CEE 204: Structural Reliability

Course websites

This course will be facilitated online through Canvas: `https://canvas.stanford.edu/courses/132203`

We will use a Slack channel to facilitate discussions: `cee204.slack.com`. Please reach out to your classmates and teaching team there, as we would love to have a collective conversation and all help each other.

Course Meeting Times

- Lecture videos will be provided on the website for viewing on your own schedule.
- Interactive discussions and office hours will be on T/Th 8:30 - 9:50 am on Zoom.

Teaching team

Instructor
Jack Baker
bakerjw@stanford.edu
Office hours: T/Th 8:30 - 9:50 am

Course Assistant
Yilin Chen
Office hours: M/W: 2:30-4:00 pm

Learning objectives

This course is designed to introduce graduate students to concepts and applications of structural reliability. Upon completion of this course, students will be able to:

- Compute first- and second-order estimates of failure probabilities of engineered systems
- Compute sensitivities of failure probabilities to assumed parameter values
- Measure the relative importance of the random variables associated with a system
- Update reliability estimates based on new observational data
- Identify the relative advantages and disadvantages of various analytical reliability methods, as well as Monte Carlo simulation
- Use reliability tools to calibrate simplified building codes
- Perform reliability calculations related to performance-based engineering

Course topics

- General component reliability
- First-order second-moment (FOSM) methods
- First order reliability method (FORM)
- Monte Carlo simulation
- Code calibration
- System reliability
- Acceptable risk/reliability

Prerequisites

This course will assume a basic knowledge of probability concepts such as random variables and their descriptions (equivalent to completion of CEE 203). Some brief videos showing the type of background knowledge required for the class are available at the following links:

1. Set theory: `https://youtu.be/BA0GXX_Un9g`
2. Total probability theorem: `https://youtu.be/JChmNGQ4PkQ`
3. Random variables: `https://youtu.be/3ydswAYdep8`
4. Joint distributions: `https://youtu.be/vGHTztxS2F0`
5. Moments and expectations: `https://youtu.be/XrW5iIj9mVo`
6. The normal distribution: `https://youtu.be/jj_WoJdijQY`

Some experience with Matlab programming is also needed. Students with any questions regarding prerequisites should talk to the instructor.

Textbooks

There is no required textbook for this course. The following resources may provide useful supplemental material. Both are available online (the Melchers and Beck book requires you to access it through the Stanford network, or have proxy access enabled).

> Melchers, R. E. and Beck, A.T (2018). Structural reliability analysis and prediction, 3rd Ed., John Wiley Chichester; New York.
> `https://onlinelibrary.wiley.com/doi/book/10.1002/9781119266105`

> Ditlevsen, O., and Madsen, H.O. (2007). Structural Reliability Methods, Internet Edition 2.3.7, John Wiley & Sons, Chichester, UK.
> `http://od-website.dk/books/OD-HOM-StrucRelMeth-Ed2.3.7.pdf`

Evaluation

You will be evaluated on your ability to explain the course concepts and perform calculations using the techniques presented. Grades will be computed using the following weighting scheme:

Homework	30%
Midterm	30%
Final assessment	40%

Homework assignments will typically consist of calculations that develop understanding of the materials presented in class. Exams will be similar to the homework in content and format. **If you have schedule conflicts with the exam dates, please speak with me immediately.**

Homework policy

- Homework assignments are to be submitted on GradeScope by 11:59pm on the date due. Late homework will be penalized 10% per day late. Homework submitted after the solutions have been provided will not be accepted.

- Some homework assignments will require simple computer calculations. Matlab will likely be the easiest tool for performing these calculations, and is the software package that will be supported by the instructor. Matlab is free for students at `https://uit.stanford.edu/news/get-matlab-and-simulink-no-charge`. You are free to use another program if you prefer, as long as you clearly document what you have done.
- Clearly explaining what you have done to solve a homework or exam problem is at least as important as obtaining a correct numerical result. Computer or calculator computations must be accompanied by appropriate documentation of how the computation was carried out. This might involve writing a few sentences of explanation, or attaching a printout of commented computer code.

Honor code

It is expected that Stanfords Honor code will be followed in all matters relating to this course. You are permitted to meet and exchange ideas with your classmates while studying and working on homework assignments, but you are individually responsible for your own work and for understanding the material. You are not permitted to copy or otherwise reference another students homework or computer code.

Course material copyrights

The materials provided to you for this course are copyrighted or licensed to Stanford University. Stanford grants you a limited license to use the materials solely in connection with the course for your own personal educational purposes. Any use of the materials outside of the course may be in violation of copyright law. You agree that you will not post, share or copy the materials. You agree that you will only save the materials for the duration of the course.

Penalties for copyright infringement can be harsh. Fines of up to $150,000 in civil statutory damages may apply for each separate willful infringement, regardless of the actual damages involved. Stanford may also take administrative action against copyright infringement, including loss of networking privileges and SUNet ID, or disciplinary action up to and including termination for faculty and staff, and expulsion for students. Proceeding with this course indicates that you have read the above statement, agree to be bound by its terms and you agree to delete course materials on the earlier date of 14 days from the conclusion of the course or 14 days after withdrawing from the course.

Respect for Diversity

It is my intent that students from diverse backgrounds, perspectives, and situations be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity in gender, sexuality, disability, age, socioeconomic status, ethnicity, race, religion, political affiliation, and culture. I acknowledge that there is likely to be a diversity of access to resources among students and aim to support all of you as best as I can. Please let me know ways to improve the effectiveness of the course for you personally or for other

students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

All people have the right to be addressed and referred to in accordance with their personal identity. Please indicate the name that you prefer to be called and, if you choose, identify pronouns with which you would like to be addressed. I will do my best to address you accordingly and support classmates in doing the same.

Students with disabilities

Students with Documented Disabilities who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend accommodations, and prepare an Accommodation Letter for faculty. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations (723-1066, `https://oae.stanford.edu/`).

Tentative schedule

I plan to provide lecture videos for your offline viewing, and to use our course meeting time for interactive discussions and office hours. The dates below are provided as a rough guide to help you anticipate your workload.

The official schedule, along with guidance regarding when you should watch course videos, is available at the following link. Please bookmark it.

`https://docs.google.com/spreadsheets/d/1MCwRBMpI-_RsYYeTft1m8vyp4GFnmSe_Zi_BIqjWvh8`

Date	Day	Topic	HW assigned	HW due
1/12	Tues	Introduction	1	
1/14	Thurs	Basic reliability formulations		
1/19	Tues	Multivariate normal & second moment methods	2	1
1/21	Thurs	Second moment methods I: MVFOSM		
1/26	Tues	Second moment methods II: Hasofer-Lind b	3	2
1/28	Thurs	Full distribution methods I: transformations		
2/2	Tues	Full distribution methods II: FORM	4	3
2/4	Thurs	Full distribution methods III: SORM		
2/9	Tues	Monte Carlo	5	4
2/11	Thurs	Monte Carlo		
2/16	Tues	Midterm	Midterm	Midterm
2/18	Thurs	Code calibration		
2/23	Tues	System reliability	6	5
2/25	Thurs	System reliability		
3/2	Tues	System reliability, Reliability updating		
3/4	Thurs	Time-variant reliability	7	6
3/9	Tues	Time-variant reliability		
3/11	Thurs	Reliability and numerical codes, risk acceptance		7
3/16	Tues	Risk communication		
3/18	Thurs	Final	Final	Final