

CVEEN 2130: STATISTICS AND ENGINEERING ECONOMICS
Department of Civil and Environmental Engineering, University of Utah
Spring Semester 2001: January 9-April 30

Instructor: Wayne D. Cottrell, Ph.D., P.E.
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Course Hours: Tuesday and Thursday 8:25-9:35 A.M.
Room: Engineering & Mines Classroom Building, Room 102 (EMCB 102)
Office: 117 Energy and Minerals Research Office (EMRO) Building
Office Hours: Monday and Wednesday 10:30-11:45 AM
Tuesday and Thursday 12:30-2:00 PM (and by appointment)

Course Description

“Statistics and Engineering Economics” is a two-part course. The first half provides an introduction to engineering probability and statistics. The second half covers engineering economics. The course represents the combination of the former statistics module that was part of CVEEN 3510, “Civil Engineering Materials,” and the half-semester course CVEEN 2130, “Engineering Economics.” “Statistics and Engineering Economics” is a full-semester, 3-credit hour course that meets twice weekly for one and one quarter hours each session.

Goal

One goal of this course is to equip the student with skills in probability and statistics; the student should be prepared to both apply these skills in civil engineering coursework and build upon these skills through further study in probability and statistics. A second goal is to provide the student with fundamental knowledge of engineering economics. As this is the only course at the University of Utah that emphasizes the engineering economy subject matter, the student has an opportunity to learn techniques that can assist in making essential engineering project decisions.

Modules

To reach the goals, CVEEN 2130 is divided into two modules:

1. Engineering probability and statistics (Lessons 1-16)
2. Engineering economics (Lessons 17-29)

The student will be receiving about 20 hours of formal instruction in engineering probability and statistics and 15 hours of formal instruction in engineering economics. In addition, one session will be devoted to a final module 1 exam. Two half-session exams will be included among the regular class meetings.

Objectives

Upon completion of this course’s two modules, the student should be able to:

Module 1:

- ?? Classify data by various methods;
- ?? Pictorially represent data through a variety of graphs;
- ?? Compute measures of central tendency;
- ?? Calculate measures of dispersion;

- ?? Describe data using percentiles and box-and-whiskers plots;
- ?? Define a set, a sample space, and an event;
- ?? Construct and use Venn diagrams;
- ?? Understand the laws and axioms of probability theory;
- ?? Determine the number of possible permutations and combinations of a set of data;
- ?? Grasp the concept of conditional probability;
- ?? Apply conditional probability notation and formulas to various problems;
- ?? Understand and use Bayes' Theorem;
- ?? Define the term "random variable;"
- ?? Explain the difference between a discrete and a continuous random variable;
- ?? Define and use probability mass functions and cumulative mass functions;
- ?? Define and use probability density functions and cumulative distribution functions;
- ?? Understand the notion of a moment;
- ?? Derive the first, second and third-degree moments of both discrete and continuous probability functions;
- ?? Relate the first, second and third-degree moments to the measures of central tendency and dispersion;
- ?? Recognize and apply some common discrete probability functions, including the Bernoulli, binomial, geometric and Poisson distributions;
- ?? Recognize and apply some common continuous probability functions, including the uniform, normal, lognormal, exponential, Student's t, Chi-squared, and F distributions;
- ?? Develop an awareness of the central limit theorem, its various manifestations, and its importance in probability and statistics;
- ?? Compute the mean, standard deviation, and variance of any of the "name" distributions;
- ?? Define and understand the concept of joint random variables;
- ?? Develop and apply joint probability mass functions and cumulative mass functions;
- ?? Develop and apply joint probability density functions and joint cumulative distribution functions;
- ?? Define covariance and correlation;
- ?? Compute and apply covariances and correlations in various problems; and
- ?? Recognize two common joint probability distributions: multinomial and bivariate normal.

