Northwestern | McCORMICK SCHOOL OF ENGINEERING

Civil & Environmental Engineering 306
Engineering Decisions Under Uncertainty

Civil and Environmental Engineering Department
McCormick School of Engineering

Instructor: Ying Chen
Office: Tech A224
In-person/on-line office hours: 1:00 - 2:00 pm on Thursdays/Flexible but by appointment
Email: y-chen@northwestern.edu
Website: http://sites.northwestern.edu/ych168/

Textbook (recommended):

1) Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, by Alfredo H-S. Ang and Wilson H. Tang
2) Applied Statistics and Probability for Engineers, 7th Edition, by Douglas C. Montgomery, George C. Runger.

Class Times and Locations:

MoWeFr: 12:00~12:50 PM, Location: Tech M144
Tu: 12:30 ~ 1:20 PM, Location: Tech M356

Course Description

Uncertainty Analysis in CEE is designed for advanced undergraduate and first-year graduate students in Civil and Environmental Engineering. The course introduces probability and statistics with a strong emphasize on risk-informed analysis and decision-making for complex engineering systems.

Building on prior coursework in probability and statistics, this course examines how uncertainty and risk influence engineering analysis, design, and policy decisions. Emphasis is placed on real-world case studies, probabilistic modeling, risk assessment, and quantitative decision frameworks applied to civil and environmental engineering problems.

Core topics include fundamental probability concepts (marginal, joint, and conditional probability), statistical inference (confidence intervals, hypothesis testing, chi-square analysis), and regression methods. These tools are integrated into structured decision-making approaches such as decision trees, expected value analysis, Bayesian updating, risk metrics, and evaluation of alternatives under uncertainty. Applications will draw from water resources, climate change adaptation, transportation systems, and infrastructure resilience.

The primary goal of this course is to develop a rigorous understanding of uncertainty quantification and risk-informed decision-making. By the end of the course, students will be able to formulate engineering problems probabilistically, assess and communicate risk, and support data-driven decisions in complex and uncertain environments. This foundation prepares students for advanced coursework in analytics, risk analysis, and data science, and equips them with essential skills for professional engineering practice.

The course format includes lectures, hands-on case studies, applied assignments, one in-class midterm examination, and a comprehensive final exam.

Course Outcomes:

1. Apply joint probability distributions, covariance and correlation to multivariate uncertainty problems.
2. Develop and implement Normal and Log-normal models for engineering data and uncertainty characterization.
3. Apply Chi-Squared and F-distribution to variance analysis and model evaluation.
4. Apply the Central Limit Theorem and *t*-distribution to sampling-based inference.
5. Construct confidence and prediction intervals for model-based decision making and anomaly detection.
6. Develop and interpret linear regression models for engineering systems.
7. Evaluate competing regression models using R^2, model-parameter confidence intervals, and parsimony principles.
8. Conduct hypothesis testing using p-values and evaluate Type I and Type II errors in engineering decision contexts.
9. Identify abnormal data and evaluate model performance using MSE, RMSE, and MAE.
10. Apply probabilistic methods to engineering risk analysis and case studies.

Tentative Schedule

It is a tentative schedule of lectures and readings for this course. We will try to keep approximately on this schedule.

(Note that we may change the agenda during the fall quarter)

Schedule	Lecture Session			Discussion Session	Handouts	Hand-ins	Topics
	Mon	Tue	Wed	Fri			
Week1			9.23	9.25	Syllabus HW1		Introduction to Course/ Role of Probability and Statistics in Engineering Multivariate Uncertainty Foundations
Week2	9.28	9.29	9.30	10.2	HW2		Multivariate Modeling & Engineering Applications
Week3	10.5	10.6	10.7	10.9	HW3	HW1	Normal and Log-Normal Models
Week4	10.12	10.13	10.14	10.16		HW2	Variance Analysis: Chi-Squared and F Distributions

Week5	10.19	10.20	10.21 **Midterm**	10.23	HW4	HW3	Central Limit Theorem & t-Distribution
Week6	10.26	10.27	10.28	10.30			Confidence & Prediction Intervals
Week7	11.2	11.3	11.4	11.6	HW5	HW4	Hypothesis Testing & Error Types
Week8	11.9	11.10	11.11	11.13			Linear Regression Fundamentals
Week9	11.16	11.17	11.18	11.20		HW5	Multiple Regression & Model Evaluation
Week10	11.23	11.24	11.25 **No Class**	11.27 **No Class**			Model Performance & Abnormal Data
Week11	11.30	12.1	12.2	12.4 **Final**			Probabilistic Risk Analysis & Case Studies

---

In-Person Instruction

Canvas

We will use Canvas to distribute readings, assignments, and grades.

