

AN INTERDISCIPLINARY CORE CURRICULUM BASED ON ENGINEERING SYSTEMS

*Ursula Gibson, Eric Hansen, William Lotko, Lee Lynd,
Ulf Osterberg, Bengt Sonnerup, Charles Sullivan, and Linda Wilson¹*

ABSTRACT — *This work-in-progress report describes the development and refinement of a triad of interdisciplinary engineering core courses based on systems analysis. Interdisciplinary courses in lumped and distributed systems, involving primarily electrical and mechanical systems with additional treatment of thermal and fluid systems, have had a long history in Dartmouth's engineering science curriculum. We are an interdisciplinary group of engineering and applied science faculty engaged in a curriculum development project to increase the multidisciplinary span of these courses to include chemical, computer, materials, and biological systems, approached from lumped, distributed and discrete systems viewpoints. This paper describes the challenges we have been experiencing in developing and teaching an introductory, interdisciplinary curriculum of this type, together with the perspectives of some of the Dartmouth students who learn engineering from a broad systems approach.*

Index Terms — *Interdisciplinary engineering curriculum, integrated curriculum, lumped, distributed, discrete systems.*

RATIONALE

Important technological advances occur at the interface between the traditional disciplines of science and engineering. In preparing engineers to think and work across increasingly fuzzy disciplinary boundaries, engineering educators face the conflicting objectives of having to broaden the curriculum while simultaneously accommodating a growing body of disciplinary knowledge. To meet this challenge, we have been developing and refining an interdisciplinary core curriculum based on engineering systems.

We have found that engineering students respond positively to interdisciplinary problem solving if they are presented with a conceptual framework that emphasizes the application of principles and analytical tools across traditional disciplines. An introductory course with this objective, familiar to most faculty, approaches engineering problems from a lumped systems viewpoint, with a common thread provided by state-space modeling and linear response of systems characterized by ODEs.

Courses treating distributed systems characterized by PDEs and field concepts, and discrete systems described by statistical and probabilistic variables, introduce students to

other broad classes of engineering systems that are as fundamental to engineering practice as lumped systems. However, the fact that few textbooks approach distributed and discrete engineering systems from an interdisciplinary viewpoint attests to the challenges educators face in attempting to present coherent interdisciplinary courses in these areas.

OBJECTIVES

The outcome of the Dartmouth Engineering Core project involves development of the introductory textbooks, classroom demonstrations, MATLAB and laboratory exercises, and illustrative design projects necessary to present an integrated approach to engineering science. The course outcomes are best described in terms of learning objectives, which, depending on the nature of the system under study and the system design criteria, should facilitate students' ability to analyze and design various engineering systems characterized in terms of lumped, discrete and/or distributed parameters and properties.

In analyzing and designing a *lumped system*, students should know how to 1) calculate its response given the system equations—initially simple 1st and 2nd order ODEs; 2) qualitatively describe the response of 1st and 2nd order electrical, mechanical, thermal, chemical, fluid, population, economic, ecological and other systems without appealing to equations, and 3) determine the system equations for various systems given i) values for linear elements, ii) rate constants for reacting systems, or iii) laws for nonlinear elements.

Proficiency in analyzing a *discrete system* requires 1) knowledge of the application of probabilistic reasoning to systems, 2) basic understanding of the underlying assumptions, properties, and applications of various probability models, 3) ability to design and simulate a probabilistic model of a real system, and 4) familiarity with design strategies that allow a system to perform adequately when its parameters undergo uncontrolled variations.

In treating a *distributed system*, students must learn how to 1) plot and visualize spatially and/or temporally varying vector fields, 2) characterize and specify vector fields in terms of their flux and circulation sources, 2) derive transport laws from general conservation principles, 3) recognize, characterize and control wave and diffusion phenomena—in simple geometries at the introductory level, and 5) reduce engineering problems involving a distributed system to a mathematical representation involving PDEs.

¹ All at Thayer School of Engineering, Dartmouth College, Hanover, NH 03755. Email for each author: firstname.lastname@dartmouth.edu.