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Electromagnetism – seeing (experimenting) and calculating

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Introduction: Problems in teaching electromagnetism (EM)

- The branch is almost neglected in Polish basics curriculum
- EM is present in the extended course, but excessively formalized and not sufficiently illustrated with simple examples
- We have set some experiments into an educational path helpful in implementing elements of electrostatics and magnetism

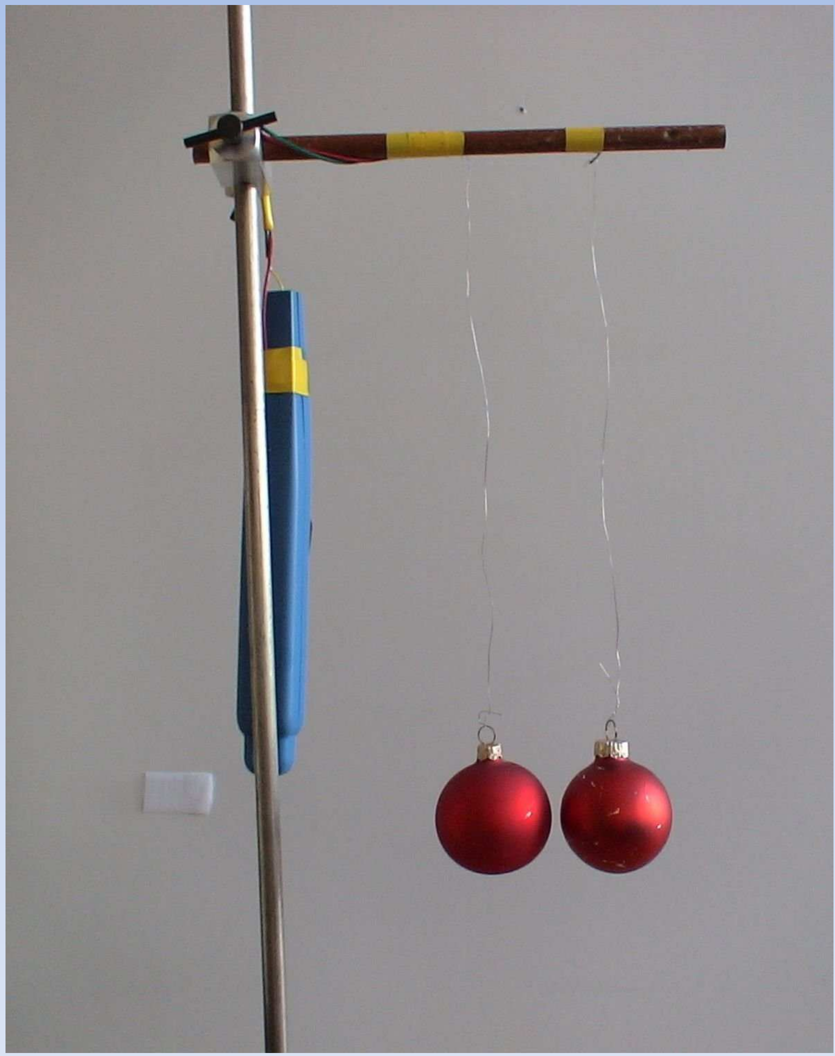
The motivation for our work

- On the national level: the lack of a didactical path towards understanding EM
- On the European level: the lack of comprehensive on-line illustrations – video, pictures, simulations
- Common project with the Czech and Slovak partners: solved problems (see the posters of S. Chalupkova and M. Snetinova)

Electromagnetism – simple experiments (excerpt)

- Coulomb’s law: two electrically charged balls (Christmas glass balls experiment)
- The interaction of a magnetic-dipole coil with the static magnetic field
- A single loop receding from a wire
- The fall of neodymium magnet inside a copper tube

