CUTTING STUDENTS' IMAGINATION LOOSE PAYS RICH DIVIDENDS

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Abstract: The *Technical Drawing* course is a freshman level course taken by engineering students at Union College. The course covers the fundamentals of engineering graphics and heavily relies on the software package *SolidWorks* in drawing parts, assemblies, and engineering plans. Project *GraphSpeak* is an exciting design project that was introduced to give the students an opportunity to put into practice the knowledge gained in this course. The project entails the design of an assembly and the drawing of a full set of engineering plans. Students were required to work in teams of two partners. Teams were allowed to select the subject of the project they like to design and draw. Students were also encouraged to visit a hardware store to get some ideas of innovative project subjects. Each team was required to submit an initial sketch drawing showing the conceptual idea and a detailed description of the project. Completed project submittals included *SolidWorks* drawings of individual parts, an assembly showing all components, views, and dimensions, sections, and Bill of Materials of all components to be used in the manufacture of the assembly. The grading criteria placed equal weight on the level of sophistication of the design, practicality and functionality, accuracy and completeness of drawings, and level of detail in the presentation of components and Bill of Materials. Furthermore, students were also required to make an oral presentation in which they show a functional assembly with animation. Students were taught how to do a stress analysis using *COSMOSXpress* finite element package that is part of *SolidWorks*, and were asked to do a similar analysis on the parts of their projects. The absence of a criterion that restricted what students can do in their projects resulted in a fierce level of competition between teams. This elevated the technical content of the student-selected projects to previously unmatched heights. Students showed that when the instructor cuts their imagination loose, they rise to the challenge, push the envelope, and implement projects of highly sophisticated nature. In the execution of their projects, students took great pride in being enormously thorough and meticulous. Students' feedback regarding their experience was extremely positive.

Key words: Engineering, Liberal Arts, Construction, Computer Graphics.

Introduction:

The technical drawing course is a basic course in any mechanical engineering curriculum. It helps students develop a fundamental skill of being able to communicate graphically. With the availability of advanced computer design and drafting software packages, courses on engineering graphics can presently achieve significantly ambitious goals. These advanced techniques, coupled with students' reasonable comfort and familiarity with computers can help instructors raise the level of expectation and allow the students to use their imagination beyond traditional boundaries.

Subjects Covered:
The main subjects covered in the technical drawing course at Union College are:
1. Introduction to Graphics Communications.
2. Sketching and Text.
3. Section and Auxiliary Views.
4. Dimensioning and Tolerancing Practices.
5. Reading and Constructing Working Drawings.
6. Design and 3-D Modeling.

After an in-depth introduction on the subject matter, students are introduced to *SolidWorks* which is the software packages used in the course. *SolidWorks* is a design and drafting tool with many advanced features. The main highlights of the software are its ease of use and simple to follow driven menu and desktop icons. Students start learning the program by drawing simple two-dimensional figures. They learn about sketching planes and the drafting tools the program makes available to its users.

Course Objectives and Outcomes:
The course aspired to achieve the following objects:
1. The ability to prepare a professional engineering drawing package describing a part or assembly that can subsequently be manufactured by a facility anywhere in the world with little or no intervention from the designer.
2. The ability to apply the basic principles of "Design for Manufacture and Assembly".
3. Familiarization with standard parts such as threaded fasteners, retaining rings, pins and springs, and the ability to integrate them into a design wherever appropriate.

In order to best achieve the above objectives, a project was required of all students. This project was named "*GraphSpeak*" which is a composite word that communicates the idea that the project aims at developing the ability to "speak" using graphics. Project *Graphspeak* was designed to be an exciting venue that will give the students the opportunity to put into practice the knowledge gained in the technical drawing course. The project entails the design of parts and an assembly, and the validation of the design process by examining the level of deformation and stress distribution in various parts.

Students were required to work in teams of two partners. Each team was given total freedom in selecting the project subject they like to design and draw. Students were encouraged to review project ideas from any source. Students were also encouraged to visit hardware stores and get some innovative ideas of project subjects. In the middle of the term, each team was required to submit a progress report that includes a brief description of the project, sketches of the intended parts and assembly, implemented steps toward the design, and anticipated final outcome. The instructor's approval of the conceptualized idea given in the progress report was required to ensure that the intended project meets the expected level of rigor.