Module 2:

- ?? Understand the role of engineering economics in engineering project decision-making;
- ?? Define total, variable, fixed, average and marginal costs;
- ?? Derive average and marginal costs from total and variable costs;
- ?? Relate cost and revenue, and determine profit;
- ?? Find the breakeven point between costs and revenues;
- ?? Define various types of costs, including sunk, opportunity, and book costs;
- ?? Describe the processes involved in life-cycle cost analysis;
- ?? Use per-unit and segmenting models to perform cost estimation;
- ?? Understand the notion of a cost index, and apply cost index calculations;
- ?? Construct cash flow diagrams and tables;
- ?? Understand the concepts of both equivalence and the time value of money;
- ?? Define simple and compound interest; recognize the difference between the two;
- ?? Calculate the various cash flow amounts involved in debt repayment;

- ?? Determine the present equivalent of a future cash flow, and the future equivalent of a present cash flow;
- ?? Diagram and explain a uniform cash flow series;
- ?? Derive and use the discount factors for the annual equivalents of future and present cash flows (and the converses);
- ?? Both calculate, using formulas, and use interest tables to find various discount factors;
- ?? Derive and apply the discount factors for uniform gradients and for geometric gradients;
- ?? Recognize the difference between nominal and effective interest rates;
- ?? Compute an effective interest rate given a nominal interest rate (and the converse);
- ?? Derive and apply the discount factors used in continuous compounding, both for discrete and continuous cash flows;
- ?? Use interest tables to find discount factors for continuous compounding problems;
- ?? Perform present worth analysis of a single alternative;
- ?? Use the capitalized cost method to analyze projects with indefinite lives;
- ?? Perform present worth analysis of multiple alternatives;
- ?? Understand the assumptions inherent in most engineering economic analyses;
- ?? Perform annual worth analysis;
- ?? Perform internal rate of return analysis;
- ?? Define the minimum attractive rate of return and the internal rate of return (IRR);
- ?? Explore some of the computation difficulties associated with the IRR.

Course Outcomes: Tailored ABET Criteria

Items a-k below represent the ABET criteria for undergraduate degree program outcomes that have been specially tailored to the Department's civil and environmental engineering program. Immediately beneath each item, in italics, is a statement regarding how or if CVEEN 2130 intends to meet the given criterion.

"By the time they graduate, students are expected to have:"

- a. an ability to apply knowledge of mathematics (including differential equations), probability and statistics, science (including calculus-based physics and general chemistry), and engineering problems.

Knowledge of mathematics, including advanced algebra and calculus are prerequisites for CVEEN 2130. One of the purposes of this course is to continue to develop the student's knowledge of these subjects through applications in probability, statistics, and engineering economics. The student will apply these tools in homework exercises and on examinations. The applications will be to simple civil engineering problems that require one or more the equations and methods taught. Applications in the sciences, including chemistry and physics, will not be emphasized in this course.

- b. an ability to design and conduct experiments, as well as to analyze and interpret data in more than one of the recognized major civil engineering areas.

The design and conduct of experiments will not be emphasized in this course. The student will begin to analyze and interpret data during the statistics module of the course. The student will be required to both graphically display data and describe data using measures of central tendency and dispersion.

- c. an ability to design a sustainable and buildable civil engineering system, component, or process that meets desired needs and considers life-cycle cost issues.

The student will be introduced to the subject of life-cycle cost analysis in the engineering economics module of CVEEN 2130. The student will also be introduced to some of the techniques that are used in project evaluation. As this is an introductory course, the student will not be expected to do any design work.

- d. an ability to function on multi-disciplinary teams.

This subject will not be emphasized in this course, although the student may have opportunities to perform both in-class exercises and homework assignments, under his or her own discretion, as part of a team.

- e. an ability to identify, formulate and solve civil engineering problems in at least four of the following areas: structural, geotechnical, transportation, environmental, and water resources.

The students will receive instruction and training in analytical techniques that will enable them to solve problems in these disciplines.

- f. an understanding of civic, professional and ethical responsibility, especially as it relates to health and safety, and the importance of professional licensure.

These topics will not be emphasized in this course. The student should begin to appreciate the ideals of professional responsibility, however, as they relate to the neatness and organization of his or her work.

- g. an ability to communicate effectively using written, graphical, and verbal skills.

