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 (recommendated):

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

2) Myers, Sharon. *Student Solutions Manual for Probability & Statistics for Engineers & Scientists*. 9th ed. Prentice Hall, 2017.

3) Jake VanderPlas. Py*thon Data Science Handbook: Essential Tools for Working with Data*, 2016.

Class Times and Locations:

MoWeFr: 12:00~12:50 PM, Location: Tech L221
Tu: 12:30 ~ 1:20 PM, Location: University Hall 102

Course Description

Uncertainty Analysis in CEE is for advanced undergraduate and first years graduate students, which introduces probability and statistics with an emphasis on solving Civil and Environmental engineering (and other) questions, and basic data engineering and data science concepts.

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.; basic process for collecting, displaying and analyzing from data; two specific topics, time series analysis and regression methods. In order to present these ideas clear, we will take the application to problems in water resources, climate change, transportation, infrastructure etc. as examples.

The ultimate 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 advanced analytics and data science courses with a firm understanding of probability, statistics, and data science.

The primary format of this course will be lectures, hands-on case study, assignments, a report, one in-class exam, and one take-home 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, Log-Normal distributions
4. Use Probability paper to analyze Normal and Log-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, Non-linear, and Multiple-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. Get familiar with data collecting, preparing, displaying, analyzing process
12. Could identify abnormal data and use MSE, RMSE, and MAE to evaluate regression model
13. Use 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			9.21	9.23	Syllabus HW1		Introduction Review of Critical Probability concepts
Week2	9.26	9.27 Introduction to Big data	9.28	9.30	Project Topics		Review of Critical Probability concepts
Week3	10.3	10.4 Office Hours	10.5	10.7	HW2	HW1	Review of Critical Probability/Statistical concepts
Week4	10.10	10.11 Lecture	10.12	10.14			Review of Critical Statistical concepts
Week5	10.17	10.18 Office Hours	10.19 MIDTERM	10.21	HW3	HW2	Review of Critical Statistical concepts
Week6	10.24	10.25 Office Hours	10.26	10.28		HW3	Correlation Simple Linear Regression
Week7	10.31	11.1 Introduction to Data Science	11.2	11.4	HW4		Multiple Regression
Week8	11.7	11.8 Office Hours	11.9	11.11		HW4	Issues in Regression Analysis
Week9	11.14	11.15 Introduction to Data Visualization	11.16	11.18			Multivariate Analysis
Week10	11.21	11.22	No Class	No Class			Time Series Analysis

Week11	11.28	11.29 Office Hours	12.1	12.3	Final Exam	Report and Code	Time Series Analysis

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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.

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.

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.

Project

We will have a class project for each group which can be self-organized with the approval from the instructor. The size of each group is three at maximum. Each group will be assigned a case with the real data and problems in the real world. Each group also can use existing online datasets or download your own datasets from online resources, like Facebook, Twitter, Yelp, etc. We expect each group could generate a report to show some interesting findings. We encourage each group to use the dataset in their fields.

Grading

Your final grade will be composed from the following items:

Attendance: 0.25% * 40 = 10%

Sometimes I will assign some open questions for the next lecture, and you will get something to read or think about it 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% *4 = 40%

Project: 20% *1 = 20%

Exams: (15% *1 +15%*1) = 30%

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 online office visits are certainly not limited to my regular office hours, but appointments by email preferred for non-regular office hour time. Even my regular office hours, if you could send me an email to confirm that will 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.