Spring 2008

CE 130L. Design and Optimization

Instructor:	Henri Gavin, 121 Hudson Annex, `henri.gavin@duke.edu`
Class Time:	Mo, We, Fr, 11:55–12:45, Room 125 Hudson Hall
T.A.:	Kevin Brightly, `kevin.brightly@duke.edu`
	Scott Harvey, `philip.harvey@duke.edu`
Recitation:	We, 4:25 - 5:40, Room 125 Hudson Hall
Office Hours:	H.G.: Fr, 2:00pm-3:30pm, by appointment, and open door polciy
	K.B.: Th, 3:00pm-4:30pm, Rm 127C Hudson
	S.H.: Th, 4:30pm-6:00pm, Rm 127C Hudson
Textbook:	Much of the course-pack materials are available through the course website.
Website:	`http://www.duke.edu/~hpgavin/ce130/`
Prerequisite:	EGR 75L. Mechanics of Solids.
Grading:	Homeworks(8) 25%; Group Projects(5): 25%;
	Presentation(s): 15%; Participation: 5%; Exam(1): 30%

BULLETIN DESCRIPTION

Principles of design as an iterative process involving problem statements, incomplete information, conservative assumptions, external regulations and constraints, and creative solutions. Formulation of the associated constrained optimization problem. Energy methods for elastic and plastic deformation. Computer programming for optimal solution of structural design problems. Application to determinate and indeterminate steel and concrete structures for static and dynamic loads. Prerequisite: EGR 75L

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, or process 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 REQUIREMENTS

Homework will generally be assigned on a Wednesday and will be due at 5pm the Friday of the following week (i.e., 8 days later), as shown in the course schedule.

You may work in groups on the homework assignments in order to help each other understand how the solutions are set-up. Carry out your solutions in a way that makes sense to you. You won't learn anything from copying solutions. Don't do it.

Any type of paper is acceptable, and you are encouraged to re-use printer paper.
Re-using is better than recycling.

Submit your solution sets to the homework mailbox in the student mail room (Hudson 118). Homework assigments are due on Fridays at 4:00 pm and the solutions sets will be collected *promptly.*. Don't submit homework solution sets to the TA.

- Each homework assignment will be scored out of 100 points.
- Fifteen points will be awarded for neatness, as described below.
- Answer keys will be posted on the course website.

Fifteen points for every homework assignment will be allocated to these guidelines:

- Use pencil (so you can erase). A mechanical pencil is recommended.
- Write neatly and clearly. Graders will lose patience quickly 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 then write "none".
- Use a straight edge (a ruler or a triangle) to draw your 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.
- Describe the process of finding your answer in words, don't just write a list of equations or calculations.
- Indicate your final answer clearly and obviously (i.e., underlined, circled) and provide the units of your answer (i.e., cm, psi).
- Staple your solution set.

GENERAL REQUIREMENTS

- **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.

- **Collaboration:** You may work together and seek help from the instructor and the TAs on collaborative efforts such as the homework sets and lab reports, to the extent specified below. By contrast, collaboration (effectively - cheating) is completely unacceptable on exams and will be handled according to the Duke Community Standard. Open copying of homework problems or lab reports is also unacceptable.

- **Attendance:** Attendance at the lectures is mandatory. Arrive before the start of class. Turn off your cell phone and put it away. Don't read the paper or browse the Internet during class. (Do I really need to write this?)

- **Communication:** I will send the class email with announcements regarding homework assignments, homework solutions, changes in office hours, etc.

- **Short-term Illness:** If you miss a due-date because you were sick, follow the university policy ...`http://www.aas.duke.edu/trinity/t-reqs/illness/` ...for submitting the missed assignment.

- **Extracurricular Activities:** Let me know if you have an extra-curricular commitment (e.g., athletics, interviews) that will conflict with course commitments. In most cases these conflicts can be resolved easily. See "Deadline Extensions" below.

- **Late work:** Grades for assignments turned in after the time they are due will be penalized ten points for each day late; late penalties are not accrued for weekends or University holidays. If you submit your homework solution before 4:00pm on the Monday after a 4:00pm Friday due-date, the grade will be penalized "only" 10 points.

