2018

Computer-Aided Design

Gary Benenson
CUNY City College

Mechanical Engineering 37100 1EF/1GH: Computer-Aided Design
Spring 2018

GENERAL INFORMATION

Staff:	Instructor: Prof. Gary Benenson; Office: ST 246; (212) 650 5211; benenson@ccny.cuny.edu Office hours: Mon. 11 AM – 1 PM, Wed. 2 – 4 PM., Fri. 3 – 4 PM, or by appointment Teaching Assistant: Kerim Ikikardaslar kikikar00@citymail.cuny.edu
Schedule:	Lecture: NAC 5/111; Mon., 9 – 10:50 AM Lab: ST-213 Section 1EF: Mon. 2 - 4:50 PM; Section 1GH: 5 – 7:50 PM Notes: First class: Mon., Jan. 29. No classes Mon., Feb. 12 or 19, or March 30- April 6. Mon. schedule, Tuesday, Feb. 20; Fri. schedule, Wed. April 11. Last class: Wed., May 16. Final Exams: May 18 - 24. Deadline for all work (unless covered by proposal for INC) and for all proposals: 5 PM, Tues., May 29.
Pre- and co-req.	ME 14500, 32200 & 33000 (pre); Math 39200 (pre or co)
Book:	None
Hardware:	Flash Drive, 8 GB or higher; available from Best Buy for under $6. Measurement tools – see Solid Modeling Project assignment sheet.
Course web site	Blackboard 9.1 available via http://www.cuny.edu.
Software:	Solid modeling, assembly modeling, drafting: SolidWorks 2016-17* Finite Element Analysis: SolidWorks Simulation 2016-17* * available in CAD Lab, ST-213: Login Name: **abc1234**, where abc = first 3 letters of your last name;1234 = last four digits of your CUNY First ID #. Password: Your complete eight-digit CUNYFirst ID #.

COURSE DESCRIPTION

The use of commercial CAD systems in mechanical engineering design. Introduction to the theory and methods of Computer-Aided Design (CAD) from a user's viewpoint. Design methodology. Simulation and modeling. Introduction to finite element methods; mesh generation; simulation of loadings, and boundary conditions. Postprocessing and evaluation of results. Application of these concepts to specific engineering design projects.

COURSE OUTCOMES

1. Solution of simple stress problems manually using numerical methods
2. Creation of a complex solid model using commercial software
3. Presentation of a design in oral, graphic and written form, including the use of presentation software
4. Design and solution of a finite element model using reasonable assumptions about loading and boundary conditions
5. Interpretation of the results of finite element analysis, and their use in making design decisions.

COLLEGE POLICIES

Attendance & lateness: Attendance will be taken only once, at the very beginning of each lecture and lab, and lateness is equivalent to absence. Special circumstances should be reported to the instructor by phone or email beforehand. More than 6 unexcused absences or more than 7 total absences will result in a grade of WU. This is consistent with the following CCNY policy:

> Students are expected to attend every class session of each course in which they are enrolled and to be on time. A WU grade will be assigned to a student by the instructor for excessive absence. Students are advised to determine the instructor's policy at the first class session. They should note that an instructor may treat lateness as equivalent to absence.

Disabilities: The CUNY Policy on Disabilities will also be observed:

> In compliance with CCNY policy and equal access laws, appropriate accommodations are administered by the AccessAbility Center. Students who register with AccessAbility, and are entitled to specific accommodations, must request a letter from AccessAbility to present to the Professor that states what their accommodations are.

Academic Integrity: All submitted work must be original, or cited with attribution of the original source. The CUNY Policy on Academic Integrity will be strictly enforced, and a violation can result in expulsion. The full policy is available on the course web site under Course Documents.

GRADING SYSTEM

All assignments are posted on the course website, and except for the final project, each assignment must be done individually. Late work is not accepted, no extensions are granted, and no credit will be awarded for work submitted after the deadline. Work that is submitted electronically must follow the Guidelines for Electronic Submissions.

