Boston University College of Engineering
ENG ME308 Statistics and Quality Engineering

Fall 2009 Offering, Tue-Thu 10:00-12:00, Soc B61
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Office Hours: Rm 137, 15 St. Mary's Street. Tue-Thu 1:00-2:00pm

Administrative/Organizational Issues

This course aims at introducing probability theory, statistics, and quality engineering topics. A carefully selected sequence of consistent and complementary examples drawn from quality engineering will be presented as elaborations of fundamental concepts in probability and statistics. **Acceptance sampling** and **on-line quality control** methods are introduced as applications of the central limit theorem, sampling distributions and confidence intervals. The third important topic is **off-line quality control and Taguchi's method** for the design of Experiments. It is introduced as the key application of analysis of variance which will be covered if time permits.

By the end of the course students can expect to be literate in the main concepts of Probability and Statistics and their applications as well as in the main principles of Quality Engineering.

Required Text: Probability and Statistics in Engineering by W. W. Hines, D. C. Montgomery and C.M. Borror, fourth edition, Hoboken, NJ: John Wiley, 2003 (Available at Amazon.com)

Notes/Attendance: Active class attendance and compilation of class notes are essential in this course. Concepts covered will be novel to most students and build upon each other. Students who fall behind may find that they are unable to follow subsequent lectures. Material introduced in class must *mature* before one becomes comfortable with it, and it is strongly recommended that study of the material covered after each lecture is undertaken without exception. Attendance is therefore a must. Students who know that they will have to miss some classes should not take the course.

Homework: Assigned weekly. Due one week after the date issued. Late homework will not be accepted. Although homework grades will represent only 10% of the grade for the course, you are strongly encouraged to work on them independently. It is impossible to learn the material and perform in the exams satisfactorily without doing problems on your own. (It is easy to follow and "understand" another person's solution). You are also encouraged to study the homework solutions that will be handed out and seek help in areas that are not clear to you.

Examinations: A short (15 min) closed book quiz will be given on most Thursdays at the end of the class. Quiz performance will determine 40% of the grade for the course. The final examination and class participation will determine 40% and 10% of the grade for the course respectively. Based on the judgment of the instructor, extraordinary performance in class and in short quizzes may earn a student a grade of A and exempt him/her from the obligation to take the final examination.

Recommended Alternative or Complementary Texts

Introductory Probability and Statistical Applications by P. L. Meyer.

Fundamentals of Applied Probability Theory by A. W. Drake. Text used at MIT for equivalent course. Good concise treatment of material with good introduction to statistics and Markov Processes.

Probability and Statistics by A. Papoulis, Prentice Hall 1990. An excellent coverage of introductory probability and statistics with coverage of advanced topics as well. Includes a good introduction to simulation, on-line quality control and Analysis of Variance which is the basis of the Taguchi method for analyzing experimental results in his design of experiments approach.

An Introduction to Probability Theory and Its Applications by W. Feller. The classic text for probability courses. Emphasis on discrete case and combinatorial analysis, extensive coverage of material.

Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences by J. S. Milton and J. C. Arnold, 2nd Edition, McGraw Hill 1990. Provides a more applied version of the theory with good introduction to statistical analysis and quality control techniques.

Introduction to Probability and Statistics for Engineers and Scientists by Sheldon M. Ross, John Wiley and Sons, 1987

Basic Statistical Methods for Engineers and Scientists by John Kennedy and Adam Neville, Harper and Row

Statistical Quality Control by Eugene Grant and Richard Leavenworth, Mc Graw Hill

Introduction to Quality Engineering by Genichi Taguchi, APO 1986

Quality Engineering: Products and Process Optimization by Yuin Wu and Willie Hobbs Moore, ASI, 1986

Taguchi Techniques for Quality Engineering by Phillip J. Ross, McGraw-Hill, 1988

ENG ME308 Statistics and Quality Engineering Topics

- Introduction: Motivation and application areas; *Events and Random Experiments*
- More on Events, *Elementary Events, Events, the Universal Set, the Null Set*.
- Elements of *Set Algebra*: *Union, Intersection, Complement*. Examples from product quality and product attributes.
- *Conditional and Joint Probability*. *Bayes Theorem*. Quality investigation through sequential sampling rather than exhaustive inspection.
- *Combined/Sequential experiments*. *Independent and dependent repetition* of experiments.
- *Combinations/Permutations* and the binomial probability law.
- Introduction to acceptance sampling and the *Gaussian approximation to the binomial* probability law.
- Introduction to *quality control charts* for the number of defective parts in small batches of products. Motivation for the *Poisson approximation to the binomial* probability law.
- Motivation of the *density and distribution functions*. The concept of *random variables*.
- *Normal, Exponential, Erlang, Geometric, Binomial, Poisson* probability distributions; use of density functions to calculate probabilities of events.
- *Memoryless* properties of the exponential and geometric distributions. Examples from machine failures/repairs and defective part production.
- Central tendency and dispersion in probability distributions. Motivation for the definition of mean, *variance* and *moments* of a random variable.
- Introduction to *quality control charts* for the mean and variance of product attributes in small batches. (X and V charts)
- Multiple product attributes and introduction to *two or more random variables*. *Dependent* and *Independent* random variables. Covariance and Correlation
- Joint statistics and probability of events involving two or more random variables; Description of events as the intersection of two or more inequalities; Area integrals.
- *Functions of Random Variables*. The distribution function of a new random variable as the probability of the *equivalent event* described in terms of the old random variable.
- *Reliability* of different system architectures when the *life distribution* of each component is known: *sum, ratio, product, order statistics, range* of independent random variables.
- *Conditional Expectation*, mean square estimation and linear mean square estimation. Discussion of applications to data analysis (from natural experiments) for product and process quality improvement.
- Sampling distributions; the *Central Limit theorem*. *Acceptance Sampling* applications; Consumer's and Producer's risk, (type one and type two errors). Sample mean and variance;
- *Parameter Estimation* and maximum likelihood estimation. Chi Square and F distributions.
- *Confidence Intervals* and *Hypothesis Testing.* Quality control charts for on-line *Statistical Quality Control (SQC)*. *Control of Mean* (when the Variance is known/unknown). *Control of Variance* (when the mean is known/unknown). *Control of two means*. *Control of two variances*.
- (If time allows) *Analysis of Variance* and its application in experimental data processing and hypothesis testing. *Design of Experiments* (deliberate experiments) for product and process design improvement; Taguchi's method and *orthogonal arrays*. Case study and review