Invited Paper

Optoelectronics Curricula

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ABSTRACT

The recommendations of a group of 36 university and industrial researchers, who met in a 3-day workshop in July 1990, are reported. The workshop addressed the question of what optoelectronics topics should be in Electrical Engineering, Physics, and Photonics curricula.

1. BACKGROUND

For several years, there has been work on optics and photonics curricula, and on the question of what optics-related topics should be included in electrical engineering and physics curricula. Others have considered what new courses should be initiated and what should be the content of those new courses. After a discussion of the possibility of a workshop to get several people together to discuss these issues, the workshop was endorsed by OSA and IEEE LEOS, and funded by several groups. The workshop was held in Estes Park, Colorado.

This workshop restricted itself to discussions of undergraduate curricula. For detailed discussions, the group split into three subgroups. One group discussed what optoelectronics or photonics topics should be in current electrical engineering courses, what new courses should be considered, and how to best implement the suggestions. A second group addressed the same questions in relation to the physics curriculum. A third group considered several current undergraduate programs in optics, optoelectronics, and photonics; and then came up with a suggested curriculum for a program in photonics that could be offered in electrical engineering, physics, or optics departments. The three groups worked independently but reported to the group as a whole to discuss their progress. The workshop participants are listed in the appendix.

2. ELECTRICAL ENGINEERING

Recommendations were made concerning the EE core courses and electives in photonics with the question in mind, "What should all electrical engineers know about photonics?" In the core electromagnetics course, the suggestion was to start with Maxwell's equations and reduce the discussion of static fields. In the

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place of much of the electrostatics, the group recommended that topics such as dielectric waveguides, polarization, and diffraction be added. The group suggested that it would be relatively easy to incorporate the concepts of two-dimensional linear systems, and perhaps that of spatial frequencies, into the linear systems course. The students of linear systems should be taught that the theory developed applies to spatial functions as well as temporal functions. In the semiconductor courses, the inclusion of light emitting diodes, laser diodes, and photo diodes should be added to the discussion of diodes. The design of laser drivers and the topics of photodetectors and preamplifiers should be incorporated into the electronics courses. In the communications course, a discussion of optical modulators, optical receivers, and optical fibers would enhance the course.

The group believed that demonstrations using lasers could convey many of the concepts and stimulate interest in several courses. For example, demonstrations of Fourier transformation, polarization, reflection, diffraction, interference, the critical angle, Brewster's angle, and mode guiding, which are easily done, could be used.

Elective courses include: Optics for Electrical Engineers; Optical Electronics; Fourier Optics; Optical Communications; Integrated Optics; Lasers; and Photonics Laboratory.

3. PHYSICS

The group that considered the Physics curriculum recommended that fields and waves be used as a unifying and organizing concept in physics and that optics be used to illustrate the concepts. The introductory general physics sequence should be updated and improved. Much of the electrostatics and magnetostatics should be eliminated and fields and waves should be emphasized as a unifying concept. More laser-based demonstrations and computer simulations should be used to impart the concepts. Similar recommendations apply to the electromagnetic theory course where the topic of dispersive media could be included. In the solid-state physics courses, the discussion of p-n junctions should be expanded to include semiconductor lasers and semiconductor detectors. Statistical and thermal physics should treat classical noise, 1/f noise, quantum noise, and photon statistics. The quantum mechanics course should cover stimulated emission, lasing, and quantum well devices. A nonlinear dynamics course could include laboratory experiments on chaos in lasers and the theory of solitons, along with experiments and simulations. A course in computational physics should include numerical simulation of Maxwell's equations and simulations showing fiber modes.

A senior laboratory course should include optical pumping, spectroscopy, Fabry-Perot experiments, interferometry, diffraction, and holography.

4. PHOTONICS

In addition to updating and modernizing electrical engineering and physics curricula, there is a need for an academic program in photonics. This should combine elements of electrical engineering and physics with an emphasis on modern optics. The suggested curriculum consists of core and elective courses. The recommended core courses include basic courses such as general physics, mathematics through Fourier analysis and probability, and introduction to computing. The electrical engineering core courses include an introduction to circuits, logic and digital systems, signals and systems, stochastic processes, and semiconductor devices. The physics core includes quantum mechanics, electromagnetism, and solid state physics. The optoelectronics core courses include an introduction to photonics, geometrical optics, physical optics, lasers, guided-wave and fiber optics, and optical detectors and modulators. Elective courses cover optical communications, holography, integrated optics, optical computing, and signal processing.

5. IMPLEMENTATION

Several steps are being taken to implement the recommendations. Discussion of the report in groups such as here is one. A special issue of the IEEE Transactions on Education is to be devoted to optoelectronics education. The Optical Society of America has a program to make available optics laboratory experiments. The National Science Foundation has a program to help develop optoelectronic courses.

Incorporation of photonics concepts and principles into core courses is an essential step in introducing students to photonics and attracting them into elective courses and research projects in this area. To accomplish this, faculty teaching the core courses must have assistance to entice them to include the photonics material. The assistance may take any of the following forms:

Prepared instruction modules including lectures,worked homework problems, and sample examinations;Class demonstration kits to support physical principles;Visual aids, such as slides, video tapes, and transparencies to support and enhance the instruction modules and demonstrations; Guest lecturers from the photonics academic, governmental, and industrial communities; Student tours of photonics industries and research laboratories.

Sets of solved homework solutions and lecture modules could be provided by researchers in the field. Industry could play an important role by providing grants, equipment donations, and guest lecturers. Industries can hold open houses with demonstrations; present talks and demonstrations; hold job fairs; and display photonics exhibits at appropriate campus locations. Donations of new and used equipment are excellent sources of support. New equipment for undergraduate laboratories is particularly important because it provides students with the opportunity for laboratory experience and exposes them to the latest technology and instrumentation. Other organizations, such as the National Electronics Association, could help.

Student chapters of appropriate professional groups (such as SPIE, OSA, and IEEE LEOS) can provide outside speakers on photonics to broaden the perspective of the students.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

The complete text of the workshop report is available: W.T. Cathey, J. Palais, J. Boero, and C. Cantrell, *Report of the Workshop on Optoelectronics Education*, Optical Society of America, Washington, D.C., 1990.

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