CEE 491 – Decision and Risk Analysis
Fall 2018

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Lecture Tu. and Th.: 12:30 – 1:50 PM in 2311 Newmark

Prerequisites CEE 202 or approval of instructor

Course Objectives

This course introduces students to applications of probability theory, statistics, and decision analysis to engineering problems. Emphasis is placed on probabilistic modeling and analysis of civil and environmental engineering problems, Bayesian statistics, risk analysis, and decision under uncertainty. For undergraduate students, this course provides a solid base in applied probability and Bayesian statistics as used by engineers, and introduces them to the increasingly important topic of engineering risk analysis. For graduate students, in addition, this course provides a strong background for pursuing more advanced courses on non-deterministic methods.

Textbook

Ang, A. H.-S., and Tang, W.-H. (2007). *Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering*. John Wiley, New York, NY.

Additional resources on regional risk analysis

Murphy, C., Gardoni, P., McKim, R., (Eds.) (2018). *Climate Change and Its Impact: Risks and Inequalities*, Springer.

Gardoni, P., (Ed.), (2017). R*isk and Reliability Analysis: Theory and Applications*, Springer.

Gardoni, P., and LaFave, J., (Eds.) (2016). *Multi-hazard Approaches to Civil Infrastructure Engineering*, Springer.

Gardoni, P., Murphy, C., and Rowell, A., (Eds.) (2016). *Societal Risk Management of Natural Hazards*, Springer.

Additional resources on probability, Bayesian statistics, uncertainty analysis, and model estimation

Bard, Y. (1974). *Nonlinear parameter estimation*. Academic Press, Orlando, Florida.

Benjamin, J.R., and Cornell, C.A. (1970). *Probability, statistics and decision for civil engineers*. McGraw-Hill, New York, NY. (A good reference book, but too old and too detailed at times. In some areas we will go beyond this book.)

Box, G.E.P., and Tiao, G.C. (1992). *Bayesian inference in statistical analysis*. Addison-Wesley, Reading, Mass.

Ditlevsen, O. (1981). *Uncertainty modeling*. McGraw-Hill, New York, NY.

Kottegoda, N.T., and Rosso, R. (1997). *Probability, statistics, and reliability for civil and environmental engineers*, McGraw-Hill, New York, NY. (A good reference for data analysis and classical statistics applications in civil and environmental engineering.)

Rubenstein, R.Y. (1981). *Simulation and the Monte Carlo method*. J. Wiley, New York, NY.

Stone, J.C. (1996). *A course in probability and statistics*. Duxbury Press, Belmont, California.

Additional resources on reliability analysis

Augusti, G., Baratta, A., and Casciati, F. (1984). *Probabilistic methods in structural mechanics*. Chapman and Hall, London, UK.

Ayyub, B.M., and McCuen, R.H. (1997). *Probability, statistics & reliability for engineers*. CRC Press, New York, NY.

Ditlevsen, O., and Madsen, H.O. (1996). *Structural reliability methods*. J. Wiley & Sons, New York, NY.

Gardoni, P., (Ed.), (2017). *Risk and Reliability Analysis: Theory and Applications*, Springer.

Haldar, A., and Mahadevan, S. (2000). *Probability, Reliability and Statistical Methods in Engineering Design*. John Wiley & Sons, New York, NY.

Hart, G.C. (1982). *Uncertainty analysis, loads, and safety in structural engineering*. Prentice-Hall, Englewood Cliffs, NJ.

Madsen, H.O., Krenk, S., and Lind, N.C. (1986). *Methods of structural theory and its applications*. Prentice-Hall, Englewood Cliffs, NJ.

Melchers, R.E. (1999). *Structural reliability: analysis and prediction*. 2nd Edition, John Wiley, New York, NY.

Thoft-Christense, P., and Baker, M. (1982). *Structural reliability theory and its applications*. Springer-Verlag, Berlin, Germany.

Thoft-Christense, P., and Murotsu, Y. (1986). *Applications of structural system reliability theory*. Springer-Verlag, Berlin, Germany.

Wen, Y.K. (1990). *Structural load modeling and combination for performance and safety evaluation*. Elsevie, Amsterdam, The Netherlands.

Bedtime reading

Bernstein, P.L., *Against the Gods*, (1996). John Wiley & Sons, New York, NY. (A bedtime reading book describing the history and evolution of risk analysis from an economists viewpoint.)

Homework Assignments

Weekly homework assignments will be given every Thursday. They will be due by 12:30 PM of the following Thursday (at the beginning of class). The homework statements and solutions will be placed on Compass2g.

Students are encouraged to use Excel, MATLAB or Python in preparing their solutions.

Exams

There will be one midterm and one final examination. The midterm will be on Thursday, October 11 during the class time (unless otherwise announced in class).

Grading

Points will be combined using the following weights

3 credit hours (for undergraduate and graduate students)	**4 credit hours** (for graduate students only)
• Homework 20%	• Homework 20%
• Midterm Examination 30%	• Midterm Examination 20%
• Final Examination 50%	• Final Examination 40%
	• Final Project 20%

Cut offs used to assigned the final grades will be defined by Prof. Gardoni.

Course Topics

Elements of set theory

Basic elements of probability theory

- Axioms of probability
- Elementary rules of probability
- Conditional probability and statistical independence
- Bayes' rule
- Theorem of total probability
- Probability rules for conditional events

- Elements of fragility analysis

Random variables

- Discrete, continuous, and mixed random variables
- Probability distributions
- Partial descriptors of a random variable
  - Median, Mean, Mode
  - Variance, Standard Deviation, Coefficient of Variation
  - Coefficient of Skewness
- Common distribution models
- Distribution conditioned on events

Multiple Random Variables

- Conditional moments
- Multivariate distribution models

Function of random variables

- First and second moments of functions
- Distribution of functions

Probabilistic models

- Bernoulli trial
- Bernoulli sequence and related distributions
- Poisson and related distributions
- Asymptotic models

Statistical inference

- Method of moments
- Method of maximum likelihood
- Bayesian statistics and conjugate distributions

Formulation of the reliability problem

- Limit-state functions
- Capacity and demand safety format
- Component vs. system reliability problems

Elements of decision theory

Additional topics may be covered based on time and interest of the students

Academic Integrity:

- The University of Illinois at Urbana-Champaign requires all students to adhere to the Student Code [see Part 4 on Academic Integrity, Part (d) on Plagiarism] www.admin.uiuc.edu/policy/code/index.html
- It is NOT acceptable to copy another student's work and represent it as your own.

- It is NOT acceptable to work problems as a group unless specifically authorized in the written assignment.
- You MAY speak with other students about the problem and methods of solutions, sticky points, etc.
    - But you MUST create-write your own solutions independently of others.
    - Solutions with similar appearance will receive a 0 score followed by consideration of other disciplinary actions.

Copyright Statement:

The handouts used in this course are copyrighted. By "handouts," it is meant all materials that have been generated for this course. Such materials include but are not limited to syllabi, quizzes, exams, problem sets, worked problems, materials posted on Compass2g, in-class materials, review sheets, additional problem sets, and solutions. Because these materials are copyrighted, you do not have the right to copy them, or possess copies of them outside of the normal course uses for which they were intended. Certain violations of these copyrights could be treated as violations of academic integrity.

American with Disabilities Act:

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. To obtain disability-related accommodations for this class, students with disabilities are advised to contact me and the Division of Rehabilitation-Education (DRES) as soon as possible.