Proposal for Honors Seminar

# PROBABILITY IN EVERYDAY LIFE

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## CATALOG DESCRIPTION

This Seminar will focus on understanding the properties of randomness.
We will take the viewpoint that the apparent stability and predictability of random phenomena (cards, dice, lotteries, hurricanes, epidemics, insurance claims, radioactive decay, airline crashes,...) is like a law of physics; and we will use the scientific method (observe, construct an explanatory theory, use theory to predict outcomes, compare predictions of theory with observations of experiment) to study it. In particular, we will construct mathematical models and compare their predictions with experimental data generated by computer simulations. We will use ordinary queues (a queue is a waiting line, where customers arrive at random instants, require random amounts of service, and wait random lengths of time to acquire that service) as a basic model for study. In the process, we will develop mathematical formulas (from a well-developed area called "queueing theory") to predict performance, and we will compare the predictions with the results of computer simulation (but this is not a programming course). These results will often turn out to be surprising and insightful; an additional benefit is that they are useful in real engineering (for example, in the design of the Internet). The prerequisites are feeling comfortable with mathematical reasoning, ability to understand simple computer programs (written in BASIC, a computer language often taught in middle school), and intellectual curiosity.

## BACKGROUND

This Seminar would combine concepts from two advanced technical courses that I teach on a regular basis, but the emphasis would be quite different. Instead of concentrating on mathematical details and specific technical applications, the Seminar would focus on self-discovery and on scientific and mathematical thinking. In the context of the Honors Seminar, the "core area" would be Mathematics. Student assignments will consist of projects that describe a mathematical model, its corresponding computer simulation model, and the conclusions that are drawn from comparison of the predictions of theory (mathematics) with the results of experiment (simulation). Besides being of intellectual interest, the subject matter has important applications in engineering; this course might be a good way to encourage participation with the College of Engineering and Computer Science.

Presently I teach the undergraduate core course Stochastic Models for Computer Science, STA 4821 ("stochastic" means random or probabilistic), and the graduate course Queueing Theory, MAP 6264 (and occasionally an undergraduate elective version, MAP 4260). Probabilistic models often reveal disagreement between the results of mathematical analysis and common-sense intuition (in which case the naive intuition is usually wrong). Queueing theory provides examples of probabilistic models that are both intellectually interesting and widely useful in engineering. My proposal is to combine the concepts from these courses in a Seminar that would emphasize the intellectual content rather than the narrow technological and practical considerations that drive many engineering courses.

STA 4821 covers the standard topics in probability, and includes computer simulation (somewhat unusual), which generates experimental data to compare with the predictions of the mathematical theory. That is, I take the viewpoint that this is really a course in physics: The real world is pervaded by randomness; probability theory provides a mathematical model that describes randomness and predicts its effects; and computer simulation provides an experimental laboratory to verify and interpret that theory.

Most of our Computer Science and Engineering majors would not go near a probability (or statistics) course if it were not required (they hate mathematics, "statistics" has a terrible reputation, probability has no direct application to an entry-level job in the computer industry), but it turns out that many of our students are surprised to find the course interesting, and it usually gets good evaluations. For more information about STA 4821, visit my course website (URL given below).

MAP 6264, Queueing Theory, concerns an area of advanced probability theory that has important technological applications. A queue is a waiting line (like customers waiting at a supermarket checkout counter); queueing theory is the mathematical theory of waiting lines. But, despite its apparent simplicity (customers arrive, request service, and leave or wait until they get it); the subject is one of some depth and subtlety.

More generally, queueing theory is concerned with the mathematical modeling and analysis of systems that provide service to random demands. In computer science, for example, queueing theory is used to describe the performance of the Internet. A queueing model is an abstract description of such a system. Typically, a queueing model describes (1) the system's physical configuration, and (2) the stochastic nature of the demands. Mathematical analysis of simple queueing models often reveals surprising effects caused by this inherent randomness; and simulation experiments confirm the predictions of the theory. For more information about MAP 6264, visit my course website. For a more detailed (but still simple) discussion of queueing theory, see my article in the ENCYCLOPEDIA OF COMPUTER SCIENCE, which can be viewed on my home page (URL given below).

The idea of the proposed Honors Seminar is to combine the subject matter of STA 4821 and MAP 6264 for presentation to freshmen, presumed to be intelligent and intellectually curious, but also mathematically and technically naive. It would be taught not as a technical course for computer professionals, but rather as a liberal arts course in which the properties of randomness are studied via their effects on simple but realistic high-tech (e.g., the now-ubiquitous call center) or low-tech (e.g., McDonald's drive-through window) models. Depending on the backgrounds of the students (I would have to play this by ear), I will develop the necessary mathematics (including simple calculus) and computer programming (using the language BASIC, which is often taught in middle school) to construct and investigate the behavior of simple queueing models. The focus of the Seminar would be on illuminating the process of scientific and mathematical reasoning, and to contemplate the "unreasonable effectiveness of mathematics in the natural sciences" (from the title of a famous paper by Nobel physicist Eugene Wigner).

The methodology will be to construct "reasonable" descriptions of reality (models) that strike a balance between accuracy and simplicity, and to study the behavior of these models by comparing the predictions of theory (mathematics) with the observations of experiment (computer simulation). Many interesting and (sometimes) counterintuitive insights about random phenomena will be discovered via the course assignments.

For a summary of my background and credentials, visit my home page: www.cse.fau.edu/~bob/.

For more information on my courses STA 4821 and MAP 6264, visit my course website: www.cse.fau.edu/~bob/courses/

To see videos of my lectures, visit http://www.vimeo.com/album/211356 (STA 4821) and http://www.vimeo.com/album/171324 (MAP 6264).