Hands-on and Virtual Labs for Juniors' Course on Applied Electromagnetics

Dr. Vladimir Mitin, University at Buffalo, SUNY

Dr. VLADIMIR V. MITIN, SUNY Distinguished Professor, Department of Electrical Engineering; University at Buffalo, SUNY, Buffalo, NY. Has more than 400 technical publications.

Vladimir Mitin has made considerable efforts to involve undergraduate and graduate students in his research. • He has established a state-of-the-art research laboratory: Materials, Device and Circuit Simulations Laboratory. • He graduated thirteen Ph.D. students and six MS students. He has taught Electromagnetic Fields and Waves for engineers five times. He has revised and developed several other courses and disseminated these developments via textbooks: • the course Solid State Electronics (I) has been developed into a textbook "Introduction to Solid State Electronics" (Addison-Wesley Publishing Company, 1996); • the textbook "Quantum Heterostructures for Microelectronics and Optoelectronics" (Cambridge University Press, 1999) has been prepared for Advanced Solid State Electronics (I); • the textbook "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications" (Cambridge University Press, 2008) has been written with two co-authors during the development of a new course for undergraduate students.

Current graduate students: • Yanshu Li, from F'2012, GRA, Ph.D. Student, SUNY at Buffalo, Buffalo, NY. • Tim Yore, from S'2011, GRA, Ph.D. Student, SUNY at Buffalo, Buffalo, NY. • Guillaume Thomain, S'2011, GTA, Ph.D. Student, SUNY at Buffalo, Buffalo, NY

Total number of graduate students advised = 22. Total number of postdoctoral scholars sponsored = 11.

Prof. Athos Chariton Petrou, SUBY at Buffalo

Athos Petrou is a professor of Physics at SUNY Buffalo. His studies the magneto-optical properties of semiconductor nanostructures

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In current submission the authors report on a workshop that was organized as part of the efforts on the outreach program of the NSF/TUES funded project "Synergy of educational tools for teaching electromagnetic fields and waves: lab experiments, educational Java applets, numerical modeling, textbook with power point presentations". Professors from the College of Nanoscience and Engineering, University at Albany; Department of Electrical and Computer Engineering, Binghamton University; Department of Electrical Engineering and Computer Science, Syracuse University; and Canisius College of Buffalo, who participated in this workshop, shortly discussed the newly developed lecture/lab course on Applied Electromagnetics for juniors, but mainly concentrated on the developed lab component of the project (hands-on labs) and accompanying educational Java applets (virtual labs).

The lab component includes an introductory lab on error propagation and seven hands-on labs that cover major topics in the developed Applied Electromagnetics course: electromagnetic (EM) waves that includes polarization properties of EM waves, standing waves and double-slit interference phenomenon, EM waves at the interface between two media, EM waves in optically active media, propagation of EM waves on a transmission line, diffraction of EM waves by a periodic structure, radiation pattern of EM waves created by a dipole antenna, and modulation and demodulation of EM waves (see Figs. 1-3).

The participants of the workshop have performed hands-on and virtual labs during the first part of the day and then produced a written report with the analysis of the conducted experiments in the afternoon. Each day was closed with the discussion about the experiments and the way how to improve the developed labs.

At the end of workshop the assessment of experiments and accompanying applets was done. The assessment data will be used for improvement of the newly developed course - especially for updating the hands-on as well as virtual labs.

The participants highlighted the positive effect of *synergy of educational tools*, i.e. "combined action" of the two types of labs on the students' learning style: virtual experiments generate thought-provoking examples and data for student's analysis, help to understand new concepts and notions, and follow-up hands-on experiments give enhance students' experimental skills which cannot be achieved carrying out only virtual experiments. From three modes of combining hands-on and virtual experiments the mode when first virtual labs are used for acquiring new theoretical concepts and notions and after this hands-on experiments are carried out is the most optimal. They also highlighted the importance of virtual labs especially when you are teaching for an audience more than 100 undergraduate students.

The participants of the workshop intend to adopt most of studied labs is their respective institutions.

Fig. 1. Lab manual for the experiments developed for the Applied Electromagnetics course.

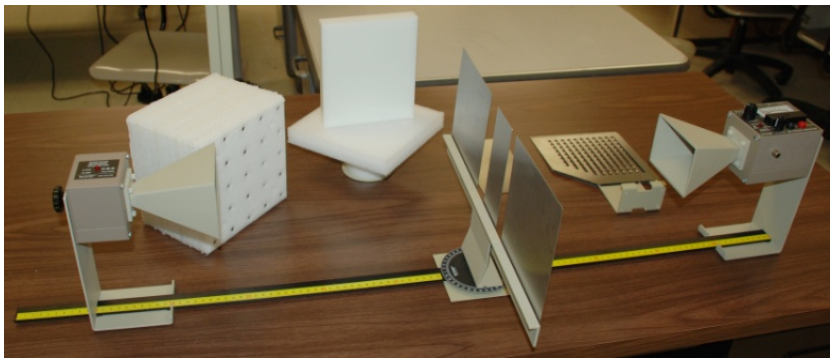

Fig. 2. Experimental setup for study of: polarization properties of EM waves, diffraction of EM waves by a periodic structure, and double-slit interference phenomenon.

Fig. 3. Students working with experimental setup for study of EM wave propagation on a transmission line.