One week before the end of the course, each team was required to submit the following:
1. Sketches showing the conception and detailed description of the design idea.
2. *SolidWorks* drawings of individual components of the project.
3. An assembly showing all components of the project, views, and dimensions.

4. A Bill of Materials of all components used in the manufacture of the part or assembly.
5. Title blocks on all *SolidWorks* drawings.
6. In addition to hardcopies, all *SolidWorks* files were required to be submitted in an electronic format that can be opened and viewed from any desired angle or projection.

The grading criteria placed equal weight on the following components:
1. Level of sophistication of design.
2. Practicality and functionality of design.
3. Accuracy and completeness of drawings, including dimensions and tolerances.
4. Level of detail in presentation of components and Bill of Materials.

In the last week of the term, each team was required to make a class presentation of their project. Teams were expected to show fully functional projects including stress analysis. Each presentation was followed by questions and answers period.

Project Selection:
In previous offerings of the course students were given a specific subject for the project. It was basically one part that all students were required to draw. The idea of allowing the students to select the subjects of their projects was based on the premise that opening the field for students to compete can result in projects of more sophisticated technical content. Students came up with very innovative ideas and were excited to design and draw their parts and assemblies. Because teams selected their own projects, there was a strong feeling of pride in what students achieved. It was also clear that students were trying to prove that they could implement the most sophisticated ideas to prove their command of the software. The outcome of this competition-like project was an impressive array of assemblies, each of which has its own distinguishing features. All the projects shown in the following were animated to show the mode of movement simulation. This was highly exciting to the students.

Implementation:
The following is a sample of the projects students conducted. The major parts used in building these assemblies are listed. One can see in the accompanying figures how meticulous and thorough the students were in putting together these assemblies. It is also worth noting that all the dimensions used in building these assemblies were actual prototype dimensions, which made it possible to use the drawing for manufacturing purposes.

Figure 1 shows a four cylinder, two-cycle engine with a synchronized motion that was best illustrated through animation. The assembly included the following parts: supports, crankshaft, collars, connecting rods, piston head, and pins. Figure 2 shows a V4, four-cycle engine with components similar to those of the two-cycle engine, however, cylinder orientation and mode of motion are different. Figure 3 shows an assembly of an elliptical workout machine which is made of the following parts: wheel base, I-support, columns, reading stands, legs, arm and leg brackets, foot piece, grips, wheel cover, and many fasteners including screws, nuts, and washers. Figure 4 shows the assembly of a fire extinguisher. The main parts are: canister, tube, hose, handle, connection rod, and several pins for joints. Figure 5 shows an assembly of a windmill with the main parts being the base, cap, trestle, main drive shaft, end gears of various sizes, grind shaft holder, grind stone, grind stone base and holder, and wind fan.

Figure 6 shows the assembly of a lock where the main parts are: housing, case, several pins with various sizes, latch, several springs with various sizes, and key. Figure 7 shows an adjustable basketball hoop with the main parts of the assembly being: base, pole, pole supports, hoop, and hoop board. The assembly also requires fasteners of various sizes including screws, washers, and nuts. Figure 8 shows a flashlight assembly made of the following parts: housing, battery conductor, shaft, switch conductor, bulb housing, bulb conductor, bulb spring, bulb cup, bulb, and batteries. Figure 9 shows the assembly of a lighter with the main parts being: body, ignition stone, valve casing, valve, valve spring, fling spring, lever spring, lever, flint, lever cap, wheel, and cap. Figure 10 shows the assembly of a lamp. The main parts are: base, body spirals, shade, shade support, bulb holder, light bulb, and switch. Figure 11 shows a corkscrew assembly with the main parts being the screw body and gear, arms, arms gears, and pins.

Stress Analysis:

Students were taught how to do a stress analysis using *COSMOSXpress* finite element package that is part of *SolidWorks*, and were asked to do a similar analysis on the parts comprising the assemblies of their projects. Students were required to do the following:

1. Assign proper material for different parts.
2. Utilize a realistic restraint system of the analyzed part to simulate the actual one.
3. Apply appropriate load (force or pressure) that represents actual loading conditions.
4. Analyze the part using *COSMOSXpress*.
5. Ensure that the Factor Of Safety (FOS) resulting from the analysis is between 2 and 5.
6. Show the stress distribution in the analyzed part.
7. Display the deformed shape of the stressed part.
8. If a part violates the FOS requirement, change any or all of the following: design, material, restraint, or applied load.

