

Western University
Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9520 – Engineering Statistics & Reliability

COURSE OUTLINE 2024-2025

DESCRIPTION

Engineering systems are analysed using probability theory and statistics to evaluate system performance under uncertainty. The course is focused on practical engineering problems and is designed to develop the students' appreciation for application of uncertainty analysis methods in engineering design. Specifically, students will learn how to analyse and draw conclusions of system performance from statistical data relating to components of engineering systems, use Monte Carlo techniques and basic probabilistic and reliability methods to perform reliability analysis for engineering systems, analyse series and parallel systems, and make decision under uncertainty. The practical problems will include, for example, consideration of uncertainty in the strength of materials, soil behaviour, and environmental loads acting on structures (wind loads, earthquake loads), and how these uncertainties are incorporated in design codes. The general topics are

- Analysis and interpretation of statistical data: data representation, descriptive measures of data, graphic representation of data;
- Analytical models for data analysis: discrete and continuous probability distribution function of one random variable, continuous probability distribution of several random variables, transformation of variables, distribution fitting (method of moments, method of maximum likelihood, and least-squares method), probability paper plots, tests for distributional assumptions, linear regression analysis.
- Reliability assessment of engineering system performance from component data: Application of central limit theorem for system analysis, calculation of system moments, response function, measure of system performance, first order second moment reliability analysis method, reliability index, first order reliability method
- Monte Carlo techniques: general concept, method for generating random values, sample size and error bands.
- Design code calibration: Evaluation of load and resistance factors for target reliability levels.

ENROLLMENT RESTRICTIONS

Enrollment in this course is restricted to graduate students in Civil and Environmental Engineering department, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

INSTRUCTOR CONTACT INFORMATION

Course instructor: Jin Wang, PhD

Email address: jwan2225@uwo.ca

Office: ACEB 4400B

Office hours: Friday's 10:30 to 11:30 AM

COURSE FORMAT

Face-to-face

TOPICS

Topic #	Description	Tentative timeline
1	Introduction	Week 1
2	Drawing conclusion from data <ul style="list-style-type: none">• Random variable, statistical data• Graphic representation of data• Descriptive measure of data	Weeks 1
3	Elements of probability theory <ul style="list-style-type: none">• Random events• Random variables and distributions• Derived distributions• Moments and expectation	Week 2-3
4	Common probabilistic models and observed data <ul style="list-style-type: none">• Probabilistic models• Methods of moments• Methods of maximum likelihood• Least-squares method• Linear regression analysis• Multivariate linear regression analysis	Week 4-5
5	Probabilistic analysis and reliability methods <ul style="list-style-type: none">• Application of central limit theorem• Structural reliability analysis• Second-moment reliability indices• First-order reliability method• Monte Carlo techniques	Week 7-8
6	Introduction to code calibration	Week 9-10
7	Fault trees, decision trees and influence diagram	Week 11
	Final examination	Week 12

There is 'No Class' in reading week (October 12th to 20th)

SPECIFIC LEARNING OUTCOMES

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	25%	<ul style="list-style-type: none"> • Assignments • Project • Examinations 	<ul style="list-style-type: none"> • Understanding of advanced concepts and theories • Awareness of important current problems in the field of study • Understanding of computational and/or empirical methodologies to solve related problems
Research & scholarship	15%	<ul style="list-style-type: none"> • Project 	<ul style="list-style-type: none"> • Ability to conduct critical evaluation of current advancements in the field of specialization • Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	30%	<ul style="list-style-type: none"> • Assignments • Project • Examinations 	<ul style="list-style-type: none"> • Ability to apply knowledge in a rational way to analyze a particular problem • Ability to use coherent approach to design a particular engineering system using existing design tools
Professional capacity / autonomy	5%	<ul style="list-style-type: none"> • Project 	<ul style="list-style-type: none"> • Awareness of academic integrity • Ability to implement established procedures and practices in the coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	15%	<ul style="list-style-type: none"> • Project 	<ul style="list-style-type: none"> • Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively
Awareness of limits of knowledge	10%	<ul style="list-style-type: none"> • Project 	<ul style="list-style-type: none"> • Awareness of the need of assumptions in complex scientific analyses and their consequences • Understanding of the difference between theoretical and empirical approaches • Ability to acknowledge analytical limitation due to complexity of practical problems

ASSESSMENTS

Assessment Type	Material Covered	Tentative Due Date	Weight
Homework Assignments (four)	Topic 2, 3, 4, 5		30%
Project	Project topic to be decided later		30%
Final Examination			40%

Activities in which students must work alone (collaboration is not permitted):

- Course projects are individual and collaborations/group work are not permitted.

REQUIRED TEXTBOOK

Prepared power point slides will be posted on OWL by Dr. Wang covering the material on a weekly basis.

OPTIONAL COURSE READINGS

Ang, A. H-S. and Tang, W. H. Probability concepts in engineering planning and design, Vol. I Basic Principles, John Wiley & Sons, Inc. New York, 1975.

Benjamin, J. R. and Cornell, C. A. Probability, statistics and decision for civil engineering, McGraw-Hill, Inc. New York, 1970.

Madsen H.P., Krenk, S. and Lind N.C. Method of Structural Safety, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1986.

Raiffa, H. Decision Analysis, Addison-Wesley, Reading, MA, 1968.

Thoft-Christensen, P. and Baker, M. J. Structural reliability theory and its application, SpringerVerlag, Berlin, Heidelberg, New York, 1982.

STATEMENT ON THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

The use of AI in the preparation of the project and assignments must be acknowledged in the submission. Please refer to the published [Provisional Guidance for the Use of Generative AI in Graduate Studies](#) at Western University.

CHEATING, PLAGIARISM/ACADEMIC OFFENCES

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence at the following website: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

CONDUCT

Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On

the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

HEALTH/WELLNESS SERVICES

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at <http://www.health.uwo.ca/>.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Faculty of Engineering has a Student Wellness Counsellor. Information on how to schedule an appointment with the counsellor is available at: <https://www.eng.uwo.ca/undergraduate/academic-support-and-accommodations/Student-Wellness-Counselling.html>.

Students who are in emotional/mental distress should refer to Mental Health@Western: <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who is going through or has gone through these traumatic events. If you are experiencing or have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at the following website: https://www.uwo.ca/health/student_support/survivor_support/get-help.html. To connect with a case manager or set up an appointment, please contact support@uwo.ca.

SICKNESS

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Students who are not able to meet certain academic responsibilities due to medical, compassionate or other legitimate reason(s), could request for academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at:

<https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.html>

ACCESSIBLE EDUCATION WESTERN (AEW)

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting,

advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.