Spring 2012

CE 130L. Uncertainty, Design, and Optimization

Instructor:	Henri Gavin, 162 Hudson Annex, `henri.gavin@duke.edu`
Class Time:	Mo, We, Fr, 11:55–12:45, Room 208 Hudson Hall
T.A's:	Gerard Zehil, `gerard.zehil@duke.edu`
Recitation:	We, 4:25 - 5:40, Room 203 Teer or Room 106 Teer
Office Hours:	H.G.: Fr, 1:30 - 3:30, and by appointment
	G.Z.: Tu 1:30-2:30 2435A CIEMAS
Textbook:	Most of the hand-out materials are available through the course website.
Website:	http://www.duke.edu/~hpgavin/ce130/
Prerequisite:	EGR 75L. Mechanics of Solids.
Grading:	Homeworks(7) 25%; Exam(1): 30%; Participation: 5%;
	Group Projects(4): 35%; Presentation(1): 10%

BULLETIN DESCRIPTION

Principles of design as a creative and iterative process involving problem statements, incomplete information, conservative assumptions, constraining regulations, and uncertain operating environments. Parameterization of costs and constraints and formulation of constrained optimization problems. Analytical and numerical solutions to constrained optimization problems. Evaluation of design solutions via sensitivity and risk analysis. Application to design problems in civil and environmental engineering. Prerequisite: EGR 75L. One course. Gavin or Scruggs.

COURSE OBJECTIVES

Students successfully completing CE130L will be able to:

1. Identify, formulate, and solve engineering problems by:
   (a) mathematically formulating a design problem from an abstract design goal,
   (b) interpreting and validating results from solutions to this mathematical problem, and
   (c) identifying strengths, weaknesses, opportunities and threats to a successful outcome.
2. Design a system, component, and processes to meet desired needs within realistic constraints, (including economic, environmental, social, and safety constraints) by:
   (a) modeling the system to be designed,
   (b) defining design attributes and parameters for the system, and
   (c) iterating on the design to meet the desired objectives without violating constraints.

HOMEWORK AND PROJECT REQUIREMENTS

- **Collaboration on problem sets:** You may work with other students on problem sets but do not copy solutions (from any source). Carry out your solutions in a way that makes sense to you and list the names of each collaborator (if any) with each of your problem solutions.

  The TAs are not allowed to solve homework problems for you. Questions like, "How did you do this problem?" or "What did you get for an answer to Problem 3?" are not appropriate. Don't ask questions like these, and don't answer questions like these. Violations will be handled according to the Duke Community Standard.

  You won't learn anything from copying solutions. It's a violation of the Duke Community Standard. Don't do it.

- **Matlab:** Some homework assignments and all projects require you to program in MATLAB.

- **Short-term illness:** If you miss a due-date because you were sick, follow the university policy for submitting the missed assignment.

- **Extensions:** You are allowed *one homework extension* (from Friday to Monday) during the semester. To obtain an extension, simply send me an e-mail stating your extension request, with Cc to yourself, and with the subject line: `CE130: <your name> extension request` at least 24 hours before the deadline. Attach a print-out of my e-mail reply to the top of your assignment. These extensions are not applicable to projects or the midterm.

- **Neatness:** On homework assignments, 15 of the 100 points will be awarded for following these rules on neatness:

  - Use pencil (so you can erase). Mechanical pencils are recommended.
  - Write neatly and clearly. Your TA's may lose patience with illegible solution sets.
  - Write your first and last name, the course number, the assignment number and the due-date in the upper right corner of the first page. Write the page number on each page (e.g., 3/6, means page 3 of 6)
  - Write out each problem statement. (i.e., Given=..., Find=..., Collaborators=...)
    For "Collaborators:" list anyone who helped you with the solution. If there are no collaborators just write "none".
  - Use a straight edge (your Duke ID card, a ruler, or a triangle) to draw straight lines.
  - Present solutions to problems in the same order as listed in the assignment, and begin every problem on a new page unless the next solution is so short that it can fit on the same page.
  - Partial credit will be awarded *only* if the solution leading to an incorrect answer describes your thinking in words.
  - Draw a box around your final answer and provide the units of your answer (e.g., cm, psi).
  - Staple your solution set.

- **Submission of work:** Submit your on-time solution sets and project reports to the CE 130L IN box in Room 118 Hudson. Do not submit your work to the TA. If your homework or project is late, or if you have an extension, submit it to me after class or in my office.

- **Group Project Peer Evaluation (optional):** For each project each student has the option to anonymously indicate the percent effort of each member of their group, including themselves, by submitting a *Project Cross Evaluation Form*. The project grade for group member i, g_i, will be apportioned according to the team project grade, g, and the contributions c_i of team member i to the project, as reported by any members of the group,

$$g_i = g - (100 - g)\left(1 - \frac{n}{m}\frac{1}{100}\sum_{i=1}^{m} c_i\right)$$

where the group has n members and m group members submit project cross-evaluation forms. For example, if a group earns a "B" (a grade g of 85) and two group members anonymously submit a project cross-evaluation form,

evaluated student	*evaluating student*		*adjusted grade*
	"X"	"Y"	$g_i = g - (100 - g)(1 - \frac{n}{m}\frac{1}{100}\sum c_i)$
Tim	40	50	90.25
Bob	30	20	81.25
Sue	30	30	83.50
	100	100	(3)(85.00)

so the individual student grades would be 84 for Sue, 81 for Bob, and 90 for Tim.

