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MAGNETIC FIELD MEASUREMENTS INVOLVED IN TEACHING OF ELECTROMAGNETISM

Jozefa Červeňová* — Branislav Korenko* — Jozef Jasenek*

In the article brief description of teaching experience in laboratory measurements of magnetic and electromagnetic phenomena is given. We describe also some solution methods of related theoretical tasks solved analytically and numerically in undergraduate study programmes at FEI STU Bratislava.

Keywords: magnetic field, electric field, measurement, Moodle, numerical solution, analytical solution

1 INTRODUCTION

The main research topics at the Department of Electromagnetic Theory of the Institute of Electrical Engineering except others are magnetic materials and magnetic measurements, other course of study are also optical fibers and sensors. We involve these topics also in education of students and users of electromagnetic technique in teaching subjects concerned electromagnetic theory. At present time when the new research results and technologies in the world are rapidly transferred into practical life the electrical engineering education has to adjust the learning methods of basic principles and methods of electromagnetic theory to new requirements. Its basic role is to give the students reliable and deep understanding of basic principles of electromagnetism. It is necessary for easier realization of future upgrading of the students acquired qualifications to new rapidly changing knowledge and technologies. In this article we analyse and briefly describe the experience gained in adjusting the teaching technologies in the above mentioned fields.

2 MEASUREMENT EXPERIMENTS

Several measurement experiments assembled in teaching laboratories explain essential principles of electromagnetic field. Practical traditional laboratory experiments enable students the verification of knowledge received from lectures and help students to obtain practical experience. This access to teaching this way is very respected by teachers in our department.

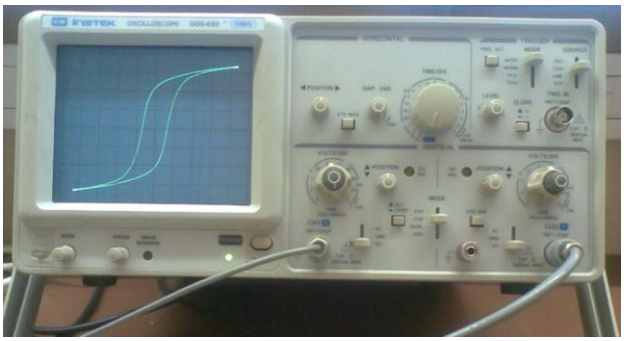

Fig. 1. Hysteresis loop

Experiments going in static fields deal *eg*. with shielding of workplaces, experiments going in dynamic fields deal with verifying of Biot-Savart law (see Fig. 3), dynamic magnetic field, electromagnetic and magnetic skin-effect (see Fig. 2). From material properties ferromagnetic materials permeability frequency dependence is measured and dynamic magnetization characteristics of ferromagnetic materials are measured (see Fig. 1). Students compare measured values with theoretical values which they calculate by in theory given formulas. As an example the working place for measurement of magnetic shielding properties of ferromagnetic materials is in Fig. 5.

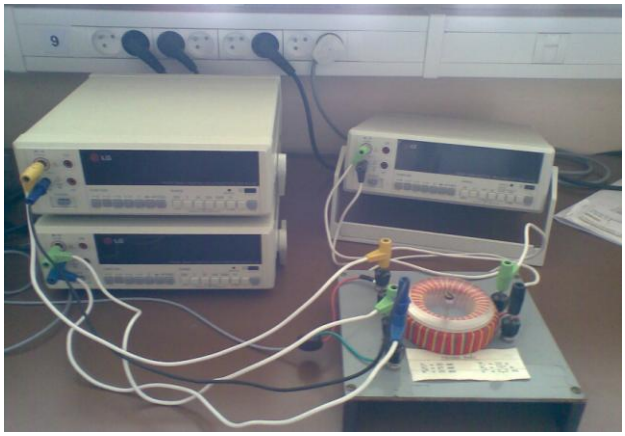

Fig. 2. Measurement of magnetic skineffect

3 NUMERICAL AND ANALYTICAL SOLUTION

One interesting part in the train of topics is numerical solution of electromagnetic field phenomena. In this part of their work students enhance their computational skills especially in the methods of simulation of rather simple static, stationary and also dynamical electromagnetic fields. The computations are performed in software system MATLAB. We also use its open-source alternative Octave.

Students have used MATLAB in their previous study subjects and now by studying electromagnetic theory they can concentrate to physical base of the solved problems, not so much to programming problems.

