Syllabus
ECE 304: Probability, Statistics and Reliability
Spring 2013

1. General:

Meeting Time: Tuesday and Thursday: 5:45 pm – 7:00 pm,
Location: KAUF 225
Instructor: Dr. Helmut Baumgart
Office hours: Tuesday and Thursday 4:30 pm – 5:45 pm and by appointment
Office: Kaufman Hall KH 231-E, and ODU-ARC Room 719, Applied Research Center, Thomas Jefferson National Accelerator Facility, Newport News, VA
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Teaching Assistant: Mahbubul Alam
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Office hours: Monday: 11:00 am -12:00 pm; Tuesday: 11:00 am - 12:00 pm
Thursday: 11:00 am - 12:00 pm;
Office Location: Vision Lab (4111-Innovation Research Park, Monarch Way, 41st Street)
Prerequisite: The following background is assumed: MATH 212 and familiarity with Microsoft Excel 2003 or higher and at least one laboratory course

2. Course Description:

The field of statistics deals with the collection, presentation, analysis and use of data to make engineering decisions, solve problems and design products and processes. Statistical techniques can be a powerful aid in designing new products and systems, improving existing designs, and designing, developing, and improving production processes. Because many aspects of today's engineering practice involve working with data, obviously a good knowledge of statistics is important for every engineer. Engineering decisions are frequently based on measurements from only a subset of objects selected in a sample. Reasoning from a sample of objects to arrive at conclusions for a population of objects is referred to as statistical inference. How can we quantify the risks of engineering decisions based on limited samples? Probability models help quantify the risks involved in statistical inference - the risks involved in decisions made every day. In this course you will understand the concept of variability and sources of variability. You will learn the basic principles of collecting engineering data, the advantages of designed experiments, statistical hypothesis testing, factorial experiments and the powerful engineering problem solving tool of statistical control charts. Control charts serve as invaluable tools to examine the variability in time-oriented data for statistical quality control and statistical process control. You will be able to understand the principles of Shrewhart Control Charts and use the major tools of statistical process control: 1) Histograms, 2) Pareto Charts, 3) Cause-and-Effect Diagrams, 4) Defect Concentration Diagrams, 5) Control Charts, 6) Scatter Diagrams, 7) Check Sheets.

3. Course Objectives:

When you complete this course you will be able to:

1. Recognize engineering problems requiring statistical methods.
2. Understand and describe sample spaces, events, samples for random experiments with graphs, tables, Venn diagrams, and lists.

3. Use counting techniques to calculate the number of outcomes of events and samples spaces.
4. Interpret and calculate conditional probabilities of events.
5. Determine the independence of events.
6. Use Bayes' theorem to calculate conditional probabilities.
7. Appraise discrete and continuous random variables and paraphrase them with respect to definitions and axioms of probability.
8. Determine probabilities from probability mass functions, probability density functions and cumulative distribution functions.
9. Select appropriate discrete and continuous probability distributions; calculate probabilities, means and variances accordingly.
10. Standardize normal random variables and use the table for the cumulative distribution function of the normal distribution to calculate probabilities.
11. Approximate probabilities for binomial and Poisson distribution using the normal distribution.
12. Calculate marginal and conditional probability distributions from joint probability distributions.
13. Interpret and calculate covariances and correlations between random variables.
14. Explain the concept of random sampling, sample mean, sample variance, population mean, and population variance.
15. Construct and interpret normal Probability Plots and Histograms.
16. Understand the central limit theorem.
17. Explain point estimators, bias, and mean square error.
18. Construct point estimators using the method of maximum likelihood.
19. Construct confidence intervals on the mean and variances of a normal distribution, using either the normal distribution or t-distribution.
20. Test hypothesis on the mean and variance of a normal distribution using either a Z-test or a t-test procedure.
21. Compute power, type-I and type-II error probabilities, and make samples size decisions.
22. Understand the different types of variability rational subgroups and how a control chart is used to detect assignable causes.
23. Construct statistical process control charts and understand 6-sigma processes.
24. Understand the general form of a Shrewhart control chart and how to apply zone rules (such as the Western Electric Rules) and pattern analysis to detect assignable causes.
25. Construct and interpret control charts for variables such as $\bar{x}$, R, S and individual charts.
26. Design and conduct engineering experiments involving a single factor with an arbitrary level of factors
27. Understand how the analysis of variance is used to analyze the data from these experiments
28. Understand the difference between fixed and random factors
29. Understand the blocking principle and how it is used to isolate the effect of nuisance factors
30. Know how to analyze and interpret main effects and interactions
31. Understand how the ANOVA is used to analyze the data from these experiments

This course is covering the following material:

Topics	Periods	Text sections
1. THE ROLE of STATISTICS IN ENGINEERING	2	**Ch. 1**
• Collecting Engineering Data, Data Representation, Graphing and Analysis (with and without EXCEL)		
• Statistics with EXCEL: sampling, Radom Number Generator, (RAND, ROUND)		
• Rank, percentile, mode, median, average, processes chart,		

- Deming's funnel
- Retrospective Study
- Observational Study
- Designed Experiments
- Observing Engineering Processes over time
- Preliminary definitions (random variable, sample, population)
- Probability and Probability Models

2.	**INTRODUCTION TO PROBABILITY – BASIC CONCEPTS**	4	**Ch. 2**

- Sample space, discrete/continuous random variables, experiments with and without repetition, experiments with and without order
- Outcome, Event, Tree Diagram, Venn Diagrams, de Morgan's Law
- Interpretations and Axioms of Probability
- Absolute/relative Frequency, Probability, Addition Rules
- Conditional Probability, Multiplication and Total Probability Rule, (HISTOGRAM)
- Independence, Bayes' theorem
- Counting Techniques, Permutations, Combinations (COMBIN)

