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SUPERCOMET 2 project

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Hands-on experiments on magnetism and superconductivity for secondary schools

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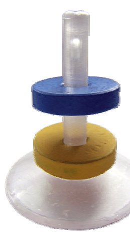
Some examples of simple experiments on magnetism, which can be introduced at a secondary school level, in a pan-European dimension are presented.

Magnetic levitation



This simple toy is build with flat magnet disks with holes in the middle. Magnets are slipped on the plastic rod.

If magnets are placed on the rod in that way, that their polarity repel each other then they floating one over another. Repelling force is increase with decrease of the distance between them. It is easy to check by pressing of the top magnet with a hand.

The pen hangs in air (and spins if started). Only on one side it touches the transparent barrier.

Both in-pen and in the horizontal support magnets are hidden. These magnets have a well-defined geometry - of the same polarity in the corresponding positions in the handle and the support - pushing the handle up and pulling it towards the barrier.
If the handle is placed "upside-down", i.e right and left directions inverted, it sticks to the support - two corresponding magnets are of the opposite polarity.

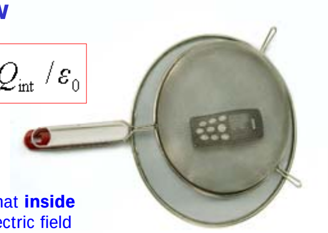
A small cube of (soft) iron is hanging between two graphite plates, attracted by the magnets above. The graphite plates repulse the cube, if it goes too close to them.

This fascinating toy is build with magnetic top and plate with built in some magnets. Magnetic field generated by these magnets is such, that top can levitate about 3 cm over the surface of the plate.

Magnetic fields (acting up) are compensated with gravitational forces (acting down). Balance of the top is conserved thanks to gyroscope effect created due to its rotation (angular momentum conservation). Levitation of the top is long due to neglecting friction of the air.

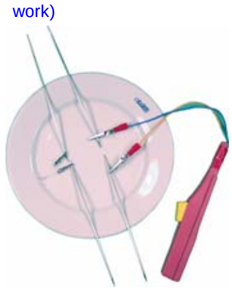
Gauss law

$$\oint \mathbf{E}\circ d\mathbf{S} = Q_{int}/\varepsilon_0$$



Gauss law says that **inside** conductors no electric field exist (the cell phone does not work)

Hertz experiment



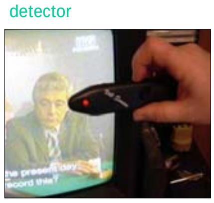
Hertz's proof of electromagnetic waves being (1887), can be repeated using the piezoelectric lighter and two couples of wires

This experiment can be repeat using the piezoelectric lighter which is lighter for gas and small neon indicator. The receiver is from two identical wires connected by neon indicator, situated parallel and 5 - 30 cm away from transmitter. The needles have to be isolated from the ground. Push the lighter causes switch on the neon. With help this simple experiment we can observe that electromagnetic waves transmission not only information, but also energy.

The currents in the piezoelectric effect aren't much, but voltage is order 10 kV. The piezoelectric effect consist in polarization dielectric under influence its deformation, what lead to appearance on its boundary potential difference. The instance of the material which shows the piezoelectric effect is a quartz. The piezoelectric effect found widely application for convert of the electrical vibrations into the mechanical ones and vice versa.

Electromagnetic waves

If you want to "touch" the waves you can use the electrical-wires detector

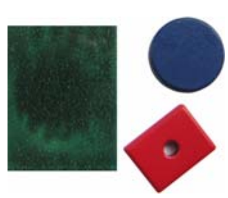


$$\oint \mathbf{B}\circ d\mathbf{l} = \mu_0 I + \mu_0\varepsilon_0 \frac{\partial \Phi_E}{\partial t}$$

Magnetic field viewer

You can see magnetic field!

The area between magnetic poles is indicated by a light green „aura", while the poles themselves appear dark green.



Magnetic "Gauss" law

$$\oint \mathbf{B}\circ d\mathbf{S} = 0$$

No Gauss law is possible for magneto-static: magnetic fields penetrate everywhere!

But if a you make a box of **a high-permeability material**, all lines will be confined inside this material: no magnetic filed is present in the box

Faraday - Lenz law

Faraday-Lenz law says, that if a magnet moves down, the electrical (eddy) currents are generated around. The magnet inside this copper tube falls 27 seconds. But if the tube has vertical cuts, the eddy currents are also cut and the magnet falls in 3 seconds.

$$\oint \mathbf{E}\circ d\mathbf{l} = -\frac{d\Phi_B}{dt}$$

Faraday experiment

Helmholtz coil (a winding of about 100 turns of 1 mm diameter copper wire on 1m2 internal surface frame) can be used for the Faraday-Lenz current (a few mV), when turned around.

What is to be shown with coil is that:

- the voltage changes its sign with turning
- the voltage rises in amplitude if the coil rotates quicker
- no voltage is generated if the coil is simple shifted in Earth's magnetic field instead of being turned