CE 398

Introduction to
Civil Engineering Systems Design

Course Information

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CE 398
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Course Type

CE 398, a core course for undergraduate studies in Civil Engineering, is useful to all undergraduate students intending to pursue a career in civil engineering and related disciplines.

Prerequisites

Students should have a basic knowledge of calculus and algebra. In addition, if students have taken STAT 511 they should be familiar with the basics of probability and statistics.

Course Objectives

Students will understand how to model civil engineering problems using systems engineering.

1. Formulate Civil Engineering problems as Systems Engineering problems (SLO 1):
   - (i) Describe what is a system
   - (ii) Recognize the notion of stakeholders, planning, prediction, evaluation and analysis
   - (iii) Describe the different phases of systems analysis
   - (iv) Identify the interdependence of different civil engineering disciplines with real-world examples
   - (v) List the various tools that can be used to solve civil systems problems
   - (vi) Appreciate global issues in Civil Engineering
     - i. Sustainability in Civil Engineering Systems
     - ii. Complexity in Civil Engineering Systems
     - iii. Ethics and Management

Students will demonstrate and apply various modeling tools to solve civil engineering systems problems.

2. Apply Mathematical Modeling Tools to solve Civil Engineering Systems Problems (SLO 2):
   - (i) Apply Optimization techniques to solve Civil Engineering Systems (CES) problems:
     - i. Define what is an optimization problem and identify different types of optimization problems
     - ii. Formulate systems engineering problems as optimization problems
     - iii. Solve optimization problems using graphical techniques
     - iv. Solve optimization problems using commercial solvers such as GAMS and Excel
     - v. Assess the advantages and limitations of various optimization techniques

(ii) Apply Multi-criteria techniques to solve CES problems:

i. Recognize that multiple criteria influence the decisions in civil systems analysis and design
ii. Solve multi-criteria systems problems using systems evaluation tools

(iii) Apply Network Analysis techniques to solve CES analysis problems:

i. Define the basic components of a network
ii. Apply network representation techniques
iii. Define a Minimum Spanning Tree (MST) and identify its applications
iv. Solve the MST problem using Kruskal's and Prim's algorithm
v. Define a Shortest Path problem and identify its applications
vi. Solve the shortest path problem using Dijkstra's algorithm
vii. Define the maximum flow problem and its applications
viii. Solve the maximum flow problem using the min-cut algorithm
ix. Recognize the importance of networks in solving complex CE systems problems

(iv) Apply Game Theory techniques to solve CES analysis and strategic problems:

i. Define a game
ii. Define the notion of payoffs, best responses and dominant strategies in a game
iii. Define and apply the notion of equilibrium
iv. Define Nash Equilibrium both mathematically and as it relates to the real-world
v. Solve for Nash Equilibrium using graphical approaches
vi. Identify that multiple equilibrium are present in games
vii. Define Mixed Strategies in games
viii. Discuss ways to compute mixed strategies for simple games and real-world games
ix. Explore how Nash Equilibrium and Mixed Strategies can be applied in CE Systems Engineering

(v) Apply Queuing Theory techniques to solve CES operational issues:

i. Define a Queuing System
ii. Represent the Queuing System using the Kendall's notation
iii. Distinguish the different types of queuing systems
iv. Define the different performance measures in a queuing systems
v. Solve for the performance measures in a D/D/1, M/D/1, M/M/1 and M/M/N queue
vi. Design the queues to satisfy various performance metrics
vii. Identify the importance of queuing analysis in various CE systems operations problems

(vi) Apply Engineering Economics techniques to select best economic alternative in CES design and planning:

i. Define costs, benefits, depreciation, interest rate and salvage value

ii. Distinguish different ways of computing annuities in engineering economics
iii. Define Cost Benefit Analysis
iv. Distinguish the different tools for performing cost benefit analysis
v. Solve engineering economics problems using cost benefit analysis and net present value
vi. Identify the importance of engineering economics as a tool to prioritize different options in CE systems problems

Students will read and write critically and communicate effectively.