  There's no need to turn in an assignment after the solution is posted; such assignments will get a grade of zero (0).

- **Extensions:** To request an extension, send e-mail explaining the circumstances for the request at least 24 hours before the deadline to: `henri.gavin@duke.edu`

  I will respond to your email. If the extension is granted then attach a copy of my email that grants the extension to the top of your assignment. Submit your assignment to me, my mailbox in 119 Hudson, or slip it under my office (161 Hudson Hall Annex) door by extended deadline. Work submitted after the extended deadline will incur the usual 10% per weekday penalty for each day after the extended deadline.

- **Solutions:** Solutions to homework, quizzes, and the final exam will be posted on the course BlackBoard website.

- **Re-grades:** If there is an error in your grade (e.g., the total number of points incorrectly added) or you feel that the grade you received is not commensurate for your solution then present your work in question with a short written description of the error and your NetID to me, Dr. Gavin.

  As a matter of policy, when you request a regrade you are agreeing that the grader may re-evaluate the grading of the entire assignment in question.

- **MATLAB:** You will program in MATLAB to complete problems assigned in this course.

- **T.A. help:** Please do not ask the T.A. to solve homework problems for you. The T.A. will, however, solve problems similar to your homework problems. Solution sets to the homeworks will be posted after the homeworks have been graded and returned.

COURSE SCHEDULE

Week	Dates	Topic	Reading
		—THE DESIGN PROCESS AND OPTIMIZATION—	
1	1/9-1/11	The design process: Innovation, Analysis, Opitmization, Evaluation, Iteration Design Analysis: design parameters, cost function, and safety constraints	
	due 1/18	HW 1: statics and stress analysis review	EGR 75 text
2	1/14-1/18	Design Optimization: full and random parameter search methods	B.V.Sheela
3	*1/21*	*Martin Luther King Day*	M.L.K. writings
	1/23-1/25	Design Optimization: quadratic forms, Hessian, gradient, and Lagrange multipliers Sensitivity of cost to constraint relaxation and parameter variation	P.T. Boggs
	due 2/1	HW 2: design formulation, quadratic programming, and probability density	
4	1/28-2/1	Design Evaluation: uncertainty, risk, and safety factors P.D.F. and C.D.F. of normal and log-normal random variables Monte-Carlo simulation	hand-out
	due 2/8	DESIGN PROJECT 1: Design a beer can.	
		—APPLICATION TO STRUCTURAL ENGINEERING—	
5	2/4-2/8	Determinacy, Indeterminacy, Stability, Redundancy trusses, beams, and frames Moment-area theorems	E.Popov, Ch.15
	due 2/15	HW 3: moment-area theorems	
6	2/11-2/15	The three-moment equation, Prestress analysis and design using the load balancing method	hand-out T.Y.Lin, Ch.11
	due 2/22	DESIGN PROJECT 2: Design a continuous bridge-beam with prestress.	
7	2/18-2/22	Internal Strain Energy and Real Work	hand-out
	due 2/29	HW 4: real work	
8	2/25-2/29	Statically Indeterminate Structures and Superposition trusses, frames, temperature loading, support settlement	E.Popov, Ch.18
	due 3/7	HW 5: Castigliano's theorems and superposition	E.Popov, Ch.18
9	3/3-3/7	Indeterminacy: the minimum energy principle, and constrained optimization Strength criteria: plastic moment, buckling, beam-column formulae wide-flange section and tube section properties	E.Popov, Ch.20 Neal, Ch.3-4
	due 3/21	DESIGN PROJECT 3: Optimize structural topology and sections.	
	3/10-3/14	*Spring Break*	
		—APPLICATION TO ENVIRONMENTAL ENGINEERING—	
10	3/17-3/21	Rainfall, streamflow, acquifer and reservoir storage, transpiration, evaporation Treatment for suspended solids, biological, and petro-chemical pollutants Seasonal and long-term variability in water supply and water demand	
	due 3/28	DESIGN PROJECT 4: Design and control a water supply system.	
	3/24	**MIDTERM** (HW 1 - HW 5)	
		—APPLICATION TO FINANCIAL ENGINEERING—	
11	3/24-3/28	Stock market data, trends and volatility, buying and selling indices	
	due 4/4	DESIGN PROJECT 5: Trade stocks and make money.	
		—APPLICATION TO EARTHQUAKE ENGINEERING—	
12	3/31-4/4	Vibration of single degree of freedom systems Free response, forced response, resonance, frequency response function	hand-out C.W.deSilva
	due 4/11	HW 6: structural dynamics	
13	4/7-4/11	Elastic and inelastic response of structures to earthquakes Effect of viscous damping and inelastic energy dissipation Seismic isolation	A.Chopra
14	4/14-4/18	Shake table testing and data analysis	
	due 4/21	DESIGN PROJECT 6: Protect a fragile object from earthquake hazards.	
15	4/21-4/23	Project presentations	