Christmas glass balls experiment



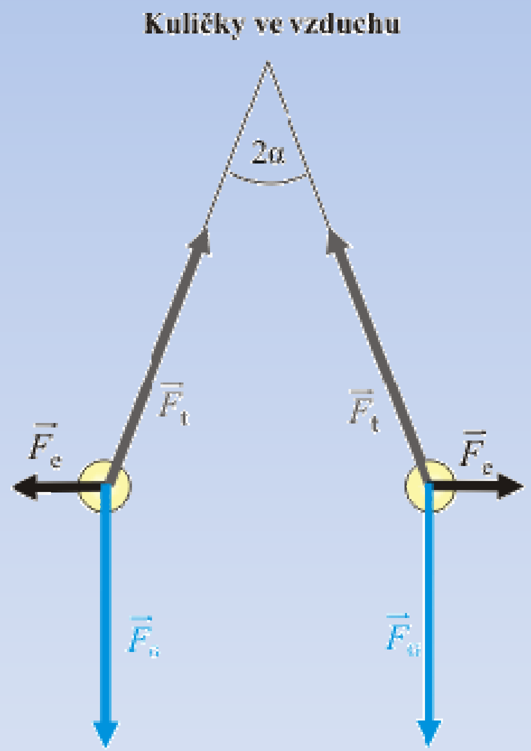
- We hang the glass balls on the two tight cords (about 1 cm apart)
- The cords are connected to the poles (ends) of piezoelectric gas lighter
- Switching the lighter on (U ~ 10 kV) we observe…

Christmas glass balls experiment

Some more details…

- We can easily determinate the size (r ~ 2 cm) and the mass (m ~ 5 g) of the balls
- We can estimate the force needed to deviate the ball (for the length l ~ 20 cm and the angle α ~ 2.5° we obtain F ~ 2.5 mN)
- From the Coulomb's law we derive the charge of each ball, $q \sim 10^{-8}$ C

