The Necessity for Acoustics in the Biomedical Engineering Program

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Abstract: Undergraduate and graduate students in biomedical engineering programs need to gain better understanding of acoustical physics, the effects of sound and ultrasound on living organisms, the principles of measurements, imaging processes, and data analysis concepts. Laboratory experience is essential, and practical experience in a teaching medical hospital would definitely be salutary.

INTRODUCTION

Biomedical engineering constitutes the fastest growing segment of all engineering fields. In order to effectively deal with a wide variety of engineering problems, the biomedical engineer needs to be a "jack of all trades" insofar that he or she should be able to meet challenging problems in mechanics, electronics, thermal analyses, fluid mechanics, materials, manufacturing techniques, etc. In the medical field, acoustics (particularly ultrasound) is used for both diagnostic and therapeutic purposes; and new devices are continuously being developed to provide better diagnostic imaging or more effective therapy. As a part of the biomedical engineering program, undergraduate and graduate students need to gain better understanding of acoustical physics, the effects of sound and ultrasound on living organisms, and the principles of measurements, imaging processes, and data analysis. Laboratory experience is essential, and practical experience in a teaching medical hospital would definitely be salutary. The time constraint imposed by a four-year undergraduate program, which also needs to meet ABET criteria, effectively limits the exploratory scope; and it follows that additional, more intensive training may be better achieved through post-baccalaureate (master's degree and doctoral levels) programs.

THE UNDERGRADUATE PROGRAM

The first two years of the undergraduate engineering program is fairly common for all engineering students, regardless of the field of engineering. Calculus, advanced physics (entailing the use of calculus), chemistry, computer science, and introduction to engineering design make up the bulk of the first two years of the customary four-year program. Non-technical courses are expected to be included, particularly those emphasizing language and expository skills. Economics, history and social sciences constitute other non-technical courses which may be taken during the latter two years of the undergraduate program. Very little remains of the undergraduate students' time for electives. Because of this, the bioengineering element needs to be incorporated into certain courses---for example, blood flow can be dealt with in a fluid mechanics course, more emphasis on transducers can be incorporated into an introductory electronics course for non-electronics majors. The elements of skeletal structure can be broached in a mechanics course. Unless the engineering undergraduate curriculum is expanded to include a fifth year on a national scale, there appears to be hardly any room for more than one or two specialized elective courses in the extremely busy undergraduate program that is subject to meeting ABET criteria. If such programs are available, they should be configured so that a student from any engineering discipline can qualify on the basis of the prerequisites fairly common to all of the disciplines. Acoustics can be taught as a separate course open to junior and senior engineering majors. To ensure the breadth and depth of coverage, fundamentals need to be taught thoroughly: wave equations for fluids, e.g., should be derived from fluid dynamic equations of continuity, momentum and energy and thermodynamic considerations; the effect of sound on materials and vice versa, measurement techniques combined with laboratory experience, the
The physiology of hearing, the impact of sound on humans from the viewpoint of physiology and psychoacoustics all need to be included. The oft-required senior design course provides an opportunity for a student to get involved in biomedical instrumentation engineering.

THE GRADUATE PROGRAM

The graduate program provides far more opportunity for concentration on biomedical engineering, which essentially is a very versatile field, one that entails knowledge of mechanics, electronics, solids and fluids, mass transfer, bioheat transfer, biomaterials, effects of radiation, and medical imaging (1). Acoustics plays an important role as a diagnostic and therapeutic tool. Frequency ranges of interest begin with infrasonic values and extend into the MHz region. At least two graduate acoustics courses would be essential to developing biomedical engineering expertise—one course would deal with the deeper aspects of sound propagation, laboratory and clinical generation, measurement and evaluation of sound, transducer theory, selection and deployment of transducers, and bioacoustics. A second course concentrates on the physics and applications of ultrasonic sound—this entails relaxation effects, the piezoelectricity, magnetostrictivity and other ultrasound generating techniques, design of transducer arrays, the physics of high-intensity propagation, and imaging tomography. A third course can be dedicated to transducers and instrumentation.

WHY KNOWLEDGE OF ACOUSTICS NEEDS TO BE INCORPORATED

A considerable number of medical devices are in use that are based on acoustical principles. The plaque remover in a dentist’s office combines a water jet stream with a 25-kHz acoustic input, ultrasound cleaners are commonly used in dental and medical offices, fetal monitoring and echocardiography entail ultrasonic scanning, ultrasound can heat and soothe sore muscles, and the Doppler ultrasound method is applied to gauge and map blood flow in a noninvasive manner, beam of ultrasound can aid in pulverizing kidney stones, and new ultrasonic surgical knives help to minimize bleeding. Researchers at the NYU Medical Center are experimenting with ultrasonic devices to treat various types of skin cancers; and recent work by Raichel and Hirsch (2) suggested that blood constitutivity can be quickly gauged through the use of ultrasound. It is apparent that much yet remains to be done in using sound (in addition to the obvious use of hearing aids and audiometric devices) in diagnostic and therapeutic tools.

THE IMPORTANCE OF WORKING WITH TEACHING MEDICAL CENTERS

Little can be gained from any graduate biomedical engineering program, particularly on the doctoral level, without linkage to a teaching medical center, which can provide the facilities, cooperating medical personnel, and patients. A doctoral dissertation project normally necessitates mentors from a medical faculty as well as those from the engineering school. The biomedical engineering program at the City University of New York is administrated by the Center for Biomedical Engineering (CBE), a CUNY institute which is a consortium of the School of Engineering at City College, the CUNY Medical Schools, the Hospital for Joint Diseases/NYU Medical School, and the Hospital for Special Surgery/Cornell University Medical College. This consortium provides graduate students with access to a diverse faculty of more than 35 researchers. The biomedical engineering concentration is thus both interinstitutional and interdepartmental in nature, with the faculty drawn from the consortium and from the departments of chemical engineering, electrical engineering and mechanical engineering.

REFERENCES
