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Galleries of CAD Generated Imagery

by

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Abstract

Galleries of imagery generated from many of the recent CAD (computer aided design, or *graphics*) projects undertaken by St. Thomas undergraduates in mechanical engineering courses are presented. The CAD projects vary widely, e.g. as characterized by the geometric features present in the parts, number of parts in the assembly, overall complexity, scale, industry represented, in addition to presentation and viewing issues, etc. In some cases, animations with overlaid audio were made. The primary purpose of this effort is to attempt to elegantly showcase the body of quality work generated in a relatively compact manner to permit an enjoyable perusal and reflection that may be of use to others teaching future CAD courses or others, such as students interested in CAD work in a BSME program. In addition, one can see the natural evolution of the course since it was first taught. The projects demonstrate the application of CAD knowledge acquired in the freshman *Engineering Graphics* course where SolidWorks™ has been taught recently. However, because of the wide applicability of CAD, projects from many other courses (such as *Introduction to Engineering*, *Kinematics and Mechanism Design*, *Machine Design*, and the *Senior Design Clinic* sequence) are emphasized (although not all of them are showcased) as well. Finally, because of the success of the *Engineering Graphics* course, a brief course description is provided along with practical advice for maximizing the successful implementation of CAD projects for students.

Keywords: computer aided design, CAD, solid modeling

Introduction

The history of computer aided design (CAD) coursework at St. Thomas dates back to 1995 when the *Engineering Graphics* course was offered for the first time. At that time, the Engineering department offered a BS in Manufacturing Engineering, but not a BS in Mechanical Engineering (BSME). Of course, CAD instruction is required for both degrees, so the course has been offered at least yearly since that time. The course was developed and taught by the second author (i.e. Allen C. Jaedike) and based upon similar courses taught at Dunwoody Institute, known for its Manufacturing and Mechanical Engineering Technology (MET) programs. The course had two tracks: (1) interpreting engineering drawings (IED) which is traditional drafting, and (2) CAD training (AutoCAD, release 12). Textbooks for the course were *Interpreting Engineering Drawings* by Jenson and Hines (for the IED track) and *Using AutoCAD Release 12* by J. E. Fuller (for the CAD track) [1,2]. Students were also required to complete a computer aided drafting project (such as the "trolley" assembly from the IED book).

Currently, the course retains the same basic format, although as technology has advanced, the CAD software has necessarily changed over the years from what was largely computerized drafting (using AutoCAD, release 12) to true solid modeling (including limited animation) using SolidWorks™ (current version: 2001); for current textbooks see [3,4,5,6].

The current course objective is:

To provide an overview of graphical communication as it applied to the engineering discipline. Topics covered will include sketching and visualization, descriptive geometry, multi-view drawings, dimensioning, creation and interpretation of working drawings and three-dimensional modeling.

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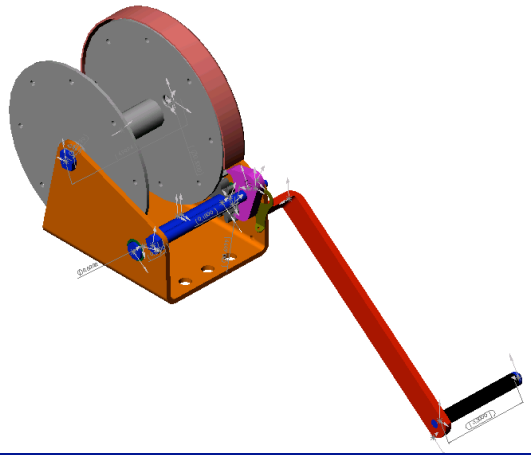
The current course description is:

Students will learn the basics of engineering graphics including freehand sketching and computer aided design/drawing using SolidWorks 2001. The course will include extensive hands-on drawing time (free-hand and computer) as well as demonstrations, some extra time on the computers during open laboratory time in addition to the time provided in class (laboratory hours will be arranged).

