ME128 Computer-Aided Mechanical Design
Course Notes
Introduction to Computer-Aided Mechanical Design

1. Introduction

1.1. Introduction to Computer-Aided Mechanical Design

This course serves as your springboard to the application of computers to mechanical design.

Most people associate computer-aided design to drafting. Computer-aided drafting programs, as a commodity, have no doubt struck the death knoll for drafting triangles and eraser shields for most engineers. The CAD vendors often extol the virtues of their computer-aided design software but emphasize only the drafting portion. However, drafting represents but a small portion of computer-aided design and perhaps only a small portion of the entire design process. Those of you who attended Berkeley for your lower division courses most likely took E28, which covered the drafting portion of computer-aided design. You might have also taken E128, which covered solid modeling, parametric modeling, surface modeling and 3D visualization and animation.

In this course, we depart from drafting towards the pursuit of writing programs that assist us as engineers in designing.

If you would like to work for companies such as Autodesk or Parametric Technology after graduation and be on the development side of the CAD industry, one other course available to you as an undergraduate is CS184 (Foundations of Computer Graphics). This essential course covers "techniques of modeling objects for the purpose of computer rendering." Those of you who intend to continue your graduate studies at Berkeley might wish to consider ME228 (Computer-Aided Optimal Mechanical Design), CS284 (Computer-Aided Geometric Design and Modeling), CS285 (Solid Free-Form Modeling and Fabrication) and EECS244 (Computer-Aided Design of Integrated Circuits). This last course has more applicability to mechanical design than might be patently obvious.

There are four modules to the course: 1) Design Automation; 2) Design Optimization I; 3) Design Optimization II; and 4) Design Information Management. Each module will develop a core skill as well as familiarize you with industry-standard computer-aided mechanical design software such as AutoCAD, Matlab, ANSYS and the Web.

The computer-aided design market is extremely competitive. In the mechanical design industry, the market is dominated by the heavyweights Autodesk (www.autodesk.com), Parametric Technology Corporation (www.ptc.com), Bentley Systems (www.bentley.com), SolidWorks (www.solidworks.com), Structural Dynamics Research Corporation (www.sdrc.com), Dassault Systemès (www.catia.com) and Unigraphics (www.unigraphics.com) among others. Yahoo

(dir.yahoo.com/Business_and_Economy/Companies/Computers/Software/CAD_CAM/) has a fairly comprehensive list of CAD vendors.

All of these vendors offer CAD software for parametric modeling, solid modeling and surface modeling as well as some analysis tools. They all contain interfaces with industry-standard design analysis tools such as MSC NASTRAN (www.macsch.com), Cosmos (www.cosmosm.com) and Algor (www.algor.com). Two other widely used mechanical engineering software packages are DADS (www.cadsi.com), a kinematics motion analysis program, and MechSlide (www.emtsoft.com), which automates the drafting of common mechanical engineering components such as pressure vessels and beams. In addition, it is usually possible, though not always 100% reliable to transfer data files from one package to another using IGES (Initial Graphics Exchange Specification) (www.nist.gov/iges/) or STEP (Standard for the Exchange of Product Model Data (ramp.scra.gov/whatstep.html).

What truly differentiate their product offerings, oddly enough, are the user interface and how the user interface allows mechanical designers to design quickly, efficiently and with the shortest learning curve. Feature wise, their product offerings are nearly identical. In this industry, the more you pay, the more you get. As you read the article from *Computer Aided Design report*, you will get a sense of how competitive the mechanical CAD market is, and how the market is segmented by cost.

As a result of the convergence of two technologies, computer-aided drafting and relational databases, and increasingly ambitious and complex products, e.g., the Boeing 777, the CAD vendors brought forth product data management software. Product data management (PDM) software is the commercialization of computer-aided simultaneous engineering (CASE) software first developed by the academic community. You can read more about CASE in the paper by Molina et al. (NB: CASE also stands for computer-aided software engineering in the computer science field.) Essentially, PDM software gives engineers the ability to manage information associated with the design of a product. This information includes basic project management and tracking information such as revision history, design change control and parts summary, as well as engineering information such as materials data and design analysis results.

One area not yet commercialized intensely is the “intelligent” CAD market. Exactly what constitutes an “intelligent” CAD system is still contested although the paper by Akman et al. tries to frame “intelligent” CAD in a scientific manner.

Obviously, we cannot cover thoroughly all of these topics in this course. The objective of this course is to introduce you to some widely used commercial CAD software and learn how to apply their features to mechanical design. Further, you will learn how to customize CAD software to automate your design and how to link analysis tools with graphical tools.

This course emphasizes problem formulation; that is, you will identify exactly what it is that you want your software tool to accomplish. You will be able to determine exactly

what the output will be given the input to your program. You will also learn how the applications arrive at the answer to minimize the possibility of "garbage in, garbage out." In short, you will learn how to select the right tool for the design task, how to customize the software product for your design task, and how to verify that the program gave you the "right" answer.

References

Molina, A., Al-Ashaab, A.H., Ellis, T.I.A., Young, R.I.M, and Bell, R., 1995, "A Review of Computer-Aided Simultaneous Engineering Systems," Research in Engineering Design, Vol. 7, No.1, pp. 38-63.

Brown, D.C., 1998, "Intelligent Computer-Aided Design," *Encyclopedia of Computer Science and Technology*, J.G. Williams and K. Sochats, (Eds.), Mc-Graw-Hill.

Homework 1: Thought Questions on CAD Systems

Answer the following Two Questions. Be Prepared to Discuss Your Answer in Class. Each answer should approximately ½ page long typed single-spaced or one page double-spaced.

1. Having read the paper on the competitive benchmarks between commercial solid-modeling CAD packages and desirable features of intelligent CAD programs, how would you conduct a benchmark for intelligent CAD programs? What metrics would you use to decide how "intelligent" a CAD package is? How would you define "intelligence" in these CAD packages? Construct a matrix of criteria to use as a means of benchmarking.
2. Many researchers and commercial CAD vendors propose the utilization of the Web as an open, integrated, design environment. Based on the challenges posed in constructing an integrated, computer-aided simultaneous engineering system as described by Molina et al., what challenges do you foresee in building a simultaneous engineering environment on the Web? What technologies need to be developed? Which technologies need maturation to support engineering design?