- **Late work:** Grades for late work will be penalized ten points for each day late; late penalties are not accrued for weekends or University holidays. For example, if you submit your work before 5:00 pm on the Monday after a 5:00 pm Friday due-date, the grade will be penalized 10 points. Assignments submitted after the the solution is posted get no credit.

- **Homework answer keys:** Homework answer keys will be posted outside my office door (not on the course BlackBoard website) when graded homework solution sets are returned.

GENERAL REQUIREMENTS

- **The Duke Community Standard** http://www.integrity.duke.edu/standard.html: Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and non-academic endeavors, and to protect and promote a culture of integrity.

  To uphold the Duke Community Standard:

  - I will not lie, cheat, or steal in my academic endeavors;
  - I will conduct myself honorably in all my endeavors; and
  - I will act if the Standard is compromised.

- **Attendance:** If you miss lectures you will have a very hard time doing well in this course. There is no textbook. Your lecture notes will be your only reference for many parts of the course. Please be on time. Please keep your cell phones and computers off. Please be attentive. (Do I really need to write this?)

- **Communication:** We will use e-mail for out-of-class communications related to the course. Please start the subject line of email to me with `CE 130:`.

- **Extra-curricular and co-curricular activities:** In most cases extra-curricular and co-curricular activities conflicting with course commitments can be resolved easily. Just let me know beforehand.

- **Grading:** The TAs will grade your solutions to homework assignments. I will grade the projects, presentation, and the exam. See me (not a TA) about any grading errors.

COURSE SCHEDULE

Week	Dates	Topic	Reading
		—DESIGN, UNCERTAINTY, AND OPTIMIZATION—	
1	1/11-1/13	Design: innovation, analysis, evaluation, iteration, and optimization;	Arora Ch 1
		design parameters, cost functions, safety constraints, and failure probability	Arora Ch 2
		safety factors, uncertainty, and risk	course-notes
	due 1/20	HW 1: Design: open-ended problems requiring creative, iterative solutions	
2	*1/16*	*Martin Luther King Day*	M.L.K. writings
	1/18-1/20	Uncertainty: histogram, ogive, random variables, distributions,	Ang&Tang Ch.1,3,5
		sets, mutually exclusive, collectively exhaustive, independence, union, intersection	course notes
		normal, log-normal, Poisson, and exponential random variables	course notes
		Monte-Carlo simulation	hand-out
	due 1/27	HW 2: Uncertainty: analytical and numerical methods	
3	1/23-1/27	Optimization: direct search and quadratic programming methods	Sheela, Boggs
		equality and inequality constraints	course notes
		Hessian matrix, gradient, and Lagrange multipliers	hand-out
		Sensitivity of cost to constraint relaxation and parameter variation	
	due 2/3	HW 3: Optimization: analytical and numerical methods	
		—APPLICATION TO STRUCTURAL ENGINEERING—	
4	1/30-2/3	Design-based analysis of structures (trusses).	
	due 2/10	HW 4: review of structural analysis (trusses and beams)	
5	2/7-2/11	Internal strain energy and the principle of real work	hand-out
		The principle of minimum total potential energy and constrained optimization	hand-out
	due 2/17	DESIGN PROJECT 1: Optimize a statically determinate truss.	
6	2/13-2/17	Castigliano's theorems for statically determinate problems	hand-out
		trusses, beams, and frames	E.Popov, Ch.18
		Determinacy, indeterminacy, stability, redundancy	course notes
	due 2/24	HW 5: real work	
7	2/20-2/24	Castigliano's theorem's and superposition	hand-out
		examples: trusses, frames, temperature loading, support settlement	hand-out
	due 3/2	HW 6: Castigliano's theorems and total potential energy	
8	2/27-3/2	Optimization of indeterminate structures	
		wide-flange section and tube section properties	hand-out
9	*3/5-3/9*	*Spring Break*	
		—APPLICATION TO ENVIRONMENTAL ENGINEERING—	
10	3/12-3/16	Rainfall, streamflow, aquifer and reservoir storage, transpiration, evaporation	course notes
	due 3/16	**TAKE HOME MIDTERM** (HW 1 - HW 6)	
11	3/19-3/23	Treatment for suspended solids, biological, and petro-chemical pollutants	course notes
		Seasonal and long-term variability in water supply and water demand	
	due 3/30	DESIGN PROJECT 2: Design and control a water supply system.	
		—APPLICATION TO FINANCIAL ENGINEERING—	
12	3/26-3/30	Stock market data, trends and volatility, buying and selling indices	course notes
	due 4/6	DESIGN PROJECT 3: Trade stocks and make money.	
		—APPLICATION TO EARTHQUAKE ENGINEERING—	
13	4/2-4/6	Vibration of single degree of freedom systems	hand-out
		Free response, forced response, resonance, frequency response function	C.W.deSilva
	due 4/13	HW 7: structural dynamics	
14	4/9-4/13	Elastic and inelastic response of structures to earthquakes	A.Chopra
		Effect of viscous damping and inelastic energy dissipation	course notes
		Seismic isolation	
15	4/16-4/20	Shake table testing and data analysis	
	due 4/20	DESIGN PROJECT 4: Protect a fragile object from earthquake hazards.	
16	4/25-4/27	presentation on a project of your choosing	

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