Skills in these areas will be required of all students in this course. The homework assignments feature a mixture plotting and computational exercises. The students will be expected to turn in neat, well-organized products. Further, the students will have various opportunities to engage in topical discussions in class.

- h. the broad education necessary to understand the ethical, economic, environmental, social and political impact of engineering solutions in a global and societal context.

During the engineering economics module, the student will work toward developing an understanding of the economic viability of engineering solutions. The student will begin to understand how the time value of money, equivalent worth, and rate of return are essential elements in determining the cost-efficiency of engineering projects. These subjects represent a broadening of the student's usual focus on the technical aspects of engineering.

- i. a recognition of the need for and the ability to engage in life-long learning and continuing engineering education as a necessary part of professional practice.

Although the importance of this criterion is acknowledged, it will not be explicitly emphasized in this course.

- j. a knowledge of contemporary issues that are affecting our infrastructure and environment.

As this course emphasizes fundamental concepts, contemporary issues will not be emphasized. The instruction will include, however, references to current events; the intent will be to help the student associate the course material with existing public concerns.

- k. an understanding of and the ability to use the techniques, skills (including engineering economics), and tools necessary for professional civil engineering practice.

The students will be required to write, compute, discuss, graph and, in a limited capacity, discuss their work. The students will be at liberty to either use computers or perform manual calculations for some of problems. The importance of the subjects being taught to the students' burgeoning careers will be repeatedly emphasized. Numerous examples and applications will be provided to facilitate the students' integration of the various tools with civil engineering practice.

Assessment

The following assessment techniques will be used in this course:

Homework assignments (semiweekly). The homework assignments will require the students to apply the techniques and consider the concerns covered in the lessons, the textbook, and supplemental reading materials. The completion of these problems will involve skills in mathematical computation, usage of spreadsheet software, preparing written summaries of results, preparing short essays, and graphically displaying data.

Examinations (four). The first exam will cover the first module of the course (roughly the first half of the course), while the second exam will cover the second module. The purpose of these exams will be to evaluate the students' understanding and mastery of the subject matter in a controlled environment. The format of the exams is under development.

Exercises (most lessons). A variety of exercises will be used during the lessons to engage the students in the material. The exercises may include short oral and written assignments. The exercises will be designed to incite discussion, get the students to think, get the students to participate, get the students to apply the techniques being explained, uncover unclear areas, and reveal a lack of preparation. The questioning techniques might include general questions, calling on students individually, getting the students to think first and then answer or write, and having pair or small-group discussions before requesting a response. Participation in the discussions will be considered in the final grades; the students will be expected to turn in their in-class work for review.

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Prerequisites: Calculus (MATH 1210-1220 series); CVEEN 1000, CVEEN 2000, a similar introductory civil engineering course.

Grading System: Full-Semester Students

Element	Percentage
Homework (27 assignments)	
Odd-numbered assignments (14)	20%
Even-numbered assignments (13)	10%
Exams 1 & 3 (mid-Module exams)	20%
Exams 2 & 4 (Module "Final" exams)	40%
Class Participation and Attendance	10%
TOTAL	100%

Grading System: Statistics Students

Element	Percentage
Homework (15 assignments)	
Odd-numbered assignments (8)	20%
Even-numbered assignments (7)	10%
Exam 1 (mid-Module exam)	20%
Exam 2 (Module 1 "Final" exam)	40%
Class Participation and Attendance	10%
TOTAL	100%

Grading System: Engineering Economics Students

Element	Percentage
Homework (12 assignments)	
Odd-numbered assignments (6)	20%
Even-numbered assignments (6)	10%
Exam 3 (mid-Module exam)	20%
Exam 4 (Module 2 "Final" exam)	40%
Class Participation and Attendance	10%
TOTAL	100%

Note: The "class participation and attendance" portion of the grade includes in-class work that is to be turned in at the end of the class. To receive credit for these exercises, the student must be present. The exercises will be "graded" with a "+" for exemplary work, a "check" for marginal to average work, and a "0" for no submittal or no name.

