

Physics in a box

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Motto: „How many physics experiments can be demonstrated with equipment placed into ferromagnetic box sized 10,2 cm x 6,2 cm x 2,2 cm?“

Abstract

Box with dimensions of 10.2 cm x 6.2 cm x 2.2 cm was filled by stuff that can be used to demonstrate more than sixty different physics experiments. This paper presents the contents of the box and selected experiments performed with it.

The competition Pocket Physics - Physics in a box

In April 2012, we participated in the conference Show Physics in Bergen, Norway. Part of the conference was the contest Pocket Physics - Physics in a box. Prior the conference the participants received ferromagnetic box with dimensions of 10.2 cm x 6.2 cm x 2.2 cm and task to place into it as many tools for physics demonstrations as possible. The box had to be completely closed. In addition to the contents of the box and the box itself, it was allowed to use only things commonly available, as part of clothing or water, for the demonstrations.



Content of our box

We filled the box with help of colleagues from Faculty of Mathematics and Physics, Charles University and we won award for "the box most filled with physics experiments." With the contents of our box we were able to demonstrate over sixty experiments.

With the contents of the second "most filled" box were its authors able to show approximately fourteen demonstrations.

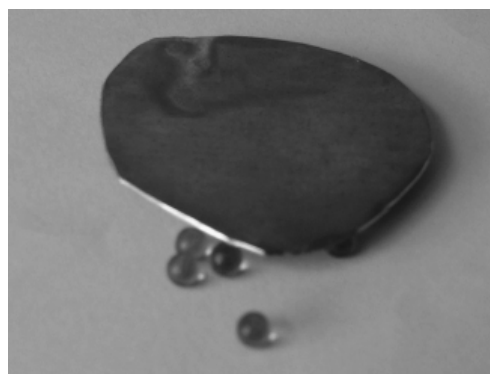
What we demonstrated with our box

With the tools from our box it is possible to demonstrate experiments from following areas of physics:

- Mechanics: Newton's laws, playing with the centre of gravity, friction, ball bearings, flight of a propeller, properties of a pendulum, drinking with straw, swimming of a little boat
- Acoustics: flutes, drum, guitar
- Molecular physics and thermodynamics: surface tension of liquids, capillarity, absorption of heat, heat conduction, ignition of a candle through the wax vapours, bimetallic strip, flying tea bag, thermo-sensitive play-doh
- Electrostatics: attractive and repulsive actuating and vice versa of consistently and oppositely charged drinking straws, actuating of charged drinking straw on the box, detector of electric charge, electrostatic shielding
- Electricity and magnetism: compass, torsion oscillations - the frequency dependence on the magnetic induction, actuating of a magnet through different materials, electromagnet, electric motor, electric circuit closed via a human, conductivity of graphite, connection of a diode, electromagnetic brake, falling of a magnet through aluminium and copper pipes
- Optics: reflection, dispersion of light in reflection, polarization of light, projection, optical grid, magnifying glass, binoculars, optical illusions
- Nuclear physics: statistical model of radioactive decay
- Quantum mechanics: non-commutativity of operators



Newton's laws



Friction and ball bearing

What all did we fit into our box

The competition's rules stated that the box has to be completely closed with the lid on it holding firmly prior to the demonstrations.

The following items were in our box:

