Society and Technology for Non-Engineering Majors

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ABSTRACT

A course to introduce non-engineering students to technology and engineering is described. The course is entitled "Society and Technology" and stresses the use of digital computers in data collection, simulation, and control operations. One purpose of the course is to introduce non-engineering students to the methods, devices, and procedures of technology and engineering for reasons discussed in the paper.

Background

For many years the engineering accrediting agencies have stressed the need for engineering students to have a minimum number of courses in humanities and social studies. During the same time it has become generally agreed that a great need exists for understanding between members of society at large and members of professions embracing technology. It seems reasonable that courses in technology should be available, or even required, for the general student population if a basis for greater understanding between society and technology is to be achieved. This seems to be particularly important considering that the ratio of non-engineering students to engineering students is usually on the order of ten to one or twenty to one in most locations. It seems to make little sense to provide a "liberalizing" element in the education of five percent, say, of the student population and completely ignore such elements in the education in the remaining ninety-five percent that constitute the "liberal arts and humanities. "

This appears especially true in view of the ever-increasing importance of technology in everyday life. This basic idea is not new. The pioneering work was done by Forrester[4,5] and others [3,6,7] a number of years ago. However, this earlier work appears especially applicable at the present because of ready availability of personal computer hardware, computer software,and computer-literate students along with the evergrowing need for better understanding of technology and its methods by the general population and for the need of engineers to better communicate their work results to the general public.

Goals of the Course

One purpose of the course is to introduce non-engineering students to the methods, devices, techniques, and procedures of technology and engineering. The long-term goals of this include (1) relieving anxieties about the impact of technology upon society, (2) increasing the abilities of the general student population to make future rational judgments on the effect of technology upon society, and (3) avoiding possible irrational expectations of the ability of technology to solve all problems.

Methodology of the Course

The central elements in the methodology used are the quantitative description of systems (including those of socio-politico-economic nature) and the use of digital computers in modeling and simulating such systems. In addition, the interconnection of the computer with other physical equipment to collect data and to do control operations is demonstrated in the laboratory experiments.

Certain elements of the course touch upon the following:

(1) Measurements of physical quantities. Here the student is introduced, for the first time in some cases, to the concepts of imprecision and noise corruption in practical measurements.

(2) Input-output relationships in static, or non-dynamic, systems.

(3) Description of dynamic systems and computer methods of solutions. Depending upon the mathematical background of the students, it may be necessary to introduce the concepts of derivative and integral of a function.

(4) Feedback and its effect in physical systems. Here the students are introduced to an important method by which engineers may cause changes in the responses of systems.

(5) Feedback models of socio-politico-economic (SPE) systems. The suggestion by Wiener [1] that there is inherent feedback, measurement, communications, and control in human systems, as well as physical systems, is discussed. “Reasonable” models of certain SPE systems are elicited from the students and then put in block diagram form and, in some cases, simulated on the computer with help from the instructor as required.

(6) Probabilistic descriptions of physical and SPE systems. The concepts of non-deterministic signals and random variables are introduced. Examples occurring in SPE systems are discussed. Probability density and distribution functions are introduced and their use in decision making under uncertainty is studied with examples.

(7) Optimization of systems. Computer programs to optimize systems with performance indices of known equations in the free parameters are applied. If time permits, examples are given of methods of optimizing such systems when the performance index is available only as a result of a test.

(8) A complete project is chosen by the student reflecting his or her personal interests. In the past, this has proven to be one of the best motivational aids in the course (and perhaps the best incentive for teaching the course) .

Expected Results

Based upon previous experience, expected results from the course may include the following:

(1) Student surprises in finding that mathematics is essential to understanding and predicting the operation of physical systems, and to some extent, in foreseeing the results in the evolution of SPE systems.

(2) Increased student awareness of the need for preparation in basic mathematics and physics in relating to the surrounding world of technology.

(3) Student papers reporting projects successfully completed, and reported in society meetings with student participation.

(4) “Trickle-down” effect to high school students. In some cases, high school visits of students in this type course have resulted in attracting interest by the high school students.

(5) Increased student awareness of both the potential applications, and of the limitations, of technology.

Conclusions

(1) The general public and non-engineering students are surprised sometimes to find that problems they are able to describe verbally can also be described by basic mathematics.

(2) Both the physical and SPE systems studies demonstrate concepts that measurement, communication, and feedback can be useful in reducing sensitivity to parameter changes, increasing stability, and in reducing error. In addition, the “best” system actually attainable usually must involve compromise among these desirable features. It is demonstrated also that instability can result from improper introduction of feedback.

(3) The examples studied also show that generalization of conclusions can be made, if at all, only after repeated simulations (or

experiments) following variation of parameters, variation of probability distributions, and alteration of functional forms[2].

References

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Appendix

Example 1 A Capacity-Load Problem with Probabilistic Data

The capacity (generating ability of an electric system or load bearing ability of a structural component) is defined in terms of a probability density function after probability concepts are introduced and discussed.

The load presented to the system is defined by a second probability density function.

The probability of system failure is defined as the probability that the capacity is less than the load. The probability of failure at a specified load is computed and plotted against load.

Questions to be answered include the following: (1) How can the probability of failures be reduced? (2) Can the probability of failures be reduced to zero; that is, can failure be eliminated completely? (3) What are the consequences of probability density functions with “tails” for (a) capacity, (b) load, (c) both?

Example 2 A Simplified Model for the National Income

Show that the model functional block diagram for an armature controlled dc motor is similar to that for a model for the national income [8]. Identify in each block diagram (a) the output variable, (b) the feedback signal, (c) the error signal, (d) the source of the disturbances, and (e) the most important dynamics.

Example 3 Effects of Intentional Feedback

Show that the nature of the response of a given physical system can be altered by the introduction of intentional feedback. Show that such intentional feedback can cause improvement in the overall behavior. Investigate model refinements, such as inexact or indefinite values of system parameters. Identify a strategy which reduces the system sensitivity to parameter changes.

Repeat the example above for a given SPE system. Identify the social phenomena which may cause parameter changes or changes in functional forms.

Example 4 Stability of Systems

In a given physical system model, show that intentional feedback can cause loss of stability of the system. What limits the operation? Investigate the effects of both large-signal and small-signal nonlinearities .

Repeat the example for a given SPE system model. Identify potential socio-politico-economic reasoning and inclinations leading to such nonlinearities.

Biographical Data

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Dr. Drake is now associated with The University of Tennessee at Martin in the School of Engineering Technology and Engineering. He specializes in control systems, industrial electronics, industrial instrumentation, and signal processing.