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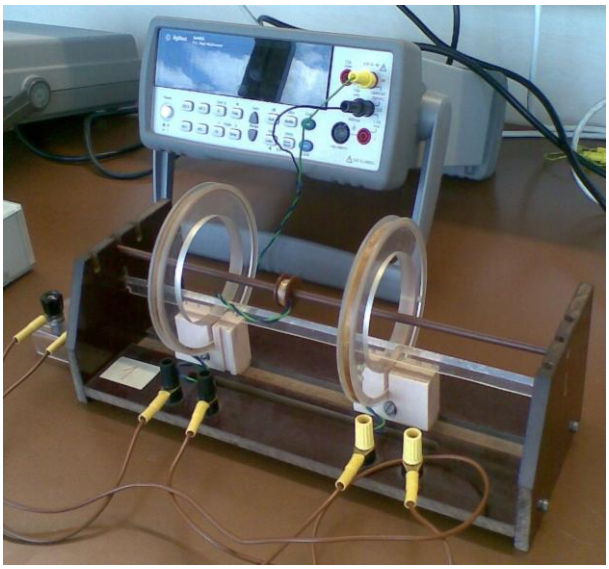

Fig. 3. Coils for verifying of Biot-Savart law

Fig. 5. Coils in Helmholtz position verifying of magnetic shielding properties of magnetic materials

In numerical methods students become acquainted with various methods of Laplace and Poisson equation solution, which they program in MATLAB. [1,2] One example of computed magnetic field in transformer sheet by method of finite elements is given in Fig. 4.

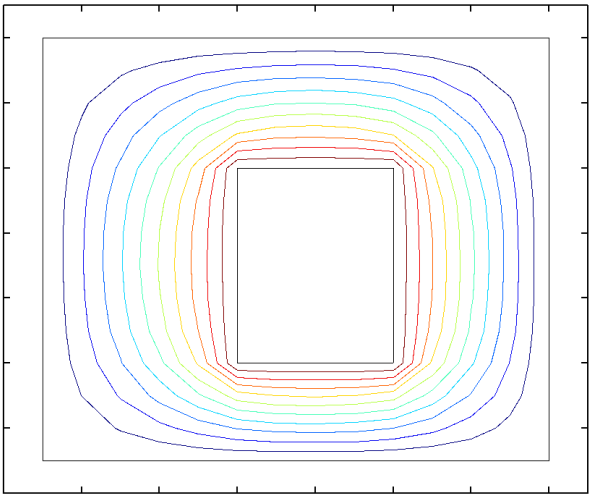

Fig. 4. Magnetic field in transformer sheet

The presentation form of the numerical solutions outputs is left to students. They like it and the results are sometimes shaped in very creative way.

Traditional analytical solutions of electromagnetic problems are taught besides of numerical methods. Students get to know the limits of analytic problem solutions and the limits of numerical solutions. [3,4]

4 E-COURSE

We prepared an application of e-learning methods in teaching and learning of electromagnetic fields in several study programmes. Face-to-face lectures and exercises at our faculty are supported by electronic courses built on an educational portal “eLearn Central”, which is available for more departments at the Faculty of Electrical Engineering and Information Technology. [5] This project uses Moodle as learning management system. We created course named “Electromagnetic fields”, in which one substantial part is devoted to magnetic field.

These electronic courses are located on the central server of the FEI STU on the following link: http://www.elearn.elf.stuba.sk/moodle/

At our department we created the course “Electromagnetic fields” by which the quality of the traditional teaching methods is enhanced and it creates better conditions for students as a supplement of the face-to-face education.

The courses include theoretical explanations of the topics, laboratory experiments, computational tasks, tests and glossaries. The courses meet requirements to fit together theoretical knowledge and practical skills. It provides the basic and extended knowledge of physical principles of electromagnetic waves in different environments.

The basic knowledge of physical principles of electromagetic waves spreading leads to better understanding of applying them in development of electronic devices and transmission systems.

The first version of the course is written in Slovak language. One of the next steps will be also creation of English version of the course.

The computer skills of students acquired before attending our courses are very good. This is a great advantage in student‘s learning process. MATLAB enables continual extension of these skills using more computational areas in study of measured physical phenomena. [6] The electronic courses are also a good base for teamwork. Students are given tasks for individual solving or for work in small groups. It is more useful by our opinion to give slightly more tasks than whole explanations.

Side-effect of the electromagnetic course study is improving students MATLAB skills, what is very attractive, because MATLAB became a standard in technical world of computation.