Homework: 3@ 5% each (lowest HW is dropped)	15%
Projects: 4 @ 15% each	60%
Final Project	25%
Total	100%

Each assignment will receive a numerical score, and a total numerical grade will be calculated using the weights shown above. This number grade will then be translated to a letter grade using the following conversions: 0-59 → F; 60-69 → D; 70-72 → C-, 73-76 → C, 77-79 → C+; 80-82 → B-, 83-86 → B, 87- 89 → B+; 90-92 → A-; 93-96 → A; 97-100 → A+.

PROPOSALS

The course requirements described above are not the only possible method of evaluation. Any or all of these requirements can be overridden by submission of a written proposal, which must include: (1) the reason for the request; (2) the work that will be submitted to replace the requirements listed above; (3) the due date for this work; and (4) how the replacement work should count in computing the total grade. To be approved, a proposal must satisfy two criteria: (1) relevance to course material, and (2) equivalence with the original course requirements and grading system. There is a limit of two proposals for each assignment. As with any other assignment, work submitted after the due date indicated in a proposal will be considered late and will not receive credit. In any case where the new grade is less than the old one, the original grade will be retained. If the due date comes after the deadline for the written Final Project, the student will receive a grade of INC, which will be converted to a final grade after the due date in the proposal. No proposals will be accepted after the deadline for the written Final Project.

References:

*Except as noted, all books listed below are on reserve for ME 37100 at the Sci/Eng Library, J29. Call numbers (**shown in bold**) are now required for checking out reserve books.*

Engineering Graphics

Plantenberg, Kirstie (2006). Engineering Graphics Essentials. Mission, KS: Schroff Development Corp. *Downloadable from course website*

Linear Algebra

Pettrofrezzo, Anthony J. (1978). Matrices and Transformations. New York: Dover. **QA188 P47**

Bronson, Richard (1991). Matrix Methods: An Introduction (2nd Ed.) San Diego: Academic Press. **QA 188 B758**.

Fekete, Antal (1985). Real Linear Algebra. New York: Marcel Dekker. Chapters 6-8. **QA 184 F45**.

Finite Element Method

Brauer, John R., ed. (1988) What Every Engineer Should Know about Finite Element Analysis. New York: Marcel Dekker. **TA 347 F5 W48**

Cook, Robert D. (1995). Finite Element Modeling for Stress Analysis. New York: John Wiley & Sons. **TA 347 F5 C665**

Zahavi, Eliahu (1992). The Finite Element Method in Machine Design. Englewood Cliffs, NJ: Prentice Hall. **TJ 213 Z25**

Becker, A.A. (2004). An Introductory Guide to Finite element Analysis. New York: ASME Press. **TA 347 F5 B41**

Fagan, M.J. (1992). Finite Element Analysis: Theory and Practice. Essex, UK: Longman. . **TA 347 F5 F34**

SolidWorks Simulation

Steffen, John R. (2013) Analysis of Machine Elements Using SolidWorks Simulation 2012. Mission, KS: Schroff Development Corp. **TJ 233 S74.** *Chapters 6 & 7 deal extensively with contact conditions between parts of an assembly.*

Stress Analysis

Young, Warren C. (1989). Roark's Formulas for Stress and Strain (6th Edition). New York: McGraw-Hill.**TA407.2 R6** *Appendix provides analytical stress concentration factors.*

Norton, Robert L. (1996). Machine Design: An Integrated Approach. Upper Saddle River, NJ: Pearson Education. **TJ 230 N64** *Excellent design examples.*

Pilkey, W.D. & Pilkey, D. F. (2008). Peterson's Stress Concentration Factors. New York: John Wiley & Sons. **TA417.6 P43** *Authoritative reference on this subject*.