Figure 12 shows the deformation and stress distribution in a part analyzed using *COSMOSXpress*. The package gives the user the flexibility to conduct the analysis using various theoretical techniques. Figure 12 shows an analysis that was carried out using the Von Mises method.

Acknowledgement:

The projects shown in this paper are the products of the students of the 2005 Engineering Graphics course.

Conclusions:

The absence of a criterion that restricted what students can do in their projects resulted in a fierce level of competition between student teams. This elevated the technical content of the student-selected projects to previously unmatched heights. Students showed that when the instructor cuts their imagination loose, they rise to the challenge, push the envelope, and implement projects of highly sophisticated nature. In the execution of their projects, students took great pride in being enormously thorough and meticulous.

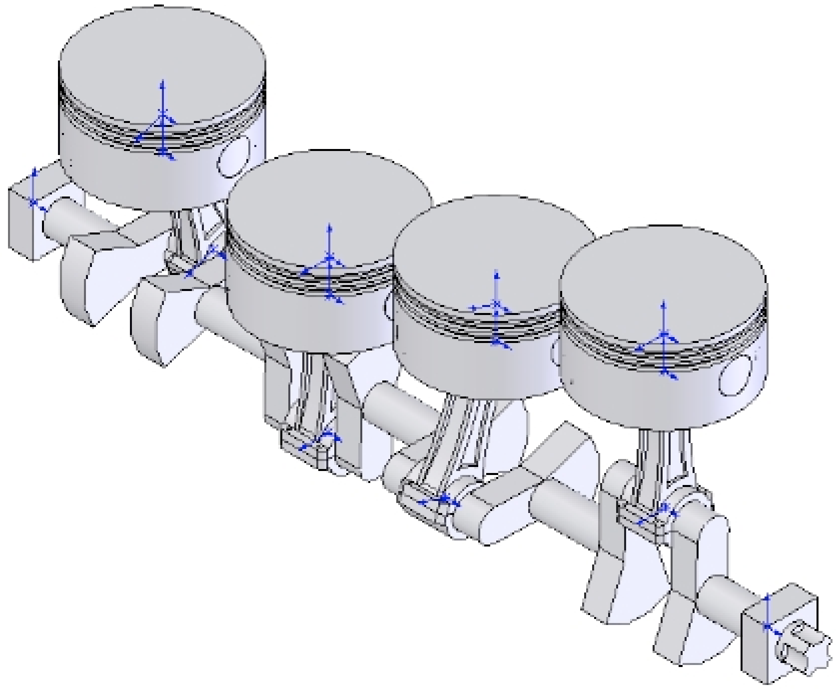

Figure 1. Four-cylinder, two-cycle engine.