Zoom

Based on students and instructors' mutual preference, we may use Zoom to host some office hours or discussion sessions.

Assignments

We have five homework assignments. These assignments are mainly from the lectures. These assignments will help you understand concepts and ideas you've learned from lectures.

Late Assignment Policy: the penalty is **10%** off the grade of your project or each assignment for every additional day after the deadline.

Grading

Your final grade will be composed from the following items:

Attendance: 0.3%*10 = 3%
Pre-class Activity: 2% * 1 = 2%
Assignments: 10% *5 = 50%
Mid-term Exam: 20% *1 = 20%
Project: 25%*1 = 25%

Letter grades are assigned as follows:

Points Letter Grade	Percentage
A	93 – 100
A-	90 – 92
B+	87 – 89
B	83 – 86
B-	80 – 82
C+	77 – 79
C	73 – 76

C-	70 – 72
F	Below 70

Office Hours, E-mail

Your office visits are certainly not limited to my regular office hours, but appointments by email are preferred for non-regular office hour time. Even my regular office hours, if you could send me an email to confirm that would be great in case I have any other conflicts. Email is a good way to communicate with me since I usually answer messages within one day of receiving them.

Accessibility Statement

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (e: accessiblenu@northwestern.edu; p: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

Religious Observance Statement

Northwestern is committed to fostering an academic community respectful and welcoming of persons from all backgrounds. To that end, the policy on academic accommodations for religious holidays stipulates that students will not be penalized for class absences to observe religious holidays. If you will observe a religious holiday during a class meeting, scheduled exam, or assignment deadline, please let me know as soon as possible, preferably within the first two weeks of class. If exams or assignment deadlines on the syllabus fall on religious holidays you observe, please reach out so that we can discuss that coursework.

Course Details Subject to Change

Please note that the specifics of this course syllabus are subject to change in the case of unforeseen circumstances. I will notify students of any changes as soon as possible. Students will be responsible for abiding by the changes.

Exceptions to Class Modality

Class sessions for this course will occur in person. Individual students will not be granted permission to attend remotely except as the result of an Americans with Disabilities Act (ADA) accommodation as determined by AccessibleNU.

Community health remains our priority. If you are experiencing symptoms of COVID-19, do not attend class and follow the steps outlined by the CDC for testing and isolation. Contact me as soon as possible to make plans to complete your coursework.

Students who experience other personal emergencies should contact me as soon as possible to arrange to complete coursework. Should public health recommendations prevent in-person class from being held on a given day, I or the university will notify students.

Prohibition of Recording of Class Sessions by Students

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University's Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

Support for Wellness and Mental Health

Northwestern University is committed to supporting the wellness of our students. Student Affairs has multiple resources to support student wellness and mental health. If you are feeling distressed or overwhelmed, please reach out for help. Students can access confidential resources through the Counseling and Psychological Services (CAPS), Religious and Spiritual Life (RSL) and the Center for Awareness, Response and Education (CARE). All Northwestern students are also eligible to access support at no cost though TimelyCare, a virtual mental health platform that provides counseling, health coaching and 24/7 on-demand services.

Additional information on the resources mentioned above can be found here:
https://www.northwestern.edu/counseling/
https://www.northwestern.edu/religious-life/
https://www.northwestern.edu/care/
https://www.northwestern.edu/studentaffairs/timelycare.html

Northwestern University Syllabus Standards

This course follows the Northwestern University Syllabus Standards. Students are responsible for familiarizing themselves with this information.

https://www.registrar.northwestern.edu/registration-graduation/northwestern-university-syllabus-standards.html