DEVELOPMENT OF THE SIGNALS AND SYSTEMS CONCEPT INVENTORY (SSCI) ASSESSMENT INSTRUMENT

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Abstract *¾ Linear systems theory is a core component of the undergraduate curriculum in electrical and computer engineering. This work-in-progress describes the Signals and Systems Concept Inventory (SSCI), an assessment tool designed to measure students' understanding of fundamental concepts in linear systems. The objective of this research is to develop a means of evaluating pedagogical techniques and curricular reform. The SSCI is patterned after the Force Concept Inventory, which is used to assess students' conceptual understanding of Newtonian physics. This paper discusses the development of the SSCI and its initial testing at the University of Massachusetts Dartmouth (UMassD) and George Mason University (GMU).*

Index Terms ¾ Assessment, electrical engineering, evaluation, linear systems, outcomes, signals and systems.

OVERVIEW

There is an increasing need for instruments to evaluate pedagogical techniques and curricular reform in science and engineering. The Force Concept Inventory (FCI) is one such tool that has been developed for introductory physics [1]. This research seeks to develop similar instruments for the linear systems curriculum within electrical and computer engineering. Linear systems, also known as signals and systems, is a core subject typically scheduled for the sophomore or junior year. Representative texts for this subject are [2] and [3]. In general, linear systems refers to both continuous-time and discrete-time systems, though these topics are often addressed in separate courses.

We are developing the Signals and Systems Concept Inventory (SSCI) as a tool to measure students' understanding of fundamental concepts in linear systems. Like the FCI, the SSCI consists of a set of multiple choice questions that require little or no computation. The questions focus on core concepts: linearity, time-invariance, impulse responses and the convolution integral, Fourier representations of signals and systems, Laplace transforms, representations of systems with linear differential equations, pole-zero diagrams and their relationship to impulse and frequency responses of systems, filtering, and stability. Over the past year we have developed drafts of both continuous-time and discrete-time versions of the SSCI.

The continuous-time SSCI was tested at GMU and UMassD in spring and summer of 2001. This initial round of testing verified that the questions are generally clear and appropriate, and that the distractor (alternate) answers cover students' common misunderstandings about the material. The SSCI answer sheet allowed students to answer "None of the above" for each question and fill in an answer that does not appear in the list of answers given. Statistics were compiled for a test population of over 125 undergraduate and graduate students in linear systems, signal processing, and communications courses. This data indicated which of the distractors represent the most common student misconceptions. The small number of alternative answers provided by students suggest that the current draft of the exam captures almost all common misconceptions. This preliminary data also indicates that the draft is too long for the 1 hour proposed time limit, and we will be discarding several questions. Our talk will cover strategies for probing conceptual understanding of this material, lessons learned from preliminary testing, and future plans for the exam.

FUTURE PLANS

In 2001-2002, we plan to test the SSCI at a broader group of institutions. Beta versions of the continuous-time SSCI and the associated instructor survey will be available at the FIE conference or from the authors. The purpose of the survey is to obtain feedback on the validity of the SSCI questions from instructors at different institutions. We also plan to begin testing of the discrete-time SSCI in 2001-2002.

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REFERENCES

[1] Hestenes, D. , Wells, M., and Swackhamer, G., “Force Concept Inventory”, The Physics Teacher, vol. 30, 1992, pp. 141-158.

[2] Oppenheim, A.V. and Willsky, A.S. with Nawab, S.H., ``Signals and Systems", 2nd edition, Prentice Hall, 1997.

[3] Lathi, B.P., “Signal Processing and Linear Systems”, Berkeley-Cambridge Press, 1998.

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