Seoul National University
Dept. of Civil and Environmental Engineering Instructor: Junho Song (junhosong@snu.ac.kr)

SPRING 2019
457.646 Topics in Structural Reliability (Theory)
MW 15:30-16:45, 317 Bldg. 35
Instructor: Junho Song

Prerequisites: Undergraduate-level course on probability and statistics

Course Objectives:

This course offers a comprehensive review of structural reliability assessment methods and their applications to engineering problems in general. Topics include formulation of structural reliability problems, first-order and second-order reliability methods (FORM and SORM), system reliability analysis, structural reliability analysis under model or statistical uncertainties, simulation methods and uncertainty quantification methods. Students will apply reliability methods to example problems using available or their own computer codes. As a final term project, each student will apply or develop reliability methods for an engineering/science application he/she chooses.

Course Website: http://etl.snu.ac.kr

Important Dates: (See 'Class Schedule' for more details)

- March 4: Classes begin
- No classes: May 6, 27 and 29 (make-up lectures will be provided)
- Midterm exam: May 8
- Deadline for term project abstracts: May 31 (5pm, Email)
- Make-up classes: June 7 and 14
- June 24: Final project presentation (oral interviews, time and location TBA)
- June 26 (5pm): Deadline for final report (by emails)

Credit: 3 hours

Required Reading: Selected readings shown in the 'Class Schedule'

Reference Textbook (NOT required):

Melchers, R.E., and A.T. Beck (2017). *Structural Reliability Analysis and Prediction*. 3rd Edition, John Wiley, New York, NY.

Ditlevsen, O., and H.O. Madsen (1996). *Structural Reliability Methods*. J. Wiley & Sons, New York, NY (Internet Edition: http://od-website.dk/books/OD-HOM-StrucRelMeth-Ed2.3.7.pdf).

(**Text for Primer**) Ang, A. H-S., and W.H. Tang, Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, 2nd edition, Wiley, New York, 2006.

Homework:

Homework assignments will be given on a weekly basis. Turn them in during class in a week. (Rules on late homework submissions: 30% penalty if submitted on the same day, and NOT accepted afterwards.) A solution set will be posted at the course website. Students are encouraged to use computer programs such as Matlab to solve these problems. Some assignments will require the use of a free Matlab toolbox, FERUM (See below).

Grading:

Homework: 40 %, Midterm Exam: 30 %, Final Term Project and Presentation: 30 %

Computer Program:

Some homework assignments in this class require the use of the reliability code FERUM, which is a Matlab toolbox for general structural reliability analysis and finite element reliability analysis that was developed by Terje Haukaas. The code and a User's guide are downloadable at:

http://projects.ce.berkeley.edu/ferum/

Final Term Project:

Each student is required to perform a final term project and make a 10-minute oral presentation at the 'Reliability Symposium' or individual oral exams (time and location to be announced). The term paper describing the results of the project is due on June 26 (5pm by email). It should be in a word-processed format and contain sufficient details of the project.

A one-page abstract of the term project should be submitted until May 31 (in class). The abstract should state the title, the name of the student, 300-word description of the proposed work, main objectives, technical approach to be used, and the expected results. The student is required to get the instructor's approval before proceeding with the proposed work. No group project is allowed.

Possible topics include

1. [Method] Development of new analytical or computational methods of structural reliability
2. [Application] Comprehensive reliability analysis or risk-quantified design of engineering components or systems
3. [Programming] Development of new computer codes, modules or a package

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Class Schedule (Spring 2019)

Class	Topics	Read
1-2	**I. Introduction**: Uncertainty & risk; Structural/system reliability	
1-2 3-4 5-6 7-8	**II. Basic Theory of Probability and Statistics ("Primer")** Events and probability – set theory Mathematics of probability: axioms, theorems and rules Random variables: probability functions and partial descriptors Normal and Lognormal distributions Distributions related to Bernoulli sequence/Poisson process Multiple random variables; Joint probability functions; Correlation Mathematical expectations of functions of random variables (linear/nonlinear) Distribution of functions of random variables	A&T*
7-8 9-10 11-12 13-14 15-16	**III. Structural Reliability – Component** Joint probability distribution models Elementary reliability analysis & indices Reliability index by Mean-Value First-Order Second-Moment Method (MVFOSM) Hasofer-Lind reliability index (HL/FOSM) Generalized reliability index Reliability "index" & "methods" First-Order Reliability Method (FORM) FORM examples and issues Second-Order Reliability Methods (SORM) FORM importance vectors FORM sensitivity measures	CRC14**
15-16 17-18	**IV. Structural Reliability - System** Definition of "system"; "Structural" system reliability analysis Inclusion-exclusion formula; FORM approximation Bounding methods: theoretical bounding formulas; bounds by linear programming Matrix-based System Reliability (MSR) method and its applications	ADK1** (CRC15**)
19-20	**V. Reliability under Model & Statistical Uncertainties; Midterm Exam** Bayesian parameter estimation; Reliability under epistemic uncertainties	ADK2**
21-23	**VI. Simulation Methods** Monte Carlo simulations; Importance sampling; adaptive sampling, etc. Latin Hypercube Sampling; Markov Chain Monte Carlo methods	REM Ch3**
24-25	**VII. Random Field; Term Project Abstract** Mathematical model of random fields Discrete representation of random fields: K-L expansion, etc.	Sudret**
25-26	**VIII. Response Surface** Basic formulations and approaches to construct RS models; UQ methods	CRC19** Tipping**
27	**IX. Finite Element Reliability and Sensitivity** Uncertainty/Reliability quantification using FE analysis; Sensitivity calculations	Haukass**
28	**X. Reliability-Based Design** Reliability-based design codes; Reliability-based design/topology optimization	Review papers**
June 24	**Final Project Presentation – Individual Oral Exams (Time and Location TBA)**	
June 26	**Final Report Deadline (by email, 5pm)**	

*: Ang, A. H-S., and W-H. Tang (2006). *Probability concepts in engineering: emphasis on applications to civil and environmental engineering*, 2nd edition, Wiley, NY.
**: Electronic or paper copies will be provided by the instructor.