REFERENCES

1. American Society of Civil Engineers, American Water Works Association, *Water Treatment Plant Design,* McGraw Hill Text, 1997.
2. Arora, Jasbir S., *Introduction to Optimum Design,* McGraw-Hill, 1989.
3. Ayyub, Bilal B., *Uncertainty Modeling and Analysis in Civil Engineering,* CRC Press, 1997.
4. Benjamin J., Cornell, A., and Shaw H., *Probability, Statistics, and Decision for Civil Engineers,* McGraw-Hill 1983,
5. Berg, Glen V., *Seismic Design Codes and Procedures,* Earthquake Engineering Research Institute, 1992.
6. Boggs, P.T., "Sequential quadratic programming," *Acta Numerica*, (1995): 1-51.
7. Booker, J.D., Raines, M., and Swift, K.G., *Designing Capable and Reliable Products,* Butterworth-Heinemann, 2001.
8. Chopra, Anil, *Dynamics of Structures — A Primer,* Earthquake Engineering Research Institute, 1981.
9. De Ridder, A.J., *Design and Construction of Complex Civil Engineering Systems,* Delft University Press, 1994.
10. Dym, Clive L., *Structural Modeling and Analysis,* Cambridge Univ. Press, 1997
11. DaDeppo, Donald A., *Introduction to Structural Mechanics and Analysis,* Prentice Hall, 1999.
12. Housner, G.W., and Jennings, P.C., *Earthquake Design Criteria,* Earthquake Engineering Research Institute, 1982.
13. Levy, Matthys, and Salvadori, Mario, *Why Buildings Fall Down,* W.W. Norton, 1992.
14. Lin, T.Y., and Burns, Ned H., *Design of Prestressed Concrete Structures,* 3rd ed. John Wiley and Sons, 1981.
15. Melchers, Robert E., *Structural Reliability Analysis and Prediction,* Wiley, 1999.
16. Meredith, Dale D., *et al.*, *Design and Planning of Engineering Systems,* 2nd ed. Prentice-Hall, 1985.
17. Metcalf, Andrew V., *Statistics in Civil Engineering,* Hodder Arnold Publications, 1997.
18. Neal, B.G., *The Plastic Method of Structural Analysis,* (3rd. ed.) Chapman and Hall, 1977.
19. Nikolaidis, Efstratios, Ghiocel, Dan M., and Singhal, Suren (editors) *Engineering Design Reliability Handbook,* CRC Press, 2004.
20. Papalambros, Panos Y. and Wilde, Douglass J., *Principles of Optimal Design,* Cambridge Univ. Press, 1988.
21. Petroski, Henry, *Design Paradigms, Case Histories of Error and Judgment in Engineering,* Cambridge University Press,
22. Pronzato, L., and Walter, E., "A General-Purpose Global Optimizer: Implementation and Applications," *Mathematics and Computers in Simulation*, XXVI (1984): 412-422.
23. Revelle, Charles, and Arthur E. McGarity (editors), *Design and Operation of Civil and Environmental Engineering Systems,* John Wiley & Sons, 1997.
24. Sheela, B.V., "An Optimized Step Size Random Search (OSSRS)," *Computer Methods in Applied Mechanics and Engineering,* 19 (1979):99-106.
25. Smith, J.W., *Vibration of Structures : Applications in Civil Engineering Design,* Chapman and Hall, 1988.