

Spring 2008

Mechanical/Nuclear Engineering 446, Reliability Concepts in Design (3)

Introduction to reliability mathematics. Failure data collection and analysis. Components and systems reliability prediction. Effects of maintenance on reliability. Prerequisite: MATH 250 or MATH 251 . Prerequisite or concurrent: STAT 401

Text: Reliability Engineering and Risk Analysis, M. Modarres, Mark Kaminsky, Vasilii Krivtsov, Marcel Dekker, NYC, NY 1999.

References: Introduction to Reliability Engineering, E.E. Lewis, 2nd Edition, John Wiley & Sons, NYC, NY, 1996.

Instructors: Professor Robert M. Edwards, 228 Reber, 865-0037, rmenuc@engr.psu.edu
Office Hours: MW 3:00-4:00
or email for appt .

ME/NucE 446 provides an introductory course in reliability with applications to probabilistic risk assessment. Upon Completion of this course, students will:

ME outcomes

- 1e demonstrate familiarity with statistics
- 2a perform analysis of mechanical components
- 2d perform analysis of mechanical systems

Nuc E outcomes

- 2d Demonstrate breadth of understanding of the various areas of the nuclear field
- 5a Be able to understand the safety analysis of nuclear systems

Course Objectives

- A. apply probability and statistics in the analysis of reliability (2a,1e)
- B. analyze component reliability using common distribution functions (2a)
- C. analyze system reliability including reliability block diagrams, fault trees, event trees, and Failure Modes and Effects Analysis (FEMA) (2d, NucE 2d)
- D. analyze components and systems with repair and determine component and system availability (2a,2d)
- E. analyze risk including Risk Perception and Acceptability, Determination of Risk Values, Formalization of Risk Assessment, and Probabilistic Risk Assessment (2d. Nuc E 5a)

Course Learning Outcomes

1. demonstrate ability to reduce complicated Boolean expressions (A)
2. use the Hypergeometric function to analyze sampling from component stockpiles (A)
3. use the binomial and poisson distributions to analyze probabilities of success and failure (A,B)
4. use the normal distribution and joint probability density functions to analyze probabilities of success and failure (A,B)
5. Use chi-squared analysis to determine goodness of fit of failure data to a given distribution (A,B)

6. demonstrate an understanding of the relationships between hazard rate, probability density function, reliability function, and mean time to failure (MTTF) (B)
7. determine MTTF from experimental data (B)
8. calculate confidence intervals on empirical distributions (A,B)
9. analyze reliability of systems using the reliability block diagram (C,D)
10. analyze the fault tree of a tank rupture (C,D)
11. analyze reliability under repair (C,D)
12. determine availability under repair (C,D)
13. perform quantitative risk analysis for a fire protection system (E)

Grading:

Homework/quizzes	=	30	points
Exam 1	=	35	points
Exam 2	=	<u>35</u>	points
TOTAL	=	100	points

All homework must be turned in on time to receive full credit. Homework will be accepted late but you will be penalized accordingly.

Academic Integrity: The College Academic Integrity Policy applies, please become familiar with the policy at <http://www.engr.psu.edu/CurrentStudents/acadinteg.asp>. Students may work together on homework, but individual solutions must be submitted.

Topics:

Definitions of Reliability and Risk—Chapter 1

Textbook
 Societal
 Personal
 Concept of Reliability
 Relationship to Risk

Basic Mathematics of Reliability—Chapter 2

Elements of Probability
 Boolean Algebra
 Basic Laws of Probability
 Bayes' Theorem
 Probability Distributions
 Concept of Random Variable
 Discrete Distributions
 Continuous Distribution
 Cumulative Distributions

Component Reliability—Chapter 3

Bathtub Curve and You
 Reliability Function
 Common Distribution Functions
 Exponential
 Weibull

Gamma
Normal
Lognormal
Extreme Value
Component Reliability Models

System Reliability Analysis—Chapter 4

Reliability Block Diagrams

Series

Parallel

Complex Systems

Fault Tree

Event Trees

FMEA

Reliability with Repair—Chapter 5

Repairable System Reliability

Availability of Repairable Systems

Methods For Determining System Availability

Availability Calculations of Complex Systems

Risk Analysis—Chapter 8

Risk Perception and Acceptability

Determination of Risk Values

Formalization of Risk Assessment

Probabilistic Risk Assessment