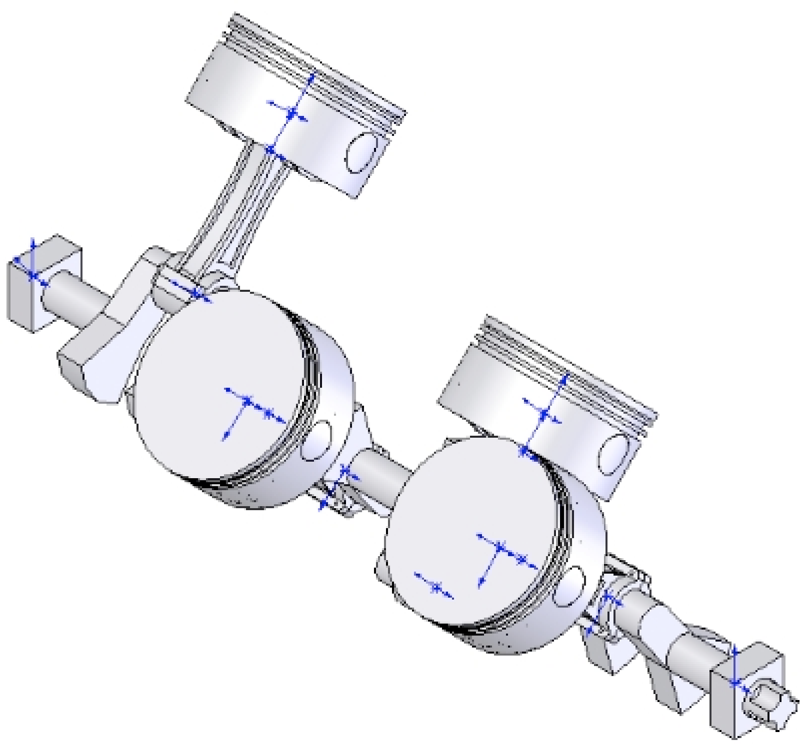

Figure 2. V4, four-cycle engine.

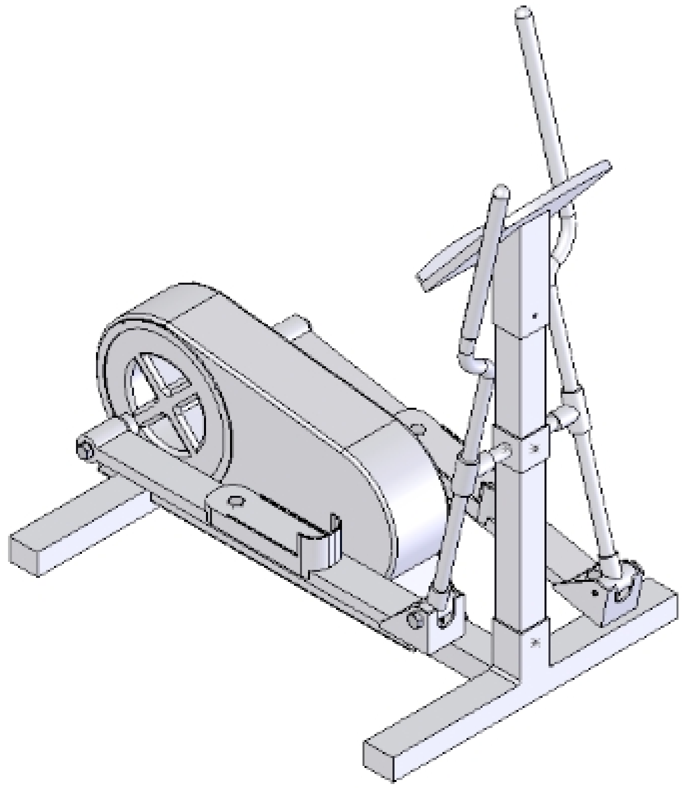

Figure 3. Elliptical workout machine.

Figure 4. Fire extinguisher.

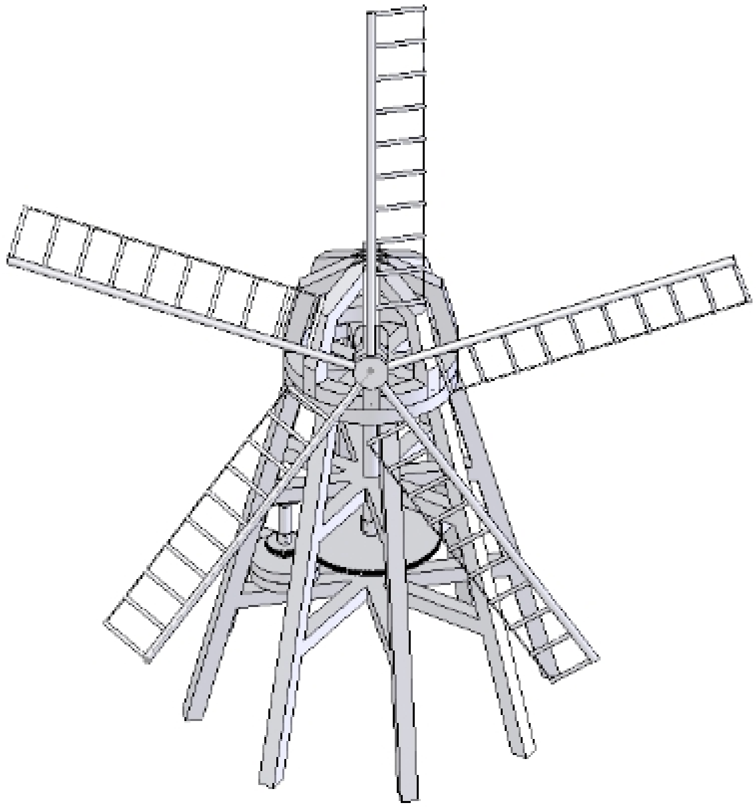

Figure 5. Windmill.

