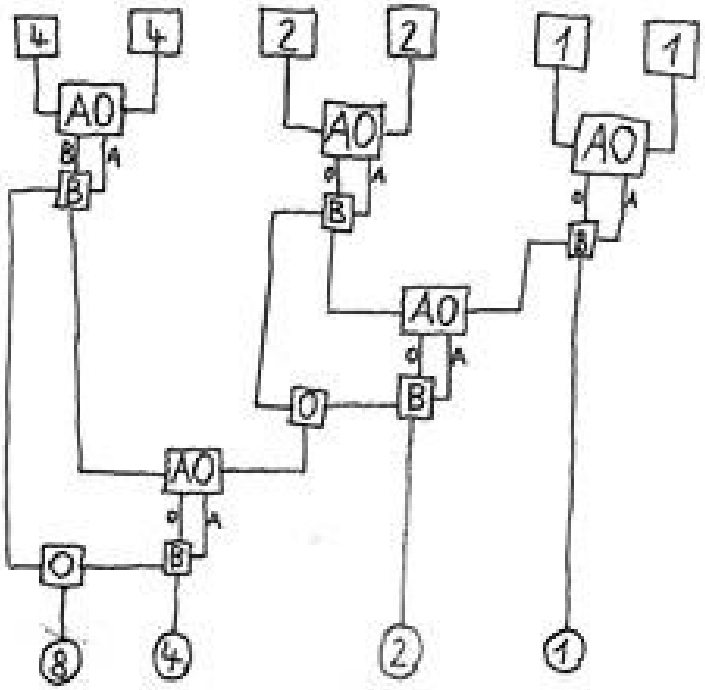


Fig. 5 – Diagram of "circuit" of mechanical calculator

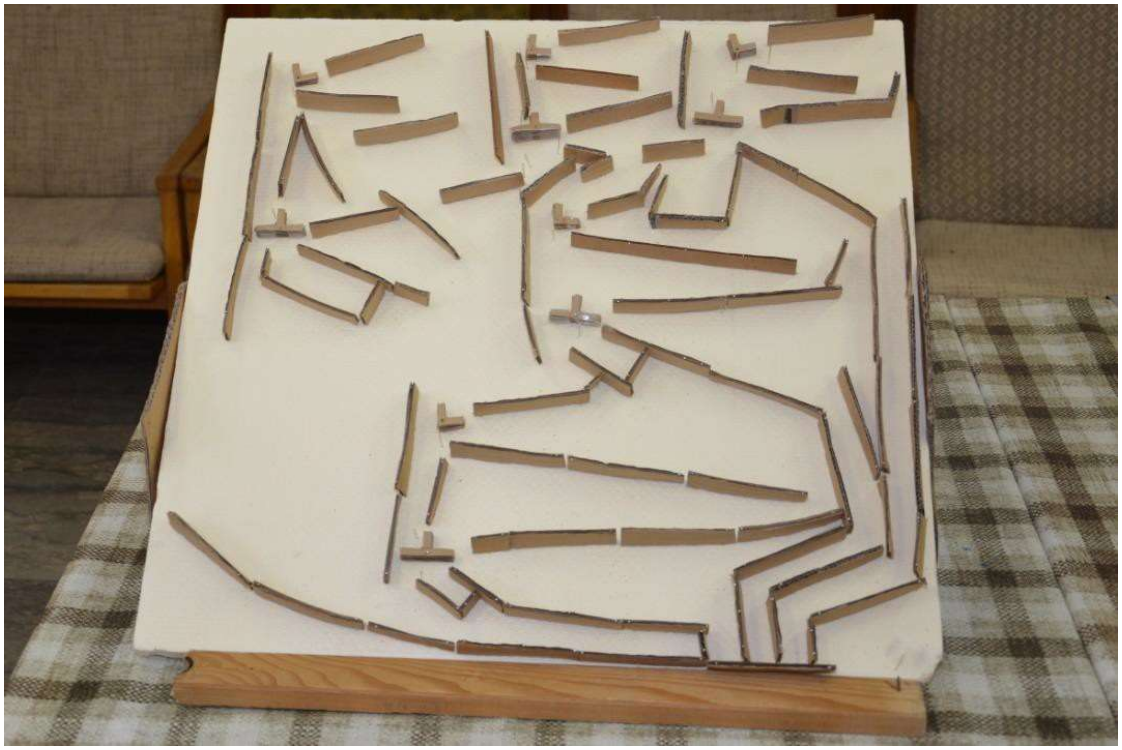


Fig. 6 – Mechanical binary calculator

Conclusion and invitation to the next year

This year's camp was also held in very friendly and relaxed atmosphere. As well as in the previous years everyone was sorry that the camp was already ending. Although everyone (participants as well as counsellors) was looking forward to proper sleep, simultaneously everyone was sorry that those nicely spent 14 days are over.

The staff of the Hořovice Cottage in Cholín also contributed to the successful and pleasant course. A subtle hint about our unusual requests was enough for our host to fulfil them very willingly and quickly. The setting for the closing feast (instead of the last supper) was the proverbial cherry on top.

Unfortunately, this year some of the participants had to leave us due to their age. We hope that they will stay in touch with the organizers of the camp and that they will come have a look next year. Where to? The same place as this year!

The camp is open to all students between the ages of 14 and 19 with an interest in physics, mathematics, computer science, playing, overcoming obstacles, … All such students are cordially invited to Cholín in the summer of 2020.

More details about the camp can be found on the camp's websites [1] and in the papers of previous years' *Physics Teachers' Inventions Fair* (e.g. [2]), or in the paper from international conference ICPE-EPEC 2013 in Prague ([3]).

References

[1] Soustředění mladých fyziků a matematiků [online]. Available from: http://kdf.mff.cuni.cz/tabor [cited 7. 8. 2019].
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