Using Class Projects to Develop a Digital Library of Case Studies

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Abstract

In the past several years, the author has assigned class projects of reverse engineering or case studies of mechanical devices, with emphasis on computer modeling and analysis. This type of projects is less structured and more open-ended than most of homework assignments and class projects, an attribute encouraged by ABET. Each student is asked to select the device to be analyzed. The device chosen could be related to his/her part-time, co-op, or summer intern employment, or from friends, parents, relatives, or others. The variety of different devices analyzed in this type of self-directed projects enriches the instructor and makes his teaching more interesting.

This type of class projects has been a satisfying experience for students since they selected their own devices for acquiring hands-on experiences in measuring, testing, and computer modeling. Students appreciated the fact that they could analyze and model real world devices, not over-simplified textbook problems. It's a gratifying experience for the instructor to see the quality of the projects and reports improve over the years as best reports from previous semesters become the benchmark for students in the current semester. Exemplary reports collected are placed on a computer server and became part of a digital library for stress analysis and motion simulation. The digital library helps students who need more examples in mechanisms, Free Body Diagrams, shear and bending moment diagrams, and fatigue analysis.

Introduction

In the late 80's and earlier 90's, design projects were highly emphasized in the author's department, yet generating a new and good design project topic for every course in every semester was a difficult process. Recycling old design project topics was less desirable as it yielded less enthusiasm among students and the instructor. Furthermore, having different design projects every semester left little room for continuous improvement, and design projects emphasizing the creative process were often poorly linked to other subjects covered in these courses.

As the new ABET 2000 criteria [1] become clear, the design project component is less emphasized and continuous improvement [2] becomes the underlining principle in teaching. In the past several years, the author has replaced design projects with projects of reverse engineering or case studies of mechanical devices, with emphasis on computer modeling and analysis.

This type of project can be helpful in new or revised courses, especially those with emphasis in computer-aided design, with textbooks having inadequate or insufficient homework problems and projects. Case studies of stress analysis are given by the author in MEEN 565 Computer Aided Design of Machine Elements using a solid modeling package IronCAD [3] and a FEA package visualNASTRAN [4]. Case studies of motion simulation are given in MEEN440 Mechanism Design and Analysis, and MEEN 647 Computer Integrated Mechanism Design using software Working Model 2D [4] and visualNASTRAN.

This type of projects is less structured and more open-ended than most of homework assignments and class projects, an attribute encouraged by ABET. Each student is asked to select the device to be analyzed. The device chosen reflects each student's different connections and resources. It could be related to his/her part-time, co-op, or summer intern employment, or from friends, parents, relatives, or others. The variety of different devices analyzed in this type of self-directed projects enriches the instructor and makes his teaching more interesting, as he becomes a consultant to different student projects.

The student project reports, including two-dimensional drawings, solid models and simulation files are submitted in electronic form, which are easier to file and search. All equations in the reports must be typed using Microsoft Equations, and all figures and diagrams are generated in electronic form to yield a professional looking result. Exemplary reports collected are placed on the Blackboard [5] server, which is used, among other teaching purposes, to disseminate course document. These files became part of a digital library for stress analysis and motion simulation.

This type of courseware fits the underpinning philosophy of the National Engineering Education Delivery System (NEEDS) [6,7], a digital library for undergraduate engineering education developed by Synthesis: A National Engineering Education Coalition to enable new pedagogical models based on internet-mediated learning environments. Since 1997, NEEDS and John Wiley & Sons has awarded the Premier Courseware [8] four times through an annual competition to recognize high-quality, non-commercial courseware designed to enhance engineering education. However, there is no courseware highlighting motion simulation or stress analysis of mechanical devices from NEEDS, nor from other digital libraries linked with NEEDS website.

Case Studies of Stress Analysis

For case studies of stress analysis, each student selects a mechanical device and calculates safety factors of static and fatigue failures for at least two major components – bolts, gears, springs, shafts, etc. The class project incorporates and integrates many subjects students learned earlier including: computer graphics, engineering materials, statics, strength of materials, mechanical design, and design of machine elements. To determine a material's property, a student can measure its hardness and analyze its chemical components using instruments in departmental Materials Laboratory. To model the device, a CAD package IronCAD is used. Three-dimensional Free Body Diagrams (FBD) can then be easily created based on solid models created in IronCAD. Devices studied in the past few semesters include: power drills (Figure 1), power saws, pencil sharpeners, can openers, automotive suspensions, door locks, scissor jacks, and oscillating fans. Students can verify their calculations by checking if the safety factors calculated are reasonable.

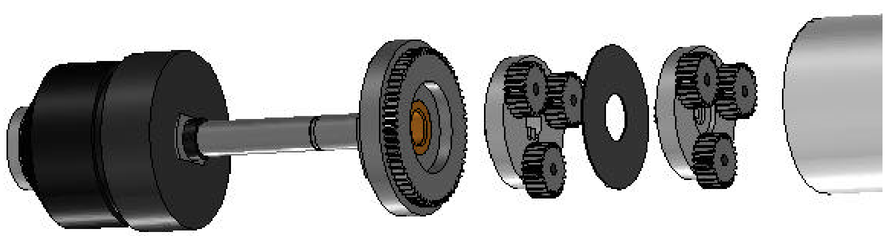

Figure 1. The Gear Train of a Cordless Power Drill

Case Studies of Motion Simulation

In motion simulation case studies, each student identifies a mechanical system to simulate its motion. This type of project is used to identify links and joints (including higher pair joints as cams and gears) in a mechanical system and simulate the motion using Working Model 2D and visualNastran (previously known as Working Model 3D). Devices studied in two-dimension software include: automobile hoods and trunks, convertible tops, futons, glider rockers, folding chairs. Devices modeled in three-dimension software include: a swash-plate compressor (Figure 2), an engine with crankshaft, piston, camshaft, and valves (Figure 3), vehicle suspensions, and industrial robots.

