Prerequisites: One year of calculus such that student is familiar with differentiation and integration of functions of a single variable and basic multivariable calculus. The course is introductory in that no specific requirements are set for background in probability or statistics. Nonetheless, students who have had statistical methods courses in the past should find that this course will complement such courses well.

Evaluation of Student Performance: Students are expected to attend and actively participate in class, complete assignments (reading, homework problems, etc.), and take the examinations. They are expected to attend recitation and office hours as needed. There will be weekly assignments due. There will be two mid-term exams and one final examination.

The final grade will be determined by a formula chosen by each student subject to the following constraints:

<table>
<thead>
<tr>
<th>Grade Components</th>
<th>Range</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class participation</td>
<td>5-10%</td>
<td>5%</td>
</tr>
<tr>
<td>Assignments</td>
<td>15-25%</td>
<td>20%</td>
</tr>
<tr>
<td>Mid-Exam 1</td>
<td>15-25%</td>
<td>20%</td>
</tr>
<tr>
<td>Mid-Exam 2</td>
<td>15-25%</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30-40%</td>
<td>35%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

The total of the percentages allocated by the student must total 100%. This allocation is intended to provide flexibility in the way a student demonstrates mastery of the course material. If no choice is made, grading will be by the default weights.

Textbook:
Mathematical Statistics with Applications 7ed
Dennis D. Wackerly
William Mendenhall III
Richard L. Scheaffer
ISBN-10: 0-495-11081-7
Description:
Since social and policy analysis is rooted in empirical studies of complex phenomena, researchers make extensive use of statistical tools in designing data capture, obtaining useful information from data, and presenting results convincingly to various audiences. Probability and statistical theory provide the basis for these statistical tools.

At the doctoral research level, you gain confidence in the application of statistical tools as you better understand probability and statistical theory. Further, probability and statistical theory provides background for more advanced methodology courses such as econometrics, probabilistic operations research, statistical machine learning, decision analysis and multivariate statistical analysis. Additionally, and importantly at the PhD level, having skills in probability and statistical theory permits the researcher to tailor statistical techniques and probabilistic methods to the problem at hand, rather than forcing the problem into a set of cookbook procedures.

Student Audience: Within Heinz College, 90-905 is appropriate for first-year PhD students plus first and second year Masters students who desire and are prepared for a rigorous theory course in probability and statistics as a base for more advanced research methodology. Outside the Heinz school, 90-905 may be of interest to graduate students in Engineering and Public Policy, Social and Decision Science, Software Engineering, Psychology, GSIA, Philosophy, Applied History, or Architecture who need background in probability and statistical theory targeted toward social and policy research.

Coverage: This is a fast paced one semester course that focuses on foundational concepts of mathematical probability and statistical theory. Topics covered include: joint, marginal, and conditional probability, Bayes rule, probability distributions, principles of statistical inference, sampling distributions, maximum likelihood, non-parametric estimation, Bayesian methods, the bootstrap, and the relationship between these topics and simple regression.
Unit 1: Wackerly Chapters 1 – 6
Topics:

- Probability Sampling
- Sample Spaces
- Probability of an Event (Independence, Conditional, Bayes Rule)
- Discrete and Continuous Random Variables (Univariate)
  - PMF, PDF, CDF
  - F, f, mean, variance, MGF of
  - Uniform, Bernoulli, Binomial, Poisson, Normal
  - Geometric, Gamma (Chi-square, exponential), Beta
- Multivariate Distributions
  - Joint, Marginal, Conditional Distributions
  - Conditional Expectation
  - Covariance/Correlation
  - Law of Iterated Expectation

Unit 2: Wackerly Chapters 7 – 10
Topics:

- Sampling Distributions
  - Central Limit Theorem
  - Normal Approximation to the Binomial
- Estimation
  - Methods for obtaining estimators
    - Method of Moments
    - Maximum Likelihood
  - Properties of point estimators
    - Bias, Mean squared error, Relative efficiency
    - Consistency, Sufficiency
- Confidence Intervals
  - Large and Small sample
  - For $\mu$ and $\sigma^2$
- Hypothesis Testing
  - Type I and Type II Error
  - Null and alternative hypotheses
  - One- and two-sided tests, rejection region
  - p-values
- Assumptions and robustness of statistical tests
Unit 3: Wackerly Chapters 11 and 16, Wasserman Chapters 7 & 8

Topics:

Nonparametric Statistics
  - Empirical Distribution Functions
  - Plug-In Estimators
The nonparametric Bootstrap
  - Estimating the CDF with the ECDF
  - Simulation
  - Bootstrap variance estimates
  - Bootstrap confidence intervals
Bayesian Statistics
  - How it differs from frequentist Statistics
  - Prior Distributions
  - Bayes Rule
  - Posterior Distributions
  - Bayesian Point and Interval Estimates
Simple Linear Regression
  - Assumptions
  - Least squares estimators – method and properties
  - Interpreting simple regression models
  - Inferences for coefficients, conditional mean
  - Prediction Intervals