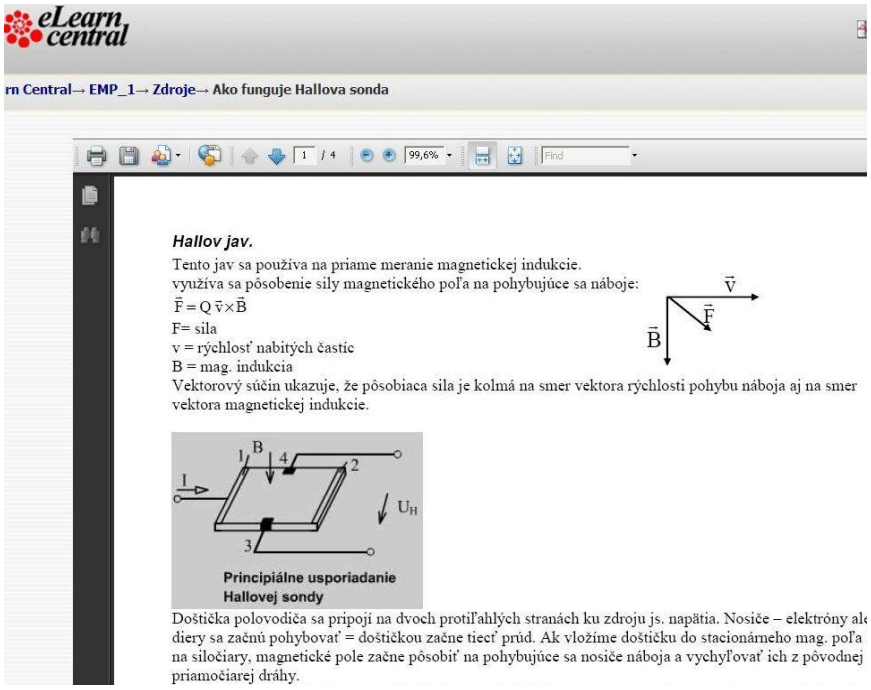

Fig. 6. Fragment of the e-course

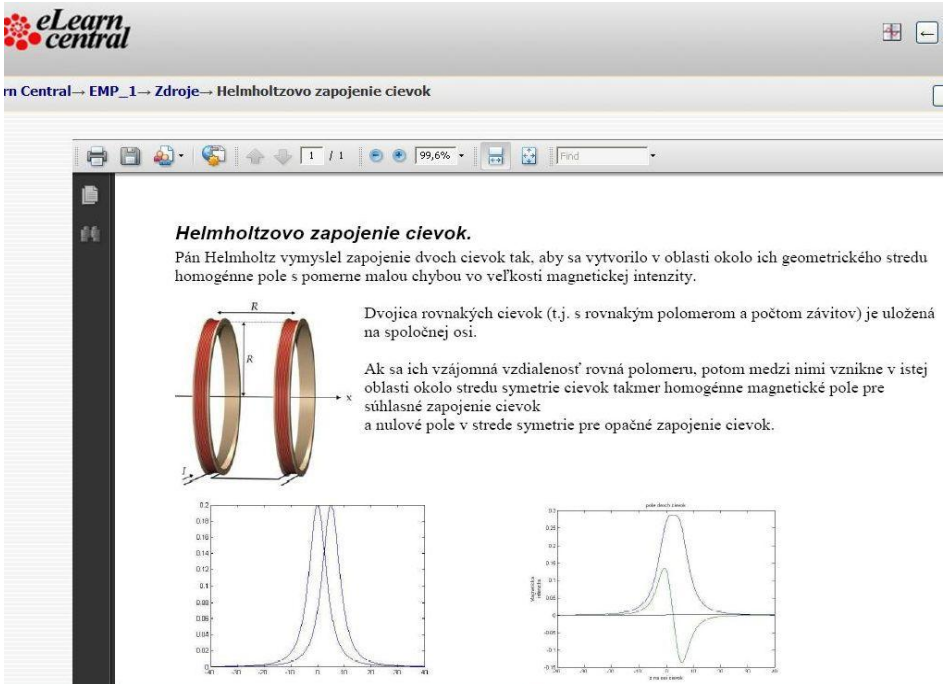

Fig. 7. View of the course as seen by the teacher

Brief description of teaching e-Learning methodology used in our institute is illustrated on a few cases concerning the magnetic field simulation, which will be given in the next parts.

Fraction of the explanation of one part of laboratory measurement task in this course is shown in Fig. 6.

