MAE 598 Probabilistic Methods for Engineering Design and Analysis

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Instructor: Dr. Yongming Liu
ERC 419; Tel: 480-965-6883
E-mail: yongming.liu@asu.edu

Office Hours: **TTh 10:00 -12:00**; and anytime when I am in the office with the door open

Lecture/Lab: TTh 1:30 – 2:45 COOR120

Web access: ASU Blackboard System

Catalog Description: Fundamental probabilistic theory, engineering statistics, data analysis, reliability methods, simulation technique, mechanical and structural analysis under uncertainties, focus on the application for mechanical, aerospace, and civil engineering structures and materials

Prerequisites:

Textbook: Probability, Reliability, and Statistical Methods in Engineering Design, Achintya Haldar, Sankaran Mahadevan, ISBN: 978-0-471-33119-3, John Wiley & Sons, 2000. (recommended)
Reliability Assessment using stochastic finite element method. Achintya Haldar, Sankaran Mahadevan, ISBN 0-471-36961-6, John Wiley & Sons, 2000. (reference book)

Software: Matlab, ANSYS/ABAQUS

Course Objectives:

1. To examine and comprehend the principle involved probabilistic analysis of engineering materials and structures
2. To enable students to use fundamental principles of engineering statistics for the development and applications of material/structural design and analysis.
3. To train students of scientific computation, engineering statistics, data analysis, and academic writing.
4. To introduce advanced and currently active research topics in the probabilistic methods and reliability assessment.

Topics Covered:

Topic	Hours
Introduction	2 hours
Fundamentals of probability theory	4 hours
Uncertainty quantification of random variables	8 hours
Uncertainty propagation with models	8 hours
Analytical and simulation methods for reliability assessment and design	6 hours
Time dependent reliability: fatigue reliability	6 hours
Advanced topics	4 hours
Exams	2 hours

Class Schedule:

Two 75-minute lectures per week

Examination policy:

The in-class exam will be given in the COOR120 on Thursday October 20 at 1:15 pm. There will be no make-up exam. In unusual circumstances excuses may be granted for the in-class exams. For predictable absences excuses must be requested well in advance of the exam day. Excused exam will increase the weight of the term paper. There will be **no Final Exam**. Exams will be open notes **ONLY**. The original problem papers and your solutions will be stapled together and turned in.
One term paper will be required. Detailed requirements and formatting will be given separately during the semester.
In class quiz will be randomly given to check your understanding of the course materials and attendance.

Evaluation Methods:

1. Exam I (October 20)	30	30%
2. Term paper	30	30%
3. Homework	30	30%
4. In class quiz	10	10%

100 total points
Letter grades will be assigned based on the following scale:

A+:	95 and above
A:	90 - 95
B+:	85 - 90
B:	80 - 85
C+:	75 -80
C:	70 -75
D:	60 -70
E:	otherwise

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Introduction
Reliability in mechanical/structural engineering
Importance of reliability in design and maintenance
Sources of uncertainties in engineering design and analysis

Fundamentals of probability theory
Set theory
Axioms of probability
Multiplication rules
Conditional probability and Bayes' theorem

Uncertainty quantification of random variables
Data collection and analysis
Continuous and discrete random variables

Multiple random variables and correlations
Commonly used probability distributions
Determination of distributions from data analysis
Statistical test and goodness of fit

Uncertainty propagation with models
Single random variable with known functional relationship
Multiple random variables with known functional relationship
Approximation with unknown functional relationship
Regression analysis
Design of experiments and response surface method

Analytical and simulation methods for reliability assessment and design
Limit state function and reliability assessment
First-order reliability method (FORM)
Reliability-based design and safety factor
Second-order reliability method (SORM)
Sensitivity analysis
Monte Carlo simulation
Sampling techniques

Time-dependent reliability: fatigue reliability
Overview of fatigue analysis of materials
Stress-life approach for fatigue reliability analysis
Fatigue crack growth approach for fatigue reliability analysis
Time-dependent reliability and probabilistic life prediction

Advanced topics
Bayesian inference technique for uncertainty calibration and updating
Non-probabilistic methods for engineering analysis and design

Persons(s) who prepared this description and date of preparation:

Y. Liu August 15, 2016