Uncertainty and Risk in Urban Infrastructure Systems

CEVE/STAT 313 – Spring 2010

MWF 10:00 AM – 10:50 AM, Ryon Laboratory, Room 201

by

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Course objectives:

To introduce methods and principles that help quantifying the effects of uncertainty in the performance prediction of engineered infrastructure systems. New concepts are presented with examples and exercise problems from all branches of engineering. Students will learn to apply quantitative risk analysis and modeling tools relevant to problems in modern infrastructure engineering and probabilistic decision making. The course emphasizes that the systematic treatment of uncertainty and risk quantification are essential for adequate engineering planning, design, and operation of urban systems. It becomes clear that uncertainties in external loads, structural strength, and interdependent conditions are unavoidable but manageable.

Scope:

The course starts with a detailed study of the roles of probability in engineering, and then focuses on computer-based methods in probability, the Bayesian approach to systematically combine real data with expert judgment, risk analysis tools, and infrastructure safety. All mathematical concepts are developed in class and illustrated in the context of real engineering problems and phenomena.

Course calendar:

Week	Date	Lecture Topic	Suggested Reading
Introduction to uncertainty and risk assessment			
1	Jan. 11 – Jan. 15	Course overview, sample risk assessment studies, rational decision making, and the role of mathematical modeling.	[1] Ch. 1, [3] Ch. 1, [2] Ch. 1-2
Elements of probability			
2	Jan. 18 – Jan. 22	**Martin Luther King, Jr. Day (01/18/10)**, random variables, distributions, conditional probability, total probability, and Bayes' formula.	[1] Ch. 2.3, 3.1

Descriptors of random variables and probability distributions

3	Jan. 25 – Jan. 29	Moments of random variables, expectation, characteristic functions, and functions of random variables, random trials, random occurrences, and summary of distributions.	[1] Ch. 3.1-3.2, 4

Limit and multivariate distributions

4	Feb. 1 – Feb. 5	Multivariate distributions, and distribution of extremes.	[1] Ch. 3.3 [3] Ch. 5

Empirically determined distribution models

5	Feb. 8 – Feb. 12	**Exam I (02/08/10)**, probability papers, and testing goodness-of-fitness of distribution models.	[1] Ch. 7

Error and uncertainty analysis

6	Feb. 15 – Feb. 19	Types of uncertainty, sources of uncertainty, and analysis of errors.	[3] Ch. 10, [4] Ch. 2, [2] Ch. 6

Regression and correlation analyses I

7	Feb. 22 – Feb. 26	Methods of parameter estimation, assessment of parameter accuracy, interval estimation, and linear regression.	[1] Ch. 6, 8

Spring break

8	Mar. 1 – Mar. 5	No class.	

Regression and correlation analyses II

9	Mar. 8 – Mar. 12	Correlation analysis, non-constant variance, multiple linear regression, and nonlinear regression.	[1] Ch. 8

Mote Carlo simulation I

10	Mar. 15 – Mar. 19	**Exam II (03/15/10)**, basics of MCS, generation of random numbers, continuous and discrete random variates, and jointly distributed random variates.	[3] Ch. 11, [4] Ch. 3

Mote Carlo simulation II

11	Mar. 22 – Mar. 26	Simulation of systems, Monte Carlo integration, and variance reduction techniques.	[3] Ch. 11, [4] Ch. 3

Reliability analysis

12	Mar. 29 – Apr. 2	Reliability evaluation, analysis methods, dynamic systems, multi-component systems, and **midterm recess (04/02/10)**.	[4] Ch. 1, 4, [5] Ch. 2-3

Bayesian Approaches

13	Apr. 5 – Apr. 9	Bayesian discrete and continuous cases, Bayesian sampling theory, and Bayesian estimation, regression, and correlation	[1] Ch. 9

Risk analysis and management I

14	Apr. 12 – Apr. 16	Complementary definitions, risk classifications, and risk assessment and management.	[2] Ch. 3, [3] Ch. 15, [5] Ch. 4

Risk analysis and management II

15	Apr. 19 – Apr. 23	Risk identification, risk modeling, and decision making under uncertainty.	[2] Ch. 4, 8, 13, [3] Ch. 16, [5] Ch. 4

Final examination period

16	Apr. 28 – May 5	Comprehensive examination.

Reading material:

[1] Ang, Alfredo H.-S., and Wilson H. Tang, (2006). *Probability concepts in engineering – Emphasis on applications to civil and environmental engineering*. 2nd Ed. New Jersey: John Wiley & Sons, Inc.

[2] Haimes, Yacov Y., (2004). *Risk modeling, assessment and prediction*. 2nd Ed. Hoboken, New Jersey: John Wiley & Sons, Inc.

[3] Singh, Vijay, Sharad Jain, and Aditya Tyagi, (2007). *Risk and Reliability analysis – A handbook for Civil and Environmental Engineers*. American Society of Civil Engineers (ASCE) Press.

[4] Melchers, Robert E., (1999). *Structural reliability analysis and prediction*. 2nd Ed. Chichester: John Wiley & Sons, Inc.

[5] Todinov, Michael T., (2007). *Risk-based reliability analysis and generic principles for risk reduction*. Amsterdam: Elsevier Ltd.

On-line resources:

Course material shared via Owlspace:
- http://owlspace.rice.edu/

Aging infrastructures, system risk, research:
- http://www.infrastructurereportcard.org/
- http://www.sys.virginia.edu/risk/
- http://scitation.aip.org/iso

Course grading:

Homework	20%
Examination I	25%
Examination II	25%
Final examination	30%

Academic honor code:

The Honor System embodies the concept of personal honor in a framework of law and practice. To quote the Constitution, Rice students are placed on their honor by the group "not to violate the trust placed in them in any way."

The result is a system of conducting examinations, writing papers, and performing other academic endeavors with regard for individual honor and without faculty proctoring. Thus, the responsibility for maintaining the validity of academic work is placed on all students.
Website: http://www.ruf.rice.edu/~honor/

Disabilities:

Any student with a documented disability needing academic adjustments or accommodations is requested to speak with me during the first two weeks of class. All discussions will remain confidential. Students with disabilities will need to also contact Disability Support Services in the Ley Student Center.

Office hours:

Wednesdays 11:00 AM – 1:00 PM