CEE4458a – Risk Analysis and Decision Making in Engineering
Course Outline, September 2022

THE UNIVERSITY OF WESTERN ONTARIO - FACULTY OF ENGINEERING SCIENCE
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

CEE 4458a - Risk Analysis & Decision Making in Engineering, Course September 2022

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 student's appreciation for the application of uncertainty analysis methods in engineering design. Specifically, students will learn how to analyze and draw conclusions about system performance from statistical data relating to components of engineering systems, use Monte Carlo techniques and basic probabilistic methods to perform reliability analysis for engineering systems, analyze series and parallel systems, and make the decision under uncertainty. The practical problems considered 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.
- 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
- Monte Carlo techniques: general concept, method for generating random values, sample size and error bands.
- Assessment of engineering system performance from basic events: series system, parallel system, fault tree analysis, event tree analysis.
- Decision making in engineering under uncertainty: risk measures, the objective function for decision analysis, decision criteria, decision analysis based on decision tree approach, decision analysis based on influence diagram.

**Prerequisites:**
Completion of the third year of the Civil or Integrated Engineering program, Statistical Sciences 2141A/B or Statistical Sciences 2143A/B

Note: It is the **student's responsibility** to ensure that all Prerequisite and/or Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also **student’s responsibility** to ensure that they have not taken the course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

**Corequisites:**
None
Antirequisites:
ES458b

Contact Hours:
2 lecture hours/week;
Lectures will be delivered synchronously (but may be changed to asynchronously through pre-recorded videos posted to the course OWL site). Lectures will be organized into learning modules which students should review on a weekly basis. Review of lecture material and self-study should take approximately 4 hours per week.

2 tutorial hours/week.
A 2-hour tutorial session will be delivered synchronously through Zoom each week during the scheduled tutorial hours. Tutorials are not mandatory but students seeking assistance with weekly assignments or clarification on lecture material are strongly encouraged to attend. The link to the Zoom meeting will be posted to OWL.

Instructor:
Dr. H. P. Hong ESB3028; e-mail: hongh@fes.eng.uwo.ca; Secretary: Room 3005 email (smckay@uwo.ca)

Textbook:
Prepared class notes should be brought to each class, and may be purchased at the UWO bookstore (purchase required)

Other references:

Units:
SI units will be used in lectures and examinations

Specific Learning Objectives [GA Indicator]:
KB1. Demonstrate competence in mathematics
KB3. Demonstrate competence in engineering fundamentals appropriate to engineering discipline
KB4. Demonstrate competence in specialized engineering knowledge
PA2. Demonstrate ability to formulate a strategy to solve an engineering problem
ET3. Demonstrates ability to create/develop/adapt appropriate engineering tools
1. Data analysis and representation. At the end of this section, the student should be able to:
   a) Draw histograms for a given set of data
   b) Quantify data using descriptive measures such as a measure of central tendency, variability, asymmetry, peakedness [KB1, KB3, KB4]
   c) Investigate possible linear relationships between data sets using linear correlation [KB1, KB3, KB4]

2. Probability theory. At the end of this section, the student should be able to:
   a) Interpret the probability [KB1]
   b) Apply the conditional probability theorem and the total probability theorem to solve engineering problems [KB1, PA2, ET3]
   c) Apply Bayes Theorem to incorporate information for solving engineering problems [KB1, PA2, ET3]

3. Probabilistic models. At the end of this section, the student should be able to:
   a) Identify physical phenomena that can be modelled using Binomial and Poisson distributions [KB1]
   b) Identify physical phenomena that can be modelled using continuous probabilistic models such as uniform, exponential, gamma, normal, lognormal, gamma, Weibull, Gumbel. [KB1]
   c) Calculate probabilities based on the assumed probabilistic models [KB4, PA2, ET3]
   c) Use extreme probability distributions for environmental parameters [KB4, PA2, ET3]

4. Probabilistic analysis: At the end of this section, the student should be able to
   a) Evaluate the reliability of additive and multiplicative engineering systems [KB4, PA2, ET3]
   b) Understand the concept of reliability index [KB4, PA2, ET3]
   c) Use the first order second-moment reliability method to calculate the probability of failure of engineering systems [KB1, KB4, PA2, ET3]
   d) Carry out analysis using simulation techniques for engineering systems [KB4, PA2, ET3]