3.	**DISCRETE RANDOM VARIABLES and Probability Distributions**	5	**Ch. 3**

- Probability Distributions, and Probability Mass Functions
- Mean, Variance, Example: Discrete Uniform Distribution, (AVERAGE, STDEV)
- Discrete Uniform Distribution
- Binomial distribution, (BINOMDIST), Bernoulli experiment
- Geometric Distribution and Negative Binomial Distribution,
- Poisson Distribution,
- Hypergeometric Distribution, (NEG BINOM DIST, HYPERGEOM DIST, POISSON)

4.	**CONTINUOUS RANDOM VARIABLES and Probability Distributions**	5	**Ch. 4**

- Continuous Random Variables
- Probability Distributions and Probability Density Functions,
- Cumulative Distribution Functions
- Mean and Variance of a Continuous Random Variable
- Normal Distribution: examples, Significance, Definition, Graph, Standardization
- Normal Distribution: Cumulative Normal Dist. Φ (z), examples (use of table, NORMDIST, NORMINV, NORMSDIST, NORMSINV))
- Exponential Distribution,
- Erlang and Gamma Distributions,
- Weibull Distribution
- Normality Criteria (normal Prob. Plot), Central Limit Theorem, Normal Distr. as Approximation (large samples, to the Binomial and Poisson Distribution), Continuity

Approximation

6. DESCRIPTIVE STATISTICS — 3 — **Ch. 6**

- Linear Function. of random variables, sample mean, variance, central limit theorem
- Stem and Leaf Diagrams
- Frequency Distributions and Histograms, , sample mean and variance, range,
- Box Plots
- Time sequence plots
- Probability Plots
- Standard error of the mean
- Point estimator, bias, mean square error
- Maximum likelihood estimator

7. INTRODUCTION TO STATISTICAL PROCESS CONTROL (SPC) — 6 — **Ch. 15**

- Quality Improvement and Statistics
- Introduction to Control Charts
- Control limits, process limits, tolerance limits for X, R & S Control Charts
- Control Charts for Individual Measurements
- Process Capability Indexes Cp & Cpk
- Attribute Control Charts (P Chart & U Chart)
- Time-Weighted Charts (CUSUM Charts)
- 6-Sigma Process and SPC Black Belts in Industry

8. DESIGN AND ANALYSIS OF SINGLE FACTOR EXPERIMENTS: ANANYSIS OF VARIANCE (ANOVA) — 4 — **Ch. 13**

- Designing Engineering Experiments
- Completely Randomized Single Factor Experiment
- The Random Effects Model
- Randomized Complete Block Design
- Design and Statistical Analysis

(Capitalized terms in parenthesis indicate EXCEL-functions.)

4. Required Main Textbook:

"Applied Statistics and Probability for Engineers" by Douglas C. Montgomery, George C. Runger, 5th Edition, John Wiley & Sons Inc., ISBN-13: 978-0-471-74589-1

5. Companion Website:
www.wiley.com/college/montgomery (solutions to selected problems, data sets)

6. Additional Reading:

"Schaum's Outline of Probability and Statistics," 2nd ed., M.R. Spiegel. J.J. Schiller and R.A. Srinivasan, 2nd Edition, McGraw-Hill Inc.

"Data Analysis using Microsoft Excel", M. Middleton, Brooks/Cole/Thomson Learning, Belmont CA, 2004

"Engineering Statistics", by Douglas C. Montgomery, George C. Runger and Hubele, 3trd Edition, John Wiley & Sons Inc.

"SPC - Practical Understanding of Capability by Implementing Statistical Process Control", by James C. Abbott, Robert Houston Smith Publishers, 3rd Edition 1999
ISBN: 1-887355-03-0

"What is Six Sigma", by Pete Pande and Larry Holpp, McGraw-Hill, 2002,
ISBN: 0-07-138185-6

"Introduction to Statistical Quality Control", by Douglas C. Montgomery, John Wiley and Sons, 6th Edition, ISBN 978-0-470-16992-6

7. Student Evaluation:

Homework 20%, 1st midterm exam 20%, 2nd midterm exam 20%, final exam 35%, Quiz 5 %

Students are responsible for the timely completion of all homework assignments. Homework has to be turned in at the assigned day no later than by the end of the class.

At the end of each chapter covered by the course a 10-min Quiz is given in class.

8. Grading:

$\geq$ 95% = A; $\geq$ 90% = A-; $\geq$ 85% = B+; $\geq$ 80% = B; $\geq$ 75% = B-; $\geq$ 70% = C+; $\geq$ 65% = C; $\geq$ 60% = C-; $\geq$ 55% = D; $<$ 50% = F

9. Class attendance: Mandatory

Notes, Syllabus, Assignment & Messages: Blackboard

10. Academic Integrity and ODU Honor Code:

As engineers you will be responsible for upholding the canons of ethics of the profession. The Honor System at ODU is based upon the integrity of the individual. This system assumes that the student will accept his or her role in the University community with a feeling of self-respect and duty. Th Honor Pledge (attested by signature) requires that each piece of work submitted by a student is to be his/ her own work unless prepared under other conditions specified by the instructor.

11. Disability:

Students with documented learning disabilities should see the instructor during the first week of class to make proper arrangements.