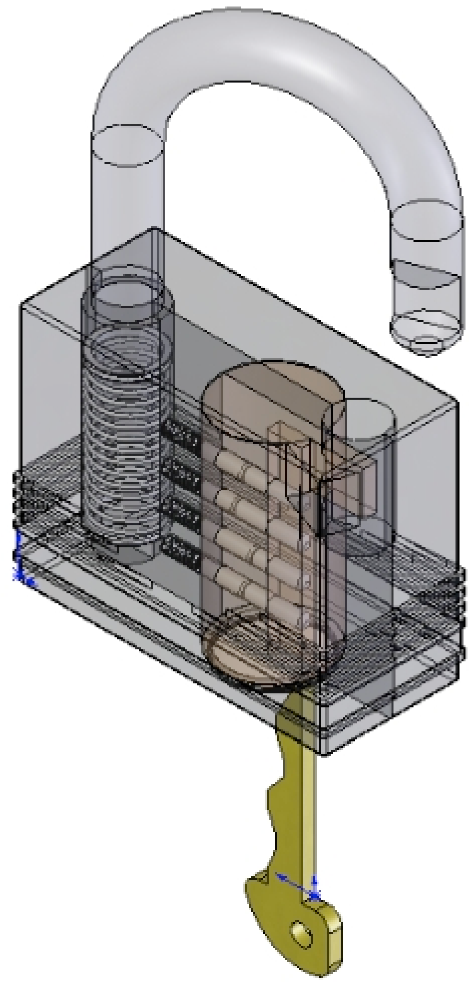
Figure 6. Lock.

Figure 7. Adjustable Basketball hoop.

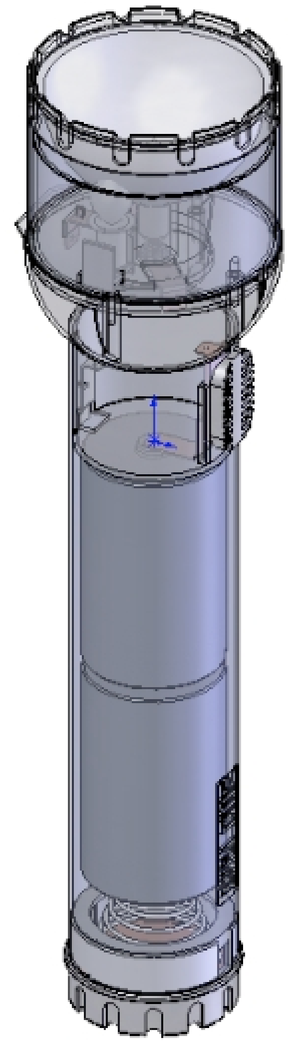

Figure 8. Flashlight.

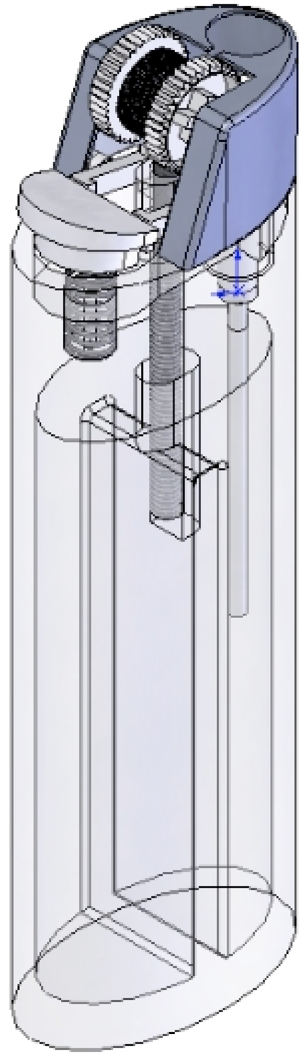

Figure 9. Lighter.

Figure 10. Lamp.

