THE UNIVERSITY OF WESTERN ONTARIO - FACULTY OF ENGINEERING SCIENCE

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

CEE 4458a - Risk Analysis & Decision Making in Engineering, Course Outline 2017

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 methods to perform reliability analysis for engineering systems, analyse series and parallel systems, and make 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, objective function for decision analysis, decision criteria, decision analysis based on decision tree approach, decision analysis based on influence diagram.

Calendar Copy:

Engineering systems are analyzed using probability theory and statistics to evaluate system performance under uncertainty. Risk based methods are used to make decisions under uncertainty.

Prerequisites:

Completion of third year of the Civil or Integrated Engineering program, Statistical Sciences 2141A/B or 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 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 per week; 2 tutorial hours per week; (recommended additional personal study 3 hours). Attendance at the tutorial session is **mandatory**.

Instructor:

Dr. H. P. Hong ESB3028; e-mail: hongh@eng.uwo.ca; *Admin. Asst*: Room 3005

Textbook:

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

Other references:

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.

Hahn, G. J. and Shapiro, S. S. Statistical Models in Engineering, John Wiley & Sons, Inc. New York, 1967.

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

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

Units:

SI units will be used in lectures and examinations

General Learning Objectives

Knowledge Base	X	Individual Work	X	Ethics and Equity	
Problem Analysis	X	Team Work		Economics and Project Management	X
Investigation		Communication		Life-Long Learning	X
Design	X	Professionalism			
Engineering Tools	X	Impact on Society	X		

Specific Learning Objectives:

1. Data analysis and representation. At the end of this section, the student should able to:

   a) Draw histograms for a given set of data

   b) Quantify data using descriptive measures such as measure of central tendency, variability, asymmetry, peakedness

   c) Investigate possible linear relationships between data sets using linear correlation

2. Probability theory. At the end of this section, the student should able to:

   a) Interpret the probability

   b) Apply the conditional probability theorem and the total probability theorem to solve engineering problems

   c) Apply Bayes Theorem to incorporate information for solving engineering problems

3. Probabilistic models. At the end of this section, the student should able to:

   a) Identify physical phenomena that can be modelled using Binomial and Poisson distributions

   b) Identify physical phenomena that can be modelled using continuous probabilistic models such as uniform, exponential, gamma, normal, lognormal, gamma, Weibull, Gumbel.

   c) Calculate probabilities based on the assumed probabilistic models

   c) Use extreme probability distributions for environmental parameters

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

   b) Understand the concept of reliability index

   c) Use the first order second moment reliability method to calculate the probability of failure of engineering systems

   d) Carry out analysis using simulation techniques for engineering systems

5. Relation between reliability and design code. At the end of this section, the student should able to:

   a) Describe the basis for assigning load and resistance factors in design codes

   b) Understand design code calibration procedures, and calculate resistance and/or load factors to achieve specific target reliability levels

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

   b) Draw and evaluate decision trees for simple engineering systems

   c) Draw influence diagrams for relatively complex engineering systems, and understand the procedure to logically evaluate the influence diagrams

Evaluation:

The final course mark will be determined as follows:

Assignments	35%
Quiz	15%
Final Examination	50%
Total	100%

Notes:

(a) Students must pass the final examination to pass this course. Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less.

(b) Students must turn in all laboratory reports, and achieve a passing grade in the laboratory component, to pass this course. Students who do not satisfy this requirement will be assigned 48% or the aggregate mark, whichever is less.

(c) Students who have failed this course previously must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.

Quiz and Examination:

An one-hour quiz will be scheduled during the term, and will be held during the term in the tutorial period. A three-hour final examination will be held during the examination period on all work covered during the course. The date of the quiz will be announced in the class at least one week prior to the quiz.

The quiz and the final examination will be OPEN BOOK.

Assignments:

Weekly assignments: Weekly assignment will be handed out in the tutorial period. One solution to Part A of each weekly assignment must be turned in by each student by the end of tutorial period. Each student must turn in one solution to Part B of each weekly assignment at 9:00 AM Monday morning in locker 58, second floor, Engineering Science Building. 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.

Plagiarism Checking:

The University of Western Ontario uses software for plagiarism checking. Students are required to submit their Laboratory Reports in electronic form to Turnitin.com for plagiarism checking.

Cheating:

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended 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, is absent too frequently from 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.

Accessibility:

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Conduct:

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Late comers may be asked to wait outside the classroom until being invited in by the Instructor. Please turn off your cell phone before coming to a class, tutorial, quiz or exam.

On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: http://www.uwo.ca/univsec/board/code.pdf

Sickness and Other Problems:

Students should immediately consult with the Instructor or Department Chair if they have any problems 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.

For more information concerning medical accommodations, please see:
http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf

Notice:

Students are responsible for regularly checking their email and notices posted outside the Civil and Environmental Engineering Department Office

Consultation:

Students 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.