Colorado State University, Ft. Collins **Fall Semester, 2004**

EE303: Introduction to Communications Principles (Really, Applied Probability and Statistics, in the Context of Communication and Signal Processing)

3 cr MWF Noon-12:50pm Wagar 232

Instructor: Prof. Louis Scharf

Office: B116
OH: 1:00pm-2:00pm, MW in Student Study Area
Extra Problem Sessions: To be organized by students

Grader: To be determined

Office: Student Study Lounge
OH: NA

Calendar:

Aug 23: First day of class
Sept 22: Midterm 1
Nov 3: Midterm 2
Nov 22-26: Thanksgiving Break
Dec 10: Last day of class
Dec 16, 1:30pm-3:30pm: Final Exam

Textbook:

R.E. Walpole, et al., *Probability and Statistics for Engineers and Scientists, Seventh Edition,* Prentice-Hall, Upper Saddle River, NJ, 2002

WWW URLs:

http://www.engr.colostate.edu/EE303/
http://www.engr.colostate.edu/ecefaculty/scharf/courses/EE303/123html.

References:

C.M. Grinstead and J. Laurie Snell, *Introduction to Probability, Second Revised Edition,* American Mathematical Society, Providence, RI, 1991
K.L. Chung and F. AitSahlia, *Elementary Probability Theory, 4th Edition,* Springer, 2003

S. Ross, *A First Course in Probability, Sixth Edition,* Prentice-Hall, Englewood Cliffs, NJ 2002
D.P. Bertsekas and J.N. Tsitsiklias, *Introduction to Probability,* Athena Scientific, Belmont, MA, 2002
R.A. Roberts, *An Introduction to Applied Probability,* Addison-Wesley, Reading, MA, 1992
R.P. Feynmann, What Do You Care What Other People Think?" Bantam, 1988, Appendix F to Challenger Disaster
Languages of Instruction: English, Mathematics, and MATLAB

Exams and Percent of Grade:

Homework	15%
Midterm 1, Sept 22	25%
Midterm 2, Nov 3	25%
Final, Dec 16	35%

Homework:
Assigned every week or two. Turn in at the start of class on the due date. Friendly advice: it is very difficult to learn this material if you do not work problems.

MATLAB Labs:
NA

Course Objectives:
Our objective is to develop the probabilistic framework required to (1) model and analyze the basic communication experiment of transmitting random data over a noisy channel, and (2) statistically analyze experimental data arising in statistical quality control. Students will leave the course with an elementary understanding of probability, random variables, statistical communication, and statistical inference.

This course is mathematical in nature, so students will develop confidence in their ability to solve mathematical problems of analysis and design. The course is essential for more advanced study in networks, communication, control, and solid-state electronics.

Course Outline

1. Counting and the Games People Play: The Hypergeometric Distribution
2. Experiments and the Probability Triple: Sample Space, Field of Events, and Probability Measure
3. Independence and Dependence
4. Thm of Total Probability, Bayes Rule, and the Evidence Game
5. Discrete and Continuous Random Variables: early introduction to pmfs, pdfs, cdfs, and characteristic functions
6. The Bernoulli Experiment for Data Transmission: Bernoulli, binomial, geometric, negative binomial, and Pascal distributions
7. Noise: The uniform and Gaussian distributions
8. Transformation of Random Variables
9. The Bivariate Normal Experiment: Gaussian, exponential, Rayleigh, Cauchy, and beta distributed random variables
10. Moments, Characteristic Functions, and the Theory of Linear Systems in Probability
11. Sums of IID Random Variables
12. Random Samples: histograms and the multinomial distribution; order statistics
13. Averaging: Chebyshev's Inequality and the Weak Law of Large Numbers
14. A central limit theorem
15. The Poisson Experiment for Packet Transmission: From binomial to Poisson, and the exponential and Erlang Distributions

16. The Communication Experiment: the MAP Rule for symbol decoding, and bit error rates in binary communication
17. Linear Regression
18. The Multivariate Normal Distribution and the Gauss-Markov Theorem for MMSE Estimation

Assumed Input Skills:

1. Elementary Set Theory
2. Geometric Sum Formulas
3. Binomial Expansion
4. Chain rule for differentiation, including Liebnitz' rule
5. Integration by parts
6. Two-dimensional integrals with interesting boundaries
7. Laplace transforms

Presumed Output Skills:
Skilled problem solving for all topics in the course outline, and enough mastery of some to solve design and analysis problems in communication and data analysis.

Assessment Methods: Mid-term and final examinations contain two types of questions, clearly identified: skills problems and mastery problems. Skills problems test a student's ability to use standard mathematical or programming tools to solve straight-forward problems with well-defined starting points. Mastery problems test a student's ability to find imaginative solutions to deeper problems of analysis and design, with undefined and mysterious starting points. A student earns a passing grade of C by passing the skills part of the exam, and earns a performance grade of B or A by solving mastery problems.

Educational Objectives for the Undergraduate Program, on a Scale of 1-5

1. Gain a broad-based understanding of the fundamentals of electrical and computer engineering: 5

2. Develop ability to think deeply and critically: 5

3. Develop the confidence and ability to solve complex problems: 5

4. Achieve advanced and in-depth understanding in key technical areas within the discipline using the latest technologies available: 3

5. Develop proficiency in critical workplace skills including teamwork, oral and written communication, and independent learning: 2

6. Become skilled in hands-on hardware and software laboratory experimentation and data analysis, and in the use of a broad range of hardware and software tools for analysis and design: 2

7. Attain a good understanding of engineering, including what is required for the practice of the profession in an industrial setting: 2

Statement of Outcomes/Goals for the Undergraduate Program

1. The ability to analyze and solve practical electrical/computer engineering problems by applying knowledge of mathematics, science, and engineering principles using modern engineering skills, techniques and tools: 5

2. The ability to identify, formulate, and solve electrical/computer engineering problems through a process that includes the steps of planning, specification development, design, application of good judgement, implementation, and verification, to meet specified requirements: 2

3. The ability to design and perform experiments and to analyze, interpret, and explain the resulting data: 3

4. The skills necessary to communicate effectively both verbally and in writing as well as to contribute to multi-disciplinary teams: 2

5. An understanding of professional and ethical responsibility, as well as a knowledge of contemporary issues: 1

6. A broad education including an appreciation of the impact of engineering solutions in a global and societal context: 1

7. A recognition of the need for, as well as an ability to engage in a process of continuous learning (sic, ABET): 5

Brief Narrative: All modern electronic devices and systems are subject to random effects. This is a core course on methods to design for predictable performance under the influence of these effects. The context is communication systems, but the methods may be applied as well to control, signal processing, optics, power, solid-state electronics, and so on. The insights are timeless, so there is more emphasis on physical principles and mathematical methods than on particular technologies for realizing a design. This explains high scores for theory and application and low scores for technology and implementation. By and large students are expected to develop their individual competence and confidence, so there is less emphasis on team-work, which however is encouraged for solving homework problems, provided students understand the difference between figuring something out on their own and understanding what someone else has figured out. There is no discussion of cultural, political, or ethical issues, but students and faculty treat each other with respect and civility, which is something of value to build on.