5. Relation between reliability and design code. At the end of this section, the student should be able to:
   a) Describe the basis for assigning load and resistance factors in design codes [PA2, ET3]
   b) Understand design code calibration procedures, and calculate resistance and/or load factors to achieve specific target reliability levels [PA2, ET3]

6. Introduction to Fault Tree, Decision Tree and Influence Diagrams: At the end of this section, the student should be able to,
   a) Draw and evaluate fault trees for simple engineering systems [PA2, ET3]
   b) Draw and evaluate decision trees for simple engineering systems [PA2, ET3]
   c) Draw influence diagrams for relatively complex engineering systems, and understand the procedure to logically evaluate the influence diagrams [PA2, ET3]
General Learning Objectives
E=Evaluate, T=Teach, I=Introduce (Introductory Level)

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Evaluation:
The final course mark will be determined as follows:

- Assignments: 35%
- One-hour Quiz: 15%

The quiz will be replaced by a Mini “project” assignment if the in-person Quiz is not feasible due to COVID or any other university policy.

- Final Examination: 50%
- Total: 100%

Note:
Students must pass the final examination to pass this course. Students who fail the final examination will be assigned the aggregated mark as determined above, or 48%, whichever is less.

Quiz and Examination:
The one-hour quiz is open book. The quiz will be replaced by a Mini “project” assignment if the in-person Quiz is not feasible due to COVID or any other university policy. The time for the quiz or mini “project” is to be scheduled during the class.

A three-hour final in-person exam will be held during the examination period on all work covered during the course.

The final examination will be OPEN BOOK.

Assignments:
Weekly assignments: Weekly assignment will be handed out in the tutorial period and due day will be specified (usually one week). Late assignments will receive a grade of zero. Extensions are to be negotiated with the course instructor, not the teaching assistants.

Use of English:
In accordance with Senate and Faculty Policy, students may be penalised up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.
Cheating:
University policy states that cheating is a scholastic offence. The commission of a scholastic offence is
treated by academic penalties that might include expulsion from the program. If you are caught
cheating, there will be no second warning.
For more information on scholastic offenses, please see:
http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

Attendance:
Any student who, in the opinion of the instructor, has not engaged sufficiently in class, laboratory, or
tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation
of the Department concerned, and with the permission of the Dean, the student will be debarred from
taking the regular final examination in the course.

Accommodation:
Students with disabilities work with Accessible Education (formerly SSD) which provides
recommendations for accommodation based on medical documentation or psychological and cognitive
testing. The accommodation policy can be found here: Academic Accommodation for Students with
Disabilities.

Academic Consideration for Student Absence
Students will have up to two (2) opportunities during the regular academic year to use an on-line
portal to self-report an absence during the term, provided the following conditions are met: the
absence is no more than 48 hours in duration, and the assessment for which consideration is being
sought is worth 30% or less of the student’s final grade. Students are expected to contact their
instructors within 24 hours of the end of the period of the self-reported absence, unless noted on the
syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student’s final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are not met, students will need to provide a Student
Medical Certificate if the absence is medical, or provide appropriate documentation if there are
compassionate grounds for the absence in question. Students are encouraged to contact their Faculty
academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly
from a student, whether in support of an application for consideration on medical grounds, or for other
reasons. All documentation required for absences that are not covered by the Self-Reported Absence
Policy must be submitted to the Academic Counselling office of a student's Home Faculty.

For Western University policy on Consideration for Student Absence, see
Policy on Academic Consideration for Student Absences - Undergraduate Students in First Entry
Programs
and for the Student Medical Certificate (SMC), see:

Religious Accommodation
Students should consult the University's list of recognized religious holidays, and should give
reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor if their
course requirements will be affected by a religious observance. Additional information is given in the
Western Multicultural Calendar.

Use of Recordings:
All of the remote learning sessions for this course will be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals under special circumstances. Please contact the instructor if you have any concerns related to session recordings. Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

**Sickness and Other Problems:**
Students should immediately consult with the instructor of Department have any problem that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

**Notice:**
Students are responsible for regularly checking their e-mail and notices posted outside the Civil and Environmental Engineering Department Office.

**Consultation:**
Student are encouraged to discuss problems with their teaching assistant and/or instructor in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

**Course Breakdown:** Engineering Science = 39 AU’s

The attached document “INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED” is part of this course outline.