More complex problem: two balls on a thread immersed in benzene



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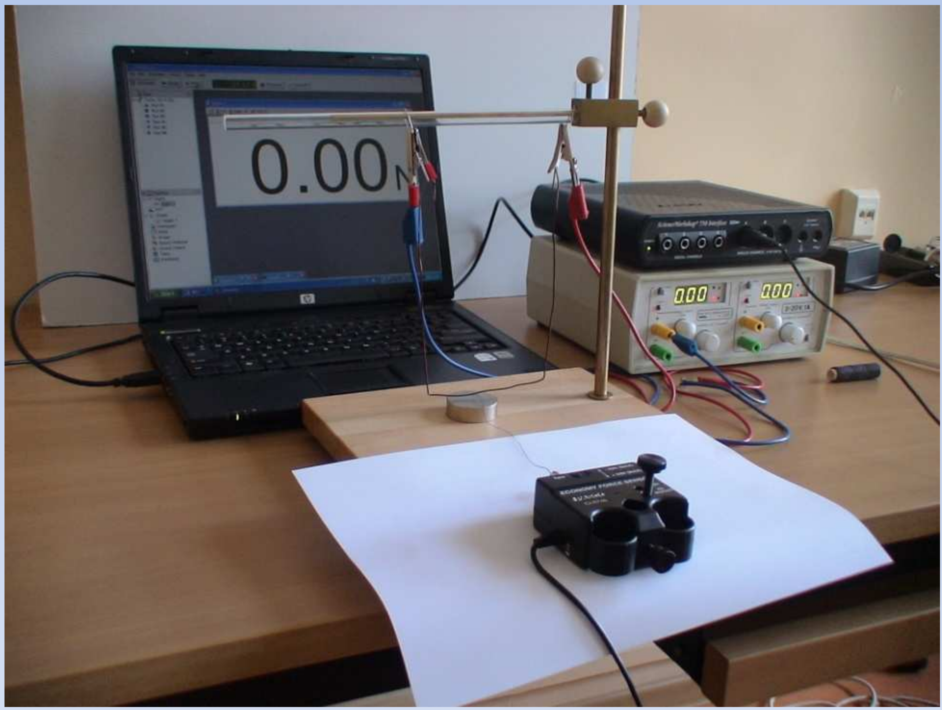
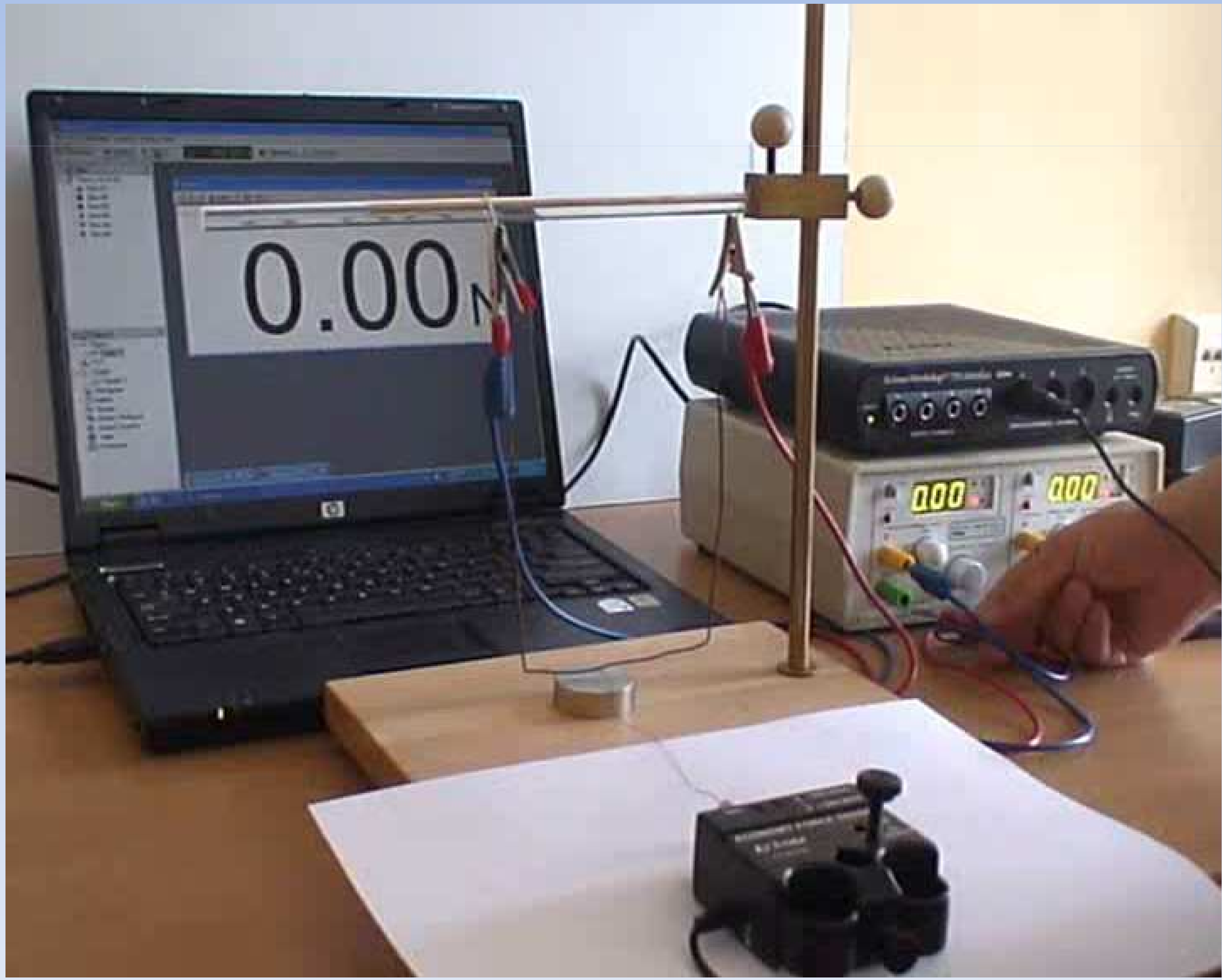
- Solving the problem after seeing the experiment is much easier and (hopefully) more interesting

The interaction of a magnetic-dipole coil with the static magnetic field

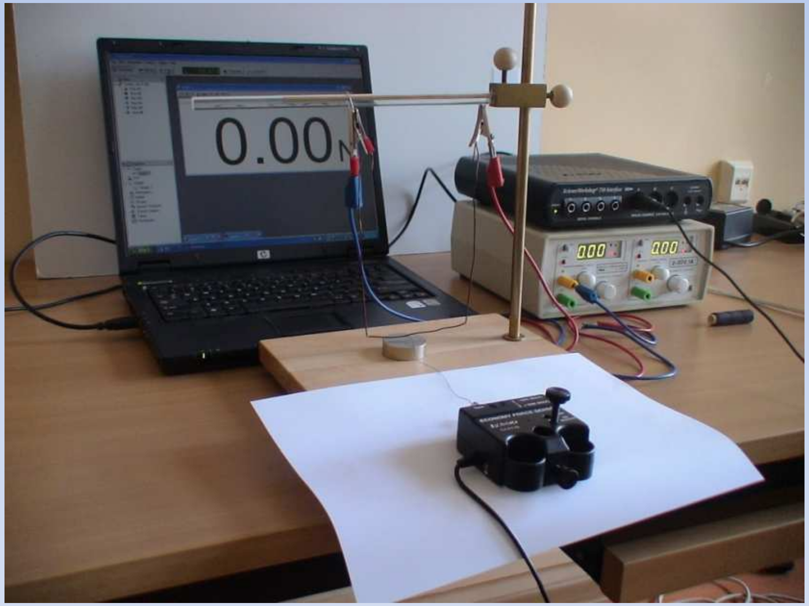


- Usually this experiment is done with a long dipole magnet
- We perform it using a big neodymium magnet
- Using the PASCO force sensor we can measure the interaction force…