Bonus Points and Low Scores

?? As an incentive toward high performance, a student receiving the highest score in the class on a homework assignment is eligible for a 10% increase to the score. In the case

of a two-way tie, each student receives a 5% increase, and so forth. No student is eligible for more than four such applications of bonus points during the semester (two per module). Students enrolled in a single module of CVEEN 2130 are eligible for two applications. The bonus points scheme applies to homework assignments only.

- ?? Each student's two lowest homework scores (one from each module) will be excluded from final grade computations. The single lowest homework score of the one-module students will be thrown out.

Classroom and Course Rules

- ?? Homework assignment solutions will, in general, be posted in one of the locked cases along the main corridor of the first floor of the EMRO building by the afternoon of the day following the due date.
- ?? Late homework will be accepted until the solution is posted. Late turn-ins (i.e., after class has concluded) will be subjected to a 5% penalty.
- ?? Late homework will not be accepted once the solution is posted.
- ?? A request for a change in a score or grade must be submitted in writing.
- ?? If a student cannot take an exam during its scheduled time, the exam must be taken *before* the scheduled time. Arrangements are to be made with the instructor.
- ?? Courtesy: Please do not carry on a non-course related conversation with a classmate while the instructor is speaking.
- ?? Courtesy: Please try to arrive at class for a prompt 8:25 A.M. start. Late arrivals can be somewhat disruptive.

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Textbooks: Statistics module: Ayyub, Bilal M. and Richard H. McCuen, *Probability, Statistics & Reliability for Engineers*, CRC Press, Boca Raton, FL, 1997.
Engineering Economics module: Newnan, Donald G., Jerome P. Lavelle, and Ted G. Eschenbach, *Engineering Economic Analysis*, 8th edition, Engineering Press, Austin, TX, 2000.

Module 1: Statistics

Date	Day	Lesson	Reading	Topics	No.	Assignment*
1/9	Tu	1	1.1-1.2 2.1-2.2	Role of Statistics in Engineering Uncertainties in Engineering Data Classification Methods	--	--
1/11	Th	2	2.3.1-2.3.7	Graphical Descriptions of Data	--	--
1/16	Tu	3	2.3.8-2.5.1	Course Objectives and Requirements Graphical Descriptions of Data Descriptive Measures	S1	<u>2-6, 2-10, 2-11, 2-12</u>
1/18	Th	4	2.5.1-2.6.2	Average or Mean Measures of Dispersion Percentiles and Box-and-Whiskers	S2	<u>2-14, 2-15</u>
1/23	Tu	5	3.1-3.2.4	Probability Theory in Engineering Design Sets, Sample Spaces and Events Venn Diagram Probability Laws	S3	2-16, 2-17, <u>2-18, 2-19</u>
1/25	Th	6	3.3.1-3.3.2	Introduction to Probabilistic Assessment Probability Axioms	S4	3-1, 3-6
1/30	Tu	7	3.3.3-3.3.5	Permutations and Combinations Conditional Probability More Probability Axioms and Bayes' Theorem	S5	3-5, 3-8, 3-9, 3-10
2/1	Th	8	3.4	Discrete and Continuous Random Variables Probability Mass Functions Probability Density Functions	S6	3-11, 3-12
2/6	Tu	9	3.5 (1st part)	Moments Mid-Module 1 Exam (Lessons 1-7)	S7	3-13, 3-14
2/8	Th	10	3.5.1-3.5.4	Using Moments to find the Mean, Expectation, Variance, and Skew	S8	3-15, 3-17
2/13	Tu	11	3.6-3.6.4	Discrete Probability Distribution Functions: Bernoulli, Binomial, Geometric, Poisson	S9	3-19, 3-20, 3-25, 3-26
2/15	Th	12	3.7-3.7.2	Continuous PDFs: Uniform, Normal Central Limit Theorem	S10	3-28, 3-29
2/20	Tu	13	3.7.2-3.7.5	Continuous PDFs: Lognormal, Exponential, Student's t	S11	3-27, 3-31, 3-32, 3-34
2/22	Th	14	3.7.5-3.8.5 4.1-4.2.1	Continuous PDFs: χ^2 (<i>Chi-squared</i>), <i>F</i> Joint Discrete Random Variables Joint Probability Mass Functions	S12	3-36, 3-37
2/27	Tu	15	4.2.2	Joint Cumulative Mass Functions Conditional Probability Mass Functions Joint and Cumulative PDFs Conditional Probability Density Functions	S13	3-39, 3-41, 3-42, 3-43
3/1	Th	16	4.2.3-4.2.4	Conditional Moments Covariance and Correlation Joint PDFs: Multinomial, Bivariate Normal	S14	3-45, 3-47

