Northwestern | McCORMICK SCHOOL OF ENGINEERING

Civil & Environmental Engineering 306
Uncertainty Analysis in CEE

Civil and Environmental Engineering Department
McCormick School of Engineering

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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) Walpole, et al. *Probability and Statistics for Engineers and Scientists*. 9th ed. Prentice Hall, 2017.

Class Times and Locations:

MoWeFr: 12:00~12:50 PM, Location: University Hall 101
Tu: 12:30 ~ 1:20 PM, Location: University Hall 101

Course Description

Uncertainty Analysis in CEE is for advanced undergraduate and first-year graduate students, which introduces probability and statistics with an emphasis on solving Civil and Environmental engineering questions.

In this course, we will cover the basic concepts of probability such as marginal probability, joint probability, and conditional probability; key statistical concepts, confidence intervals and their interpretation, hypothesis testing procedures, chi-square analysis, etc.; a specific topic: regression methods. To present these ideas clearly, we will take the application of problems in water resources, climate change, transportation, infrastructure, etc. as examples.

The goal of this course is to thoroughly understand all the material presented and master these basic concepts and procedures. After you study and work through this course, you should be prepared to participate in advanced analytics and data science courses with a firm understanding of probability and statistics.

The primary format of this course will be lectures, hands-on case studies, assignments, one in-class midterm exam, and one final exam.

Course Outcomes:

1. Define Random Variables, Sampling, and Mathematical Expectation
2. Compute Joint Probability Distributions, Covariance and Correlation
3. Develop and apply Uniform, Binomial, Poisson, Normal and Log-normal distributions
4. Use Probability paper to analyze Normal random variables
5. Use Chi-Squared Distribution to develop a Goodness-of-fit test; apply Chi-Squared and *F*-distributions to Sampling Distribution of Variance
6. Apply Central Limit Theorem and *t*-distribution to Sampling Distribution of Mean
7. Estimate Confidence Intervals with known and unknown Population Variance; use Prediction Intervals to detect Outliers
8. Use Linear Regression to model relationships between variables
9. Use the Coefficient of Variation ($R2$) and Model-Parameter confidence intervals to find the most Parsimonious Regression Model
10. Postulate Null and Alternative Hypotheses/calculate Type I and II errors; test Hypotheses using *p*-values
11. Could identify abnormal data and use MSE, RMSE, and MAE to evaluate a regression model
12. Use a probabilistic approach for risk analysis

Course Outcomes the following ABET program outcomes will be addressed in this course:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to communicate effectively with a range of audiences.
3. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
4. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
5. Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

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	Mon	Tues	Wed	Fri	Handouts	Hand-ins	Topics
Week1			9.25	**9.27**	**Syllabus HW1**		**Introduction to Course/ Role of Probability and Statistics in Engineering**
Week2	9.30	10.1	10.2	10.4	HW2		Sample spaces, Events, Probabilities, Bayes' Theorem
Week3	10.7	10.8 Office Hours	10.9	10.11	HW3	HW1	Random Variables, Probability Function, Uniform Distribution
Week4	10.14	10.15 Office Hours	10.16	10.18		HW2	Normal, Lognormal, Bernoulli, Binomial, Poisson Distribution, Describing Qualitative Data
Week5	10.21	10.22 Office Hours	10.23	10.25	HW4	HW3	Describing Quantitative Data, Normal Distribution Table
Week6	10.28 MID TERM	10.29 Lecture	10.30	11.1			Sampling, Chi-square Distribution, F and t Distribution, Point and Interval Estimation
Week7	11.4	11.5 Office Hours	11.7	11.8	HW5	HW4	Introduction to Hypothesis Testing, Hypothesis Mean Testing (One population)
Week8	11.11	11.12 Office Hours	**11.13**	11.15			Hypothesis Mean (Two population), Variance (one/two population) Testing
Week9	11.18	11.19 **Lecture**	11.20	11.22		HW5	Type I & II Errors, Correlation, Introduction to Regression
Week10	11.25 **No Class**	11.26 Office Hours	11.27 **No Class**	11.29 **No Class**			
Week11	12.2	12.3 Office Hours	12.4	12.6			Simple Linear Regression, Model Evaluation, Course Review

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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: 5%

Sometimes I will assign some open questions for the next lecture, and you will get something to read or think about in advance. Please be prepared for a three or five-minute in-class presentation. Depending on the time, I may randomly ask some students to present their findings.

Assignments: 10% *5 = 50%

Exams: (20% *1 + 25%*1) = 40%

Letter grades are assigned as follows:

Points	Letter Grade Percentage
A	100 – 90
A-	89 – 85
B+	84 – 80
B	79 – 75
B-	74 – 70
C+	69 – 65
C	64 – 60
F	Below 60

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.