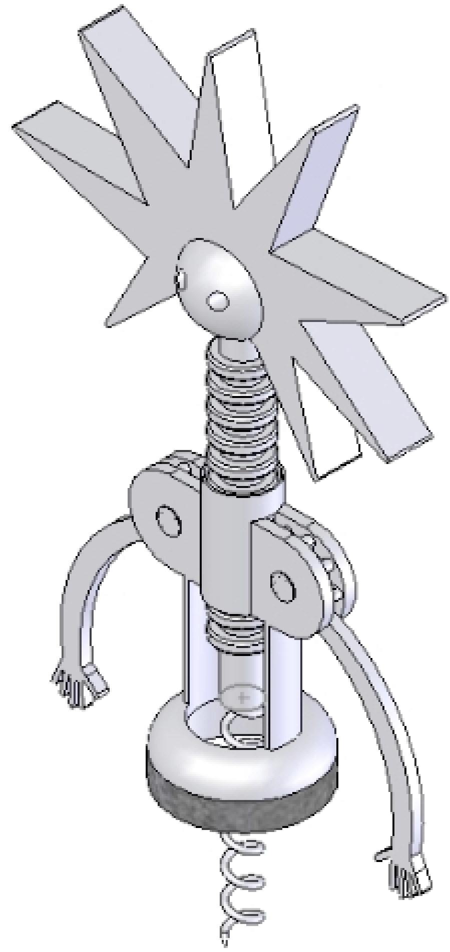

Figure 11. Corckscrew.

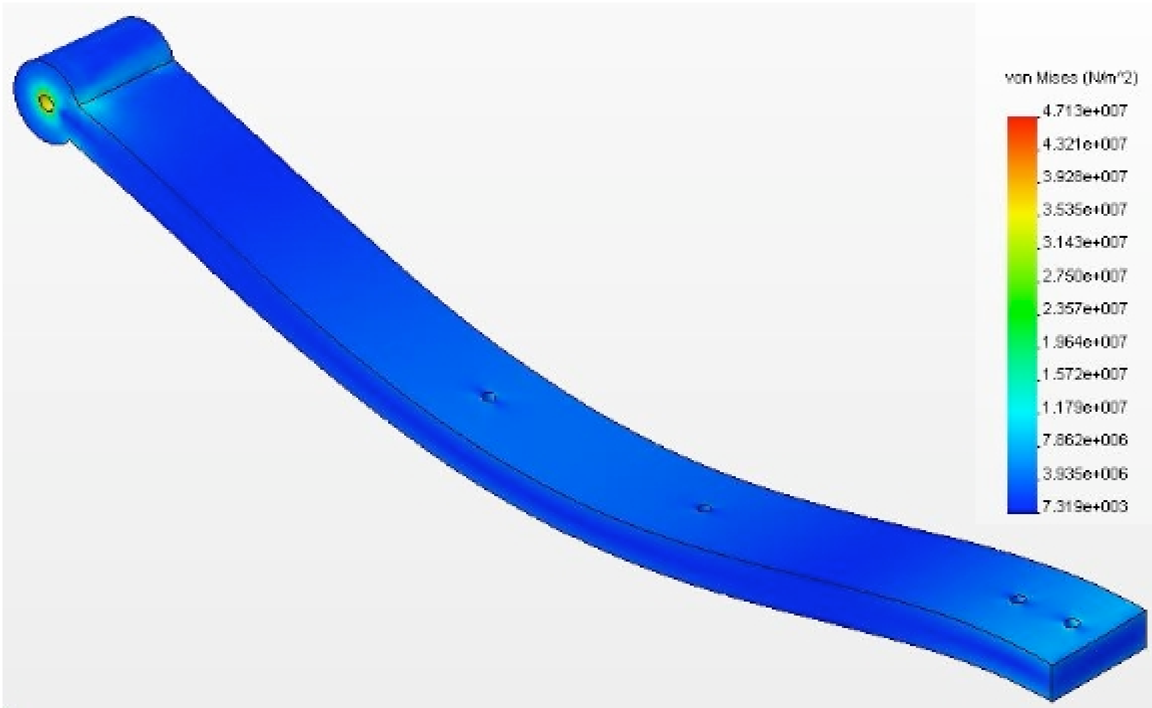

Figure 12. Deformation and stress distribution in a part analyzed with *COSMOSXpress*.