The interaction of a magnetic-dipole coil with the static magnetic field

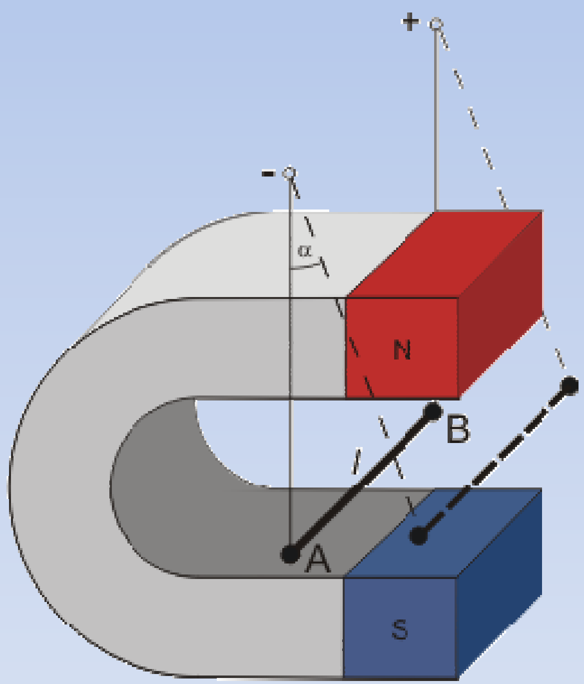


Some more details…



- For the current I = 1 A we have measured F = 0.01 N
- Putting the length of a conductor l = 0.1 m we can estimate the magnetic induction B ~ 0.1 T

More complex problem: current-carrying wire in a magnetic field



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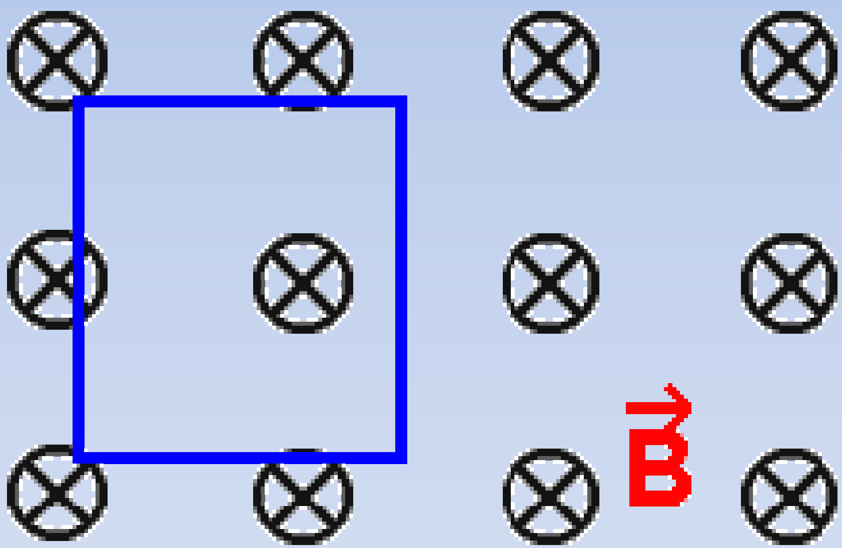
- Again, solving the problem after seeing the experiment is much easier and more challenging