3. Demonstrate professional communication and team work in this course (SLO 3):
   (i) Communicating effectively using in-class feedback, surveys and in-class quizzes
   (ii) Document the steps and answers clearly in homeworks
   (iii) Articulate ideas clearly in the project report
   (iv) Working effectively in teams for course projects
   (v) Presenting the project report in a professional manner

Course Description

This course introduces the fundamental concepts associated with civil engineering systems design from needs assessment to implementation. Topics covered will include basic design principles, systems analysis and modeling, evaluation (on basis of benefit-cost, environmental impacts, and multi-criteria decision-making etc.), resource allocation, optimization, and decision analysis. The course applies the concepts to problems in the various areas of civil engineering and provides an array of case studies in various civil engineering disciplines, such as transportation networks, environmental systems, construction management and structures.

The course comprises lecture presentations, quizzes, online videos, group discussion, exams, homework assignments and a team-based project.

Course Material

Course notes will be provided on the course web site. The address is
https://mycourses.purdue.edu/

Class Attendance

All students are expected to attend the classes. Absences should be preceded by notification (e-mail or otherwise). Class attendance records will be taken at random in the form of surprise quizzes and your class participation score will be partly based on these records.

Homework Policy

Please turn in your homework just before the start of class session on the day that they are due. A folder will be passed during the class for homework submissions and you can place it in the correct folder based on the starting alphabet of your last name. Similarly, all homework's will be distributed in class once they are graded. Justifiable excuses for late submission should be preceded by early notification (e-mail or otherwise) with a good explanation. Every late day of submission results in 20% loss of overall points for the assignment. We should resolve any adjustments to homework grades and exams within one week of the day on which that homework assignment or exam is returned. All questions about homework scores should first be directed to the TA. All grades must be finalized within this period -- in other words, no additional points shall be awarded at the end of the semester to "boost" your grade even if you are near the grade cutoff. In order to help you avoid the usual homework policy problems, I'll try to make the homework interesting so you'd actually look forward to receiving them!

Course Project

To allow you to work on real systems problems, students will work in groups of 5 on a course project which will involve data gathering, analysis and recommendations based on a real-life example. The instructor will provide examples of course project; however students having innovative ideas for a course project can consult the instructor. Since the course project is team based and there will be one grade for the entire team, it is important that all students contribute to the project work. Any complaints about the lack of participation of one or more team members will be taken seriously and each group will be responsible for bringing these issues to the instructor early on so that appropriate measures can be taken to correct the situation.

Grading Policy

There will be two exams in the semester and a cumulative final exam. All exams will be closed book and will be problem based. There may be in-class quizzes at the beginning of any class. Typically, each class will be a combination of concepts and problem solving.

The grading distribution for the course is as follows:

Two Exams	15% + 15% = 30%
Term Project	15%
Homework	20%
Final Exam	25%
Quizzes/Surveys	7%
Course Feedback Form	3%

Grade limits typically in the past have been as follows (this may not be true this semester):

>96	A+
90 – 100%	A
80 – 89.99%	B
70 – 79.99%	C
60 – 69.99%	D
< 60%	F

In the course of the semester, the above grading scheme may be amended at the discretion of the Instructor. Grade modifiers will be used based on the distribution of the overall points. The descriptions at the right will however remain the same.

Student Conduct

Students are expected to abide by the Purdue University Student Conduct Code. Further, it is assumed that each and every student subscribes to a personal code of ethics based on a value system and adheres to the highest standards of academic integrity. Any breach of academic honesty or disruptive classroom behavior will be handled in accordance with established university procedures. You will be required to carry out assignments independently (simply put: “thou shall not copy thy neighbor’s homework”).

I am assuming you want to have a great and stress-free semester. And let’s try to make it an interesting one! **Go Boilers!**