Analogies

Olson, Harry F. (1958). Dynamical Analogies. Princeton, N.J.: Van Nostrand. **QA871 .O4 1958**

COURSE OUTLINE AND SCHEDULE

Week	Date	Lecture Topics	Lab Topics	Assignments **
1	1/29	Course overview: responsibilities of an engineer, role of CAD in engineering; purpose, structure, requirements and support system	SolidWorks (SW) user interface; SW sketches and drawings; review of orthographic views and dimensioning.	HW #1 Feb. 2
2	2/5	Linear algebra I: matrices as linear operators, coordinate transformations; compatibility; symmetry, transpose, inverse, scalar products and orthogonality.	SW features and feature operations	HW #2 Feb. 16
3	2/20 *	Linear algebra II: Eigenvalue problem, Principal Axis Theorem, diagonalization, minimization of symmetric positive definite quadratic forms.	SW 3D sketching, surface modeling and advanced feature operations; Solid Modeling Project	
4	2/26	Introduction to stress analysis and FEM: Mechanical failure, stress, and specification of stress states; stress analysis in mechanical design; stress analysis methods and origins of the finite element method (FEM).	Solid Modeling Project	HW #3 Feb. 28
5	3/5	Finite element method I: Principle of Minimum Potential Energy, interpolation, shape functions & constitutive equations; construction of element stiffness matrix.	Overview of SolidWorks Simulation (SWS): Study type, material selection, setting boundary conditions, meshing, solution and post-processing	Solid Modeling Project March 7
6	3/12	Finite element method II: direct and formal methods; equilibrium equations and node compatibility; assembly of global stiffness matrix; singularity of [K]; applying boundary conditions (BC's), secondary variables	SWS element types, refinement methods and convergence tests	HW #4 March 16
7	3/19	Element types and performance: element order, displacement and strain fields; performance of CST, LST, Q4 & Q8 elements, h- and p-refinement methods, convergence, and implications for modeling	Viewing stress and displacement results in SWS	FEM Project #1 March 21
8	3/26	Issues in modeling and in understanding stress results: Load paths, stress concentration theory, symmetry and element quality	SWS symmetry boundary conditions and element quality checks	
9	4/9 *	Failure theory: Need for a failure theory; stress tensor, diagonalization and principal stresses; Rankine, Tresca, & von-Mises theories of failure.	Evaluation of a model vs. evaluation of a part; model evaluation methods; stress components; safety factor	FEM Project #2 April 11
10	4/16	Gaussian quadrature: Newton-Coates vs. Gaussian integration, Gauss points and weights for n = 2 in 1-D, extension to 2-D & 3-D; triangular & tetrahedral coordinates	Preparation for final project	Final project Proposal April 20

Week	**Date**	**Lecture Topics**	**Lab Topics**	**Assignments ****
11	4/23	Automatic mesh generation: Benchmarks and categories of mesh generation methods; Structured methods: boundary processing. Unstructured methods: Delaunay-Voronai and Advancing Front. Surface recovery, mesh modification and enhancement.	Final Project group meetings	
12	4/30	Matrix solution: Benchmarks and categories of solution methods. Matrix types. Direct (LU decomposition) iterative (Gauss-Seidel) and semi-direct methods (steepest descent, conjugate gradients, pre-conditioning).	Final projects	Reflective Project May 2
13	5/7	Analogies in engineering: Assets, operations, states, variables, conservation and linearity laws and references; energy conversion and storage; storage devices, transformers and converters.	Final Project group meetings	
14	5/14	FEM in engineering: Derivation and meaning of Laplace and Poisson equations. Field problems in 2-D and 3-D, boundary conditions and sources. FE examples from groundwater flow, electrostatics, electromagnetic, aerodynamics, heat transfer and multiphysics.	Final projects	
15	5/21	Final Project Oral Presentations 8:00 – 10:15 AM, 1:00 -3:15 PM, 6:00 – 8:15 PM		
	5/29	Final Project Written Reports, + all other work (unless covered by proposal for INC) & proposals		

* No classes Mon., Feb. 12 & 19 or April 2; Mon. schedule, Tues., Feb. 20

** All written assignments are due at 5 PM on the day indicated