In Figure 7 there is shown another screenshot of the Moodle page for the subject discussed above (both are represented as if user is logged as a teacher). In Figure 9 there is a screenshot of the Moodle page for the subject Electromagnetic waves connected with the topic discussed above. The course made as a whole is divided into thematic blocks, but in the beginning of every semester the division is changed to up-to-date version, what is one taken advantage of the offered design features of LMS Moodle. This used week division enables better orientation in the course of running tasks for students.

Educational texts are given in different formats, primarily PDF and HTML, for quicker actualization and in the same time for better compatibility with other e-Learning platforms.

5 THEORY AND PRACTICE

Teaching of subjects dealing with electromagnetic theory gives great platform not only for theory knowledge, but also for understanding how to explore theoretical principles.

Understanding of basic principles is served by small demonstrations, which can refer to the possibility of using these phenomena in practical objects. One of these experiments is a levitating sphere –"Kneppo's sphere". It was designed and constructed by our former department founder prof. Ľudovít Kneppo and it is used for demonstration of magnetic field levitation capabilities. The explanation of levitation of bodies in electromagnetic field can lead to understanding of hovercraft utilization. The levitating "Kneppo's sphere" is shown in the Fig. 8.

Fig. 8. Levitating „Kneppo's sphere"

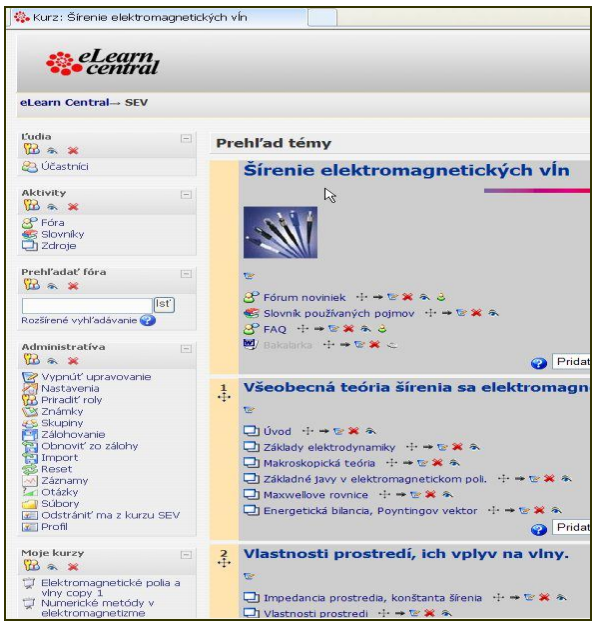

Fig. 9. **Fraction of the course Electromagnetic waves**

6 CONCLUSION

The complete chain of teaching of electromagnetism in our institute comprises several subjects (Electromagnetic fields, Modelling of Electromagnetic Fields, Numerical Methods in Electromagnetism, Electromagnetic Fields and Waves) and is a complex of theoretical base, solving theoretical problems by analytical and numerical methods and series of laboratory experiments. Not every student attends lectures in every subject, it depends on his study program. We decided to offer to interested persons e-Learning course satisfying the requirements of combination of knowledge in taught subjects at our institute. By using the combination of offered learning methods everybody interested in the topic will be capable to increase his/her qualification in permanently needed qualification steps.

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REFERENCES

[1] BONDERSON, A. — RYLANDER, T. — INGELSTROM, P.: Computational Electromagnetics, Berlin, Germany, Springer 2005, ISBN 0-387-26160-5

[2] NOVOTNÝ, K. — ŠKVOR, Z. — MAZÁNEK, M. — PECHAČ, P.: Numerical Methods of Electromagnetic Fields,. Praha ČVUT, 2005 (Numerické metody elektromagnetizmu in Czech)

[3] IDA, N.: Engineering Electromagnetics,. 2nd Edition 2003, ISBN 978-0-387-20156-6.

[4] RILEY, K. F. — HOBBSON, M. P. — BENCE S. J.: Mathematical Methods for PHYSICS and ENGINEERING, 3rd Edition, Cambridge, University Press, ISBN 13-978-0-521-67971-8

[5] STUCHLÍKOVÁ, Ľ.: How to Enjoy Acquiring Knowledge? In ICETA 2010, ISBN 978-80-8086-166-7. pp. 73 – 78.

[5] KRÁLIKOVÁ, E. — ONDRÁŠOVÁ, I.: Blended Learning in Measurement Information Systems. In: Nové technologie ve výuce, PedF MU Brno, 2011.

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