A single loop receding from a wire

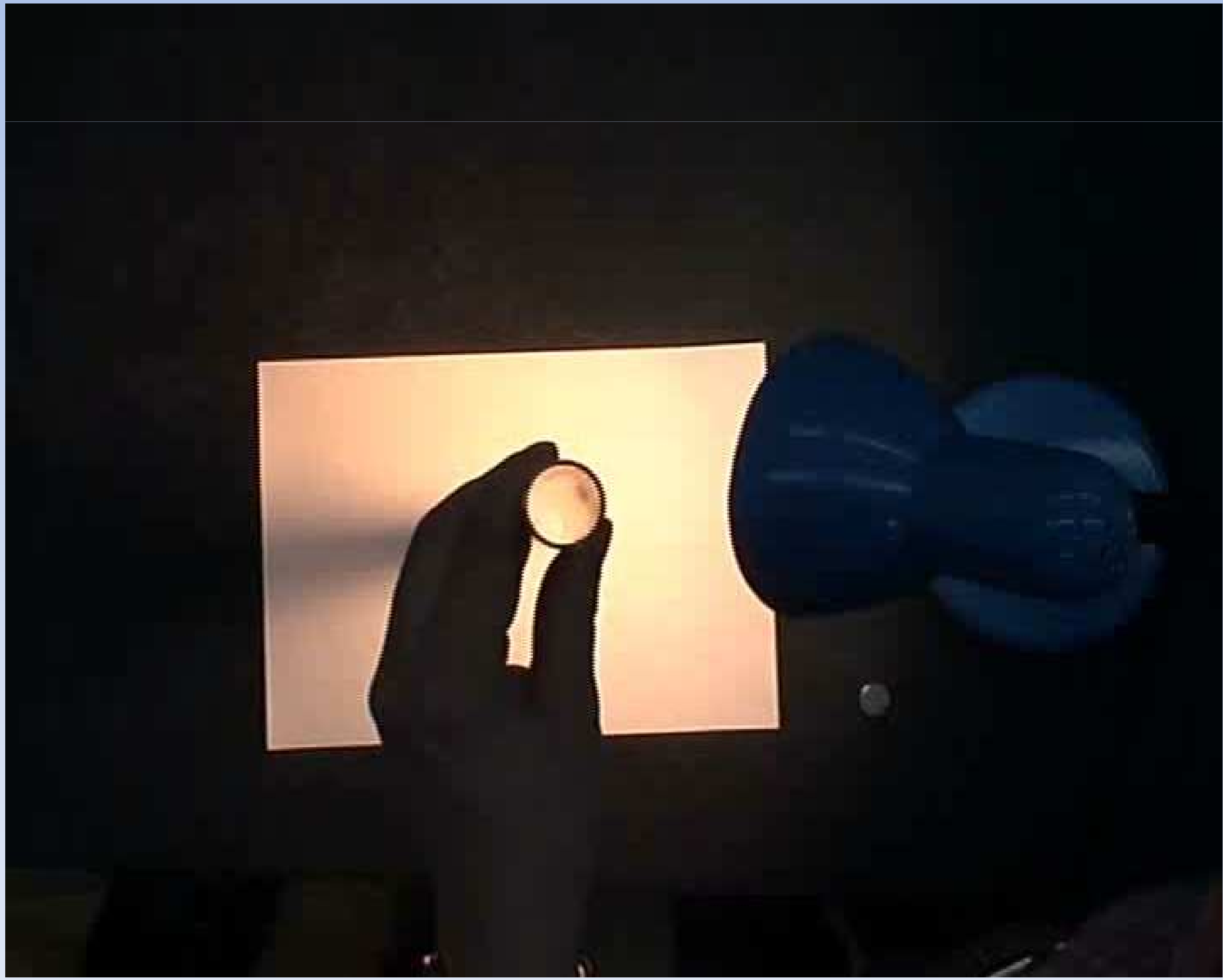


- Aplet introducing the problem
- The solved problem as an example

The fall of neodymium magnet inside a copper tube

- In this experiment the fall time is easy to be measured (see below)
- In order to calculate it, some assumptions on the geometry of the experiment (the thickness of wall tube, the tube diameter, electrical conductivity of copper) are needed

The fall of neodymium magnet inside a copper tube



The solution of the problem

This simple experiment can be used by requiring students to predict trends from limited evidence – see the paper of Gren Ireson and John Twidle „Magnetic braking revisited: activities for the undergraduate laboratory" (2008), *European Journal of Physics*, **29**, 745

More materials on EM: http://dydaktyka.fizyka.umk.pl/TPSS

- EM multimedia textbook
- Interactive applets
- Experiments (using experimental set)
- Lessons' scenarios
- Presentations

Summary and conclusions

- We have showed only some examples of the interaction between the theory and practice
- The two-direction interaction is highly stimulating: the experiment can enrich didactical aspects of solving EM problems and results of calculations can indicate the feasibility of didactical experiments

References

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