CivEnv 304 – Civil and Environmental Engineering Systems Analysis
Spring 2024

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Class Times and Locations:	Tuesday and Thursday 9:30–10:50 in Tech A110
Class Website:	Canvas – Northwestern Course Management System

Course Description

This course explores problems that arise in planning and managing CEE systems. The methods introduced in the course, often used in the management sciences, will provide a basis for developing descriptive and prescriptive models that can address a broad range of problems. Examples include space allocation in an industrial park, equipment selection for energy generation, scheduling construction projects, designing warehousing and distribution strategies for companies, locating (emergency) services such as fire stations, docks for bike-sharing services, and the design and management of water distribution systems. We will model problems using techniques from decision analysis, mathematical programming, input-output analysis, and solve them using commercial software (Excel, Matlab, etc.).

Intended Audience

The intended audience for this course consists of upper-division undergraduate and first-year graduate students in Engineering and Sciences.

Course Goals

During the course, students will:

CG1: Develop a "systems perspective" necessary for planning or managing complex and large-scale engineering systems;

CG2: Formulate and solve quantitative models for a range of problems in civil and environmental engineering systems; and

CG3: Use commercial software to solve engineering problems.

Prerequisites

There are no formal prerequisites, though, the course will build on your earlier work in Calculus and Probability.

Materials

The required textbook for the class is Revelle, C.S., Whitlatch, E.E., and Wright, J.R. (2003); *Civil and Environmental Systems Engineering*, Second Edition; Prentice Hall. Because it's available online, I am making the book available in .pdf format via Canvas.[1]

Other reference texts include:

1. deNeufville, R. (1990); *Applied Systems Analysis*; McGraw-Hill. This book is out of print, but available on-line for free. `https://web.mit.edu/ardent/www/ASA_Text/asa_Text_index.html`
2. Hillier, F. and Lieberman, G. (2021); *Introduction to Operations Research*; 11th Edition, McGraw-Hill.
3. Hendrickson, C., Lave, L., and Matthews, H.S. (2006); *Environmental Life Cycle Assessment of Goods and Services: An input-output approach*; RFF Press.

Outline

The course integrates methodological tools with applications. Lectures will be devoted to learning the tools and solving problems to reinforce the material. In addition, there will be sessions devoted to learning how to solve the problems using commercial software. The material covered addresses two important elements in systems engineering: Policy Evaluation and Policy Selection, i.e., System Optimization. The material includes:

Topic	**Approximate Duration**
Mathematical Programming Review of Calculus (constrained optimization) Formulation & Numerical Solution of Linear Programs Sensitivity Analysis	3 weeks
Environmental Life Cycle Assessment Input-Output Analysis	2 weeks
Decision Analysis Decision trees Backwards induction Value of information	2 weeks
Dynamic Programming Deterministic and Stochastic Models	2 weeks

This outline is subject to change in order to accommodate time and interests.

[1] Please don't tell anyone :-).

Requirements and Assessment

1. Homework will be assigned approximately on a weekly basis and will be due by the start of class as indicated on the assignments. Homework submission will be via file upload to Canvas. While all file types will be accepted, we strongly suggest that you restrict yourself to .pdf, .docx, .xlsx, .jpg files. Taking pictures or scanning work that you do by hand, and uploading spreadsheets is probably the most efficient approach. To avoid technical problems and various restrictions, links to cloud drives/files or other storage devices will not be accepted. Long story short, if we can't access your homework, we can't grade it. Solutions will be posted shortly after the assignments are due. Therefore, no late homework can be accepted. Given the size of the class and the available resources, $\tilde{5}0\%$ of the homework problems may be selected at random and graded thoroughly. The remaining problems will be graded for completion. The assignment with the lowest score (by percentage) will be dropped from the final homework score. You should start working on the homework early so that you have time to ask questions in class, and during office hours before the due date. Please feel free to work in groups, or to ask for help from fellow students, the instructor, the teaching assistants, or the grader. However, please note that each student must submit **their own work** unless otherwise stated. To earn credit on assignments, you must **show your work**, i.e., writing an answer, even if correct, is not sufficient to earn credit.

   The assignments may have some in-depth problems that will be labeled "Extra Credit". These problems are not required for the course but thorough solutions may be rewarded with extra credit. To avoid getting side-tracked, you should only work on the extra-credit problems once you complete the required problems.

2. There will be two projects/case studies assigned. These assignments are meant to give the students experience addressing problems in civil and environmental engineering that are richer (in scale and scope) than textbook problems. At their core, the case studies will involve formulating quantitative models for the problems, using software to solve them, and making recommendations. A short report will be submitted for each project. The report will give the students an opportunity to discuss issues that may not be captured in the models.
   Students will have 2–3 weeks to complete the case studies. Specific instructions will be provided along with each assignment. Students are highly encouraged to work in groups of 4 (one report/deliverable per group).

3. There will be 2 in-class examinations. They will be open-book/notes and will be designed to test your understanding of the material presented in class and in the homework assignments. The dates for the exams are **Thursday, April 25, and Thursday, May 30**.
   Special arrangements for the exams must be discussed with the instructor 2 weeks prior to the exam's scheduled date. Following guidelines provided by AccessibleNU, any student requesting accommodations related to a disability or other condition is required to register with AccessibleNU (accessiblenu@northwestern.edu; 847-467-5530) and provide professors with an accommodation notification from AccessibleNU, preferably within the first two weeks of class. All information will remain confidential.

In terms of assessment, the final class score will be computed as described below:[2]

$$0.2 \times (\text{homework} + \text{exam 1} + \text{exam 2} + \text{project 1} + \text{project 2})$$

[2]The terms in the expression below correspond to percentages, and thus the final class score is a percentage.

ABET Educational Outcomes

For students completing undergraduate degree programs in civil engineering or in environmental engineering, this course supports the programs' educational objectives by addressing the following student outcomes:[3]

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. This is related to CG1, CG2 and CG3, and is assessed via (H,E,R).[4]

(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. This is related to CG1 and CG2, and is assessed via (R).

(3) An ability to communicate effectively with a range of audiences. This is related to CG1 and is assessed via (R).

(4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. This is related to CG1 and is assessed via (R)

(5) 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. This is related to CG1 and is assessed via (R).

Additional information can be obtained from the following URLs:
`https://www.mccormick.northwestern.edu/civil-environmental/academics/undergraduate/civil-engineering/abet-objectives-outcomes.html`
`https://www.mccormick.northwestern.edu/civil-environmental/academics/undergraduate/environmental-engineering/abet-objectives-outcomes.html`

[3]These outcomes are from the "1–7" list of student outcomes specified by the Accreditation Board of Engineering and Technology (ABET)

[4]Homework (H), Exams (E), and (Case Study) Written Reports (R) refer to the deliverables that are used to meet the outcomes.