Preliminary Course Outline for SIO 223, Fall 2005

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Chapter 1: Introduction
Probability and statistics compared: Reality, models, and inference
What kinds of questions can you ask? Estimation, Hypothesis testing

Chapter 2: Probability and random variables
Probability for events
Conditional probability [and Bayes' Theorem]
PDF's and CDF's; Lebesgue's Decomposition Theorem
Expectations, means, variances, moments
The Central Limit Theorem

Chapter 3: Some distributions
Uniform, Normal, Poisson, chi-square, Exponential, gamma, lognormal, Weibull, chi-squared, t and F, von Mises

Chapter 4: Multivariate Random Variables, Correlation and Error Propagation
Multivariate PDFs
Conditionals and Marginals
Moments of Multivariate PDFs
Independence and Correlation
Regression
Multivariate Normal Distribution

Chapter 5: Parameter Estimation
The simplest estimation: Method of Moments
Order Statistics
Trimmed estimates
Sampling distributions for Statistics
Monte Carlo Methods
Bootstrap Methods
Confidence Limits for Statistics
Desirable properties for estimators:
unbiasedness, efficiency, minimum Mean Square Error, consistency, robustness
Maximum likelihood
Cramer-Rao Inequality
L_1 norm estimation

Chapter 6: Hypothesis testing
How does hypothesis testing work
what does "95% confidence" mean and why do you care?
The general framework
Examples: the Schuster tests
Tests for the same mean
Test for pdfs: Kolmogorov-Smirnov test; χ^2 test for goodness of fit; Q-Q Plots

Chapter 7: Least Squares Estimation
Least squares estimation
Assessing Fit
Correlation and Regression
Normal equations in matrix form
Statistical Properties of LS estimates, inferences about derived parameters
Weighted LS
Numerical issues

Chapter 8: Total Least Squares and Robust methods
Total Least squares and the bootstrap
Robustness, Non-Guassian data errors and M-type Estimation

Chapter 9: Non-parametric Density Function Estimation
Density estimates and sample distribution functions - comparing data and theory
Adaptive Estimation: Nearest Neighbors and Variable Kernels
Maximum Penalized likelihood estimators

Chapter 10: Interpolation, Trend removal, and Data smoothing
Local and global techniques
Polynomials, moving least squares
Local regression, kernel smoothing
Splines as interpolators and smoothers

Chapter 11: Data display
Displaying what you want to show
Using variables that can be decoded