NOTE: The Module 1 "final exam" is scheduled for Thursday, March 8th.
 Also, the final statistics assignment (S15) is due on Tuesday, March 6th.

Module 2: Engineering Economics

Date	Day	Lesson	Reading	Topics	No.	Assignment*
3/6	Tu	17	Chapter 1	Module 2 Objectives Decision-Making in Engineering Role of Engineering Economics	S15	4-2, 4-5, 4-11, 4-12
3/8	Th	--	--	Module 1 Exam (Statistics: Lessons 1-15)	--	--
3/13	Tu	--	--	SPRING BREAK	--	--
3/15	Th	--	--	SPRING BREAK (continued)	--	--
3/20	Tu	18	Ch. 2: 31-40	Total, Fixed, Variable, and Marginal Cost Cost-Revenue Relationships Finding the Breakeven Point Sunk, Opportunity, Book and Other Costs	E1	1-18, 1-19, 1-27, 1-32
3/22	Th	19	Ch. 2: 40-51	Life-Cycle Costs Cost Estimation Per-Unit and Segmenting Models Cost Indexes	E2	<u>1-33</u> , 1-34
3/27	Tu	20	Ch. 2: 56-61 Ch. 3: 73-76	Estimating Benefits Cash Flow Diagrams and Tables Time Value of Money Simple Interest	E3	2-2, 2-4, 2-7, <u>2-12</u>
3/29	Th	21	Ch. 3: 77-87	Debt Repayment Equivalence Compound Interest Present and Future Equivalents	E4	2-17, 2-21
4/3	Tu	22	Ch. 3: 88-93 Ch. 4: 97-108	Using Compound Interest Tables for P/F & F/P Uniform Cash Flow Series (Annuities) Discount Factors for F/A, A/F, P/A and A/P	E5	2-31, 2-33, 3-1,3-2
4/5	Th	23	Ch. 4: 108-121	Arithmetic or Uniform Gradient Geometric Gradient	E6	3-4, 3-7
4/10	Tu	24	Ch. 4: 122-132	Nominal and Effective Interest Rates Continuous Compounding, Discrete Cash	E7	3-17, 3-18, 4-7, 4-8
4/12	Th	25	Ch. 4: 133-144	Continuous Compounding, Continuous Cash Mid-Module 2 Exam (Lessons 17-22)	E8	4-10, 4-11
4/17	Tu	26	Ch. 5: 167-179	Using Interest Tables for Continuous Interest Present Worth Analysis Capitalized Cost	E9	4-13, 4-17, 4-19, 4-21
4/19	Th	27	Ch. 5: 179-189 Ch. 6: 207-220	Present Worth Analysis of Multiple Alternatives Engineering Economics Assumptions Annual Worth Analysis	E10	4-34, 4-35
4/24	Tu	28	Ch. 7: 241-261	Rate of Return Analysis Minimum Attractive Rate of Return (MARR) Internal Rate of Return (IRR)	E11	5-8, 5-11, 5-12, 5-28
4/26	Th	29	Ch. 7A: 275- 287	IRR Computational Difficulties	E12	5-37, 5-39
4/30	M	--	--	FINAL EXAM (Engineering Economics)	--	--

NOTES:

- ?? * = Homework assignments are **due** on the date shown.
- ?? Bold lesson numbers indicate that a guest will serve as the instructor.
- ?? The student may prefer to perform all or part of underlined homework problems on a computer. Other problems should be done using manual calculations.