A Cardiovascular Engineering Training Program

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ABSTRACT

To meet a need for bioengineering training programs designed for life scientists The University of Nebraska has initiated a Cardiovascular Engineering Training Program.

I. INTRODUCTION

Bioengineering is a multidisciplinary field which is in a process of continuing evolution. The existen of bioengineering has been definitely established as evidenced by the number of journals published, the number of societies formed, and the number of conferences which are held. There seems to be agreement on what bioengineering, in general, involves even though it is difficult to formulate a concise definition of bioengineering1 (regardless of whether it is called bio-medical engineering, or one of the other names used).

A bioengineer is not identified by his college degrees or by his professional license, but by his participation in bioengineering activities. Medical doctors have been identified with medical electronics and bioengineering since the formation of the I R E Professional Group on Medical Electronics.

Bioengineering Conferences were held as early as 1960 2, 3. One problem which continues to receive considerable attention is the problem of bioengineering education. Most bioengineering curricula are graduate level and are designed for engineers, physicists, or people who have considerable background in the physical sciences 4. The prerequisites are such that the equivalent of a bachelor degree in engineering or the physical sciences is usually required. Those who have a degree in the life sciences must take many prerequisite courses in mathematics, engineering, and the physical sciences. Since these courses must be taken in sequence, those with life science background find that the time required makes many of the bioengineering training programs prohibitive.

It is no longer necessary for research groups to design and construct most of their own research equipment. Comercially manufactured units are available for use in instrumentation systems. Hence, more bioengineering effort has shifted to research on the living systems and to education.

The need for bioengineering training for life scientists is continuing to increase in many specialties within the life sciences. Life scientists have traditionally studied living systems. System engineering concepts and models which are so useful to engineers are equally useful to life scientists. In particular, cardiovascular research involves increasing quantification and higher levels of sophistication in the application of engineering system concepts.

In a recent address, Perkins 5 pointed out that the medical scientist will probably take over some of the living system engineering problems. The engineers will then move on to new problems which include education. Engineering educators have an opportunity for performing a service by offering courses especially designed for life (and medical) scientists. One of the educational problems involves the fact that many present-day life scientists do not receive the background required for graduate level engineering system courses. A one-year, intensive training program in engineering system concepts and analysis for life scientists was designed to meet some of the needs. A proposal was submitted to the Heart Institute of the National Institutes of Health by The University of Nebraska. This program was funded and initiated on July 5, 1965.

II. CARDIOVASCULAR ENGINEERING TRAINING PROGRAM

The training program was designed for pre and post-doctoral researchers on the assumption that the trainees would have no more background in mathematics and the physical sciences than the average medical student. The first consideration was to provide the additional required prerequisites in the shortest possible time. The goal of the training program is not to make engineers of the life scientists but rather to better train the life scientists for research. This suggests that the emphasis should be placed on fundamental concepts rather than on the manipulative skills which are required in the solution of engineering design problems.

The one-year training program begins in July with a nine-week summmer session which includes the following courses:

1. **Mathematics**: This is an intensive course beginning with a brief review of trigonometry followed by analytical geometry, differential calculus, and integral calculum. In addition, an introduction to Laplace Transform is taught in parallel during the last four weeks of the summer.

2. **Physical Principles**: This course begins with units and definitions and proceeds through topics covering models of the atom, conduction phenomena, electron emission, semi-conductors, P - N junctions, and diodes.

3. **Electrical Circuit Analysis**: This is an introductory course which includes the major topics from the first two regular electrical engineering courses. Includes laboratory.

The summer session may appear to be rather formidable, but considerable effort is made to have the courses complement each other. Instructors work very closely together so that, for example, the concepts introduced in the mathematics courses are applied in the engineering courses. This is one of the significant features of the program.

The post-doctoral researcher will ususally be unable to spend more than one calendar year in a training program, so the time limit and the desired levels of attainment were the major considerations in the design of the program.

The fall semester involves the following courses. The first three are undergraduate engineering level and do not count toward a graduate engineering degree.

1. **Instrumentation:** Electronic instrumentation systems for biological research. Includes laboratory.

2. Electronic Circuits: The emphasis is on circuit representations for electronic control devices and circuit applications such as amplifiers. Includes laboratory.

3. **Electromagnetic Fields and Waves:** This is an introduction to electromagnetic fields using vector representations and in introduction to traveling wave phenomena.

The following fall semester courses are the level of senior elective courses and may be applied toward a graduate degree in electrical engineering:

4. **Linear Systems:** The study of electrical and mechanical systems using transform methods.

5. **Probability and Statistics:** This is an introduction to probability and statistical methods applied to engineering problems.

6. **Bioengineering Seminar:** This meets weekly with lectures given by outside experts, staff, and participating graduate students.

The spring semester courses are all senior level or graduate level. The course on Information and Signals does not apply toward a graduate electrical engineering degree because it is required for the B.S. degree. The spring courses are as follows:

1. **Advanced Control Systems:** A graduate level course covering the analysis and synthesis of control systems.

2. **Information and Signals:** This is a senior level course best described by listing the text: **Information Transmission, Modulation, and Noise** by Schwartz.

3. **Analog Computer Circuits:** Basic design and operation on analog computers and analog simulation. This is a senior level course carrying graduate credit.

4. **Digital Computers:** This is a senior level course which includes programming but the main emphasis is on numerical analysis using digital computers.

5. **Communication Theory:** This is a graduate level course on stochastic processes.

6. Bioengineering Seminar: Continuation of the fall seminar.

The trainees "live" in a medical college environment so that they are in contact with other researchers who share their professional interests. The courses included in the one-year training program are all given on the medical college campus in Omaha. These are special courses so that the orientation is especially for the life scientists. At the present time, there are six instructors teaching these special courses. All have had prior experience in bioengineering.

The trainees may apply for admisison to the Graduate College and, if admitted, register for the courses included in the training program. Degree programs are incidental to the training program. If a trainee elects to work toward a graduate electrical engineering degree, he will need to complete the remaining degree course requirements by taking regular electrical engineering courses. The one-year training program is special for the trainees, but any additional work will be done as a regular electrical engineering graduate student meeting the same requirements.

Since the training program is supported by the Heart Institute of NIH, fellowship stipends are available only to those interested in the cardiovascular system. However, the courses are not limited to those receiving fellowship stipends. A post-doctoral trainee this year is an obstetrician and gynecologist who has completed his residency.

The performance of the trainees in the program has been most gratifying. A full evaluation of the success of the program will not be possible until the trainees have had an opportunity to apply their training to their research problems. However, the present indications are that the select group of research-oriented life scientists will benefit considerably. The trainees seem to comprehend the fundamental concepts.

III. CONCLUSIONS

There is a need for bioengineering training programs which are especially designed for the life scientists. The most challenging problem it to provide the prerequisite background in a minimum of time. Until the life scientists receive more background in mathematics and the physical sciences, special courses which emphasize the fundamental concepts are needed. A training program which is designed for a select group has been initiated at the Univeristy of Nebraska. The present indications are that it is quite successful.

IV. ACKNOWLEDGEMENT

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