- matches and a strip of striking surface from matchbox
- three drinking straws (the length of the box)
- skewers (the length of the box)
- mirror foil glued to the inside lid of the box
- strip of paper (5 cm x 15 cm)
- 3 paperclips
- 2 pins
- piece of yarn (about 25 cm)
- piece of aluminium foil (about 5 cm x 5 cm)
- copper tube (the length of the box)
- aluminium cylinder with a diameter slightly smaller than the diameter of the tube (height approx 2 cm)
- cylindrical magnet (3 pieces) with the same dimensions as the aluminium cylinder
- 4 small magnets (diameter and height of about 2 mm)
- wooden rod with drilled holes, partly cut at the bottom - the pendulum holder (the length of the box)
- copper disk and paper disk (diameter about 4 cm)
- 2 rubber bands
- paper dragonfly
- paper propeller
- small glass beads
- 3 balls of wax
- one aluminium coin
- cork disk
- model "boat" from the film foil
- piece of soap
- piece of thermo-sensitive play-doh
- piece of paper for chromatography
- an indicator of electric charge
- graphite from a pencil
- LED
- nail with the coiled wire (solenoid)
- coil for electromotor
- batteries (single-cell round AA 1.5V with added (soldered) connectors, coin-shaped 3 V)
- spiral from wire
- "bimetal" (strips of paper and aluminium foil pasted together)
- empty tea bag
- whistles made from straws and whistles made from lids from jars



Pendulum

- fragment of CD
- 2 convex lenses
- Fresnel lens
- strip of optical grid
- two strips of polarizing film
- optical illusions "cat-dog" and "laughing sun"
- halved orange lentils (at least 300 pieces)

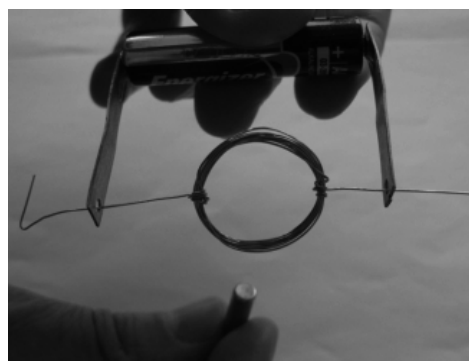
When packing the box it is necessary to be careful not to short circuit the battery connectors. It is also necessary to carefully wrap the thermo-sensitive play-doh, for example with piece of plastic bag, to protect it from melting and overspreading on other things in the box.

Detailed information about our box

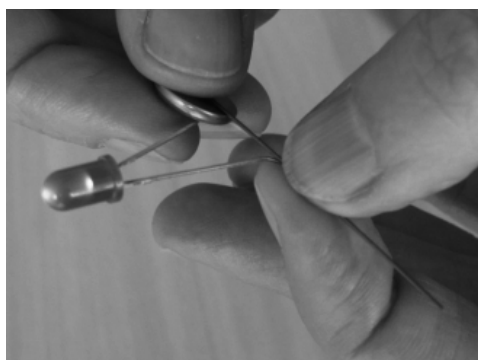
Detailed pictures of the experiments from our box are available at http://kdf.mff.cuni.cz/~jitkaadana/Fyzika_v_krabicce/.



An electromagnet



An electromotor



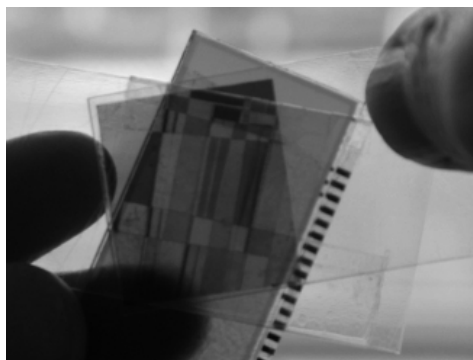
Graphite is a conductor



A telescope



A guitar



Looking through polarisation filters at a pattern from adhesive tape



Putting out a candle and lighting it again by a metallic spiral



Electrically charged drinking straws can attract or repulse each other

Conclusion

When selecting equipment and experiments for our box, we tried to cover as many areas of physics as possible and have there "something from each area." Another option is to make monothematic boxes.

The box can be used for occasional motivational experiments in classes and lectures. Students themselves can invent additional experiments that can be demonstrated with equipment from the box. Due to its small size and ease of transport the box is suitable aid for school trips and camps or other excursions. It is also possible to organize similar competition in the manufacturing of boxes for pupils in the class or in the whole school. From our own experience we can say that it is a lot of fun and one can learn a lot, too.

Acknowledgement

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