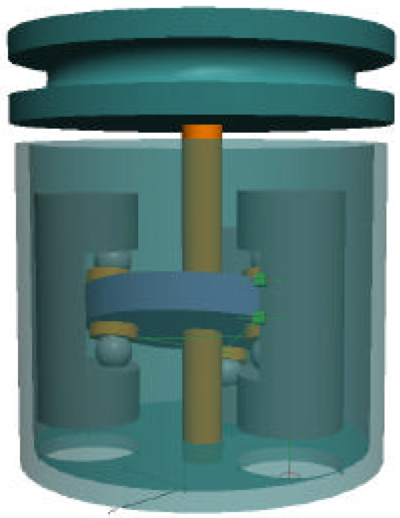

Figure 2. A Compressor

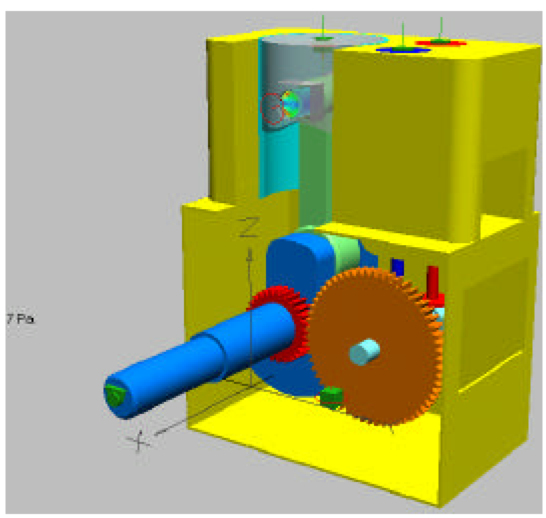

Figure 3. An Engine

Projects are often given with a general category: car hoods (Figure 4), car trunks (Figure 5), or wind-up toys (Figures 6 and 7), and each student works on a different kind of mechanism in the general category. Students enjoy the synergy that although each one is working on a different project, they can learn from one other since all mechanisms are similar.

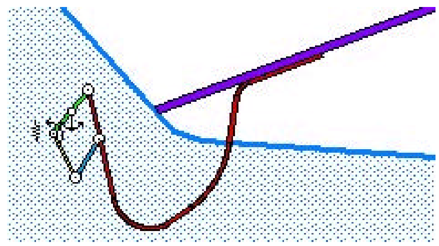

Figure 4. An Automobile Trunk

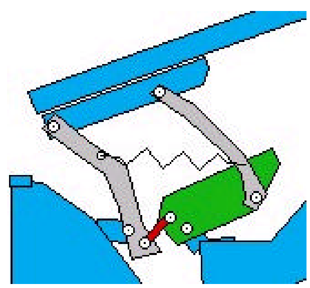

Figure 5. An Automobile Hood

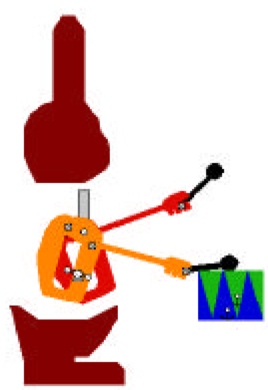

Figure 6. The Computer Model of a Wind-Up Toy

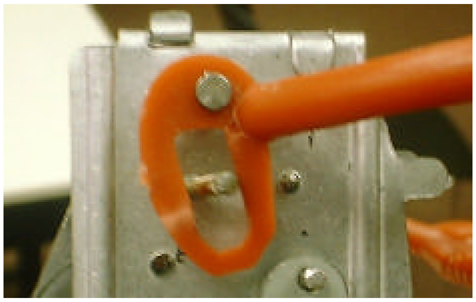

Figure 7. A Close-up Photo of a Wind-Up Toy

Discussion

Cases studies have been a satisfying experience for students since they selected their own devices for acquiring hands-on experiences in measuring, testing, and computer modeling. Students appreciated the fact that they could analyze and model real world devices, not over-simplified textbook problems. Additionally, they developed self-confidence when generating quality reports that can help other students in following semesters. Several students donated the devices after their projects and therefore there are many physical models with the instructor for students to compare with the respective computer models.

It's a gratifying experience for the instructor to see the quality of the projects and reports improve over the years- meeting the continuous improvement requirement in ABET outcome assessment- as best reports from previous semesters become the benchmark for students in the current semester. Useful resources for students are compiled to help these projects, such as tips on taking photographs, report writing, and the measurement of forces, rotational speeds, gear diameters, etc.

The resulting digital library helps students who need more examples in mechanisms, Free Body Diagrams, shear and bending moment diagrams, and fatigue analysis. Students are encouraged to place their project reports and motion simulation files on their personal homepages to highlight their project work and use them as a tool to demonstrate their competence in securing a job.

References

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