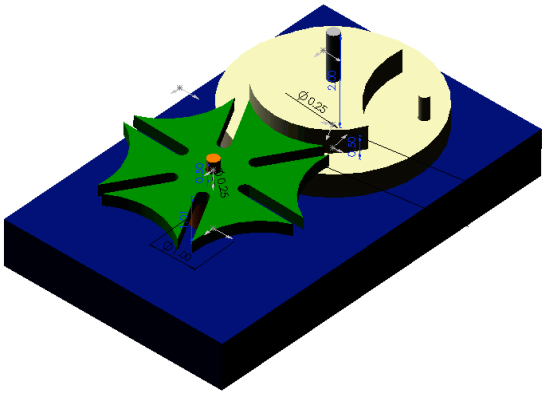
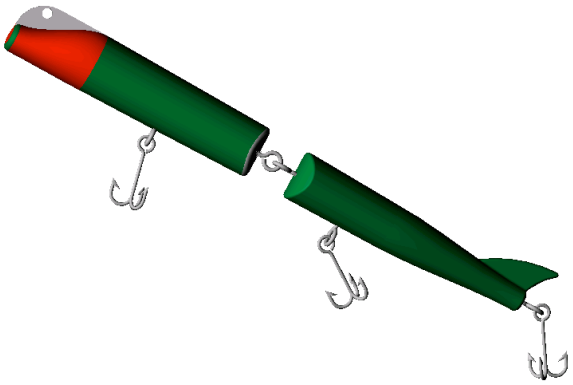
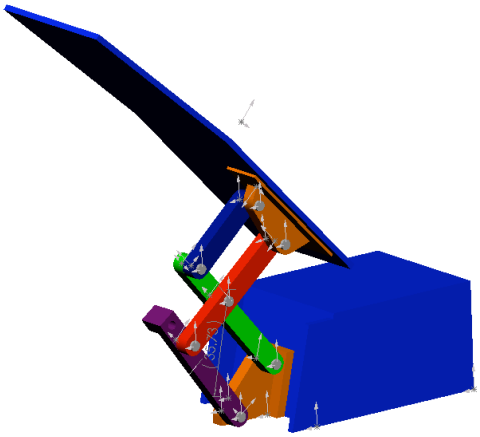
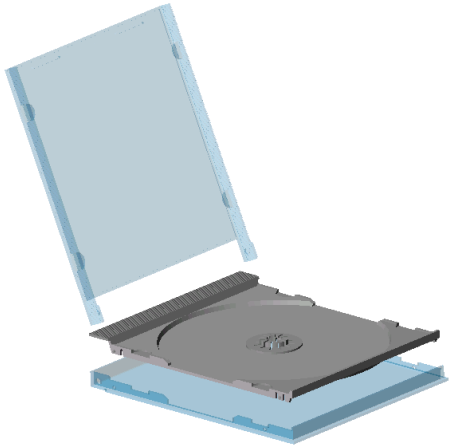
CAD is used in other courses (i.e. besides *Engineering Graphics*) throughout the BSME program as well as in St. Thomas' entry in SAE's 2002 Midwest Mini-Baja competition. Specifically, it is used in *Introduction to Engineering, Kinematics and Mechanism Design, Machine Design,* and in the *Senior Design Clinic* sequence [7]. Some of the freshman in the *Engineering Graphics* course (Spring 2002) who were also taking *Introduction to Engineering* used SolidWorks™ to create their "cable-car" designs for their design projects. Several student teams in *Machine Design* used SolidWorks™ to create their mousetrap powered vehicle designs [8]. For the 2000-2001 *Senior Design Clinic* sequence projects were with 3M and National Mowers (both of St. Paul, Minnesota) and AutoCAD was used to characterize their designs. For the 2001-2002 *Senior Design Clinic* sequence, projects were with Augustine Medical and Graco (both of Minneapolis, Minnesota) and SolidWorks™ was used in both cases. Finally, SolidWorks™ was used to prepare the *basic design report* for St. Thomas' entry in the SAE 2002 Midwest Mini-Baja competition [9].

Galleries of CAD Generated Imagery

Representative galleries of CAD generated imagery using SolidWorks™ from projects undertaken by students in *Engineering Graphics* (3 semesters) and *Kinematics and Mechanism Design* (1 J-term course) over the last several years are shown below in chronological order (for a total of 4 galleries)[3]. In some respects, this follows the efforts of the first author's prior experience at teaching computer aided engineering coursework, where the IDEAS™ package was used [10]. The projects vary considerably, in terms of geometric features represented, number of parts in the assemblies, overall complexity, scale, industry represented, in addition to presentation and viewing issues, use of animation, etc. For each course the projects have a special theme to them. During Spring Semester 2001, the theme in *Engineering Graphics* was "Mike's hand-held gadgets from his house." During Fall Semester 2002, the theme in *Engineering Graphics* was "pick your own" project. In the J-term 2002 *Kinematics and Mechanism Design* course, students used SolidWorks™ to characterize slop in mechanical assemblies [11,12,13]. During Spring semester 2002, there were two sections in *Engineering Graphics* with the theme being transportation devices.

***Engineering Graphics* Gallery (Spring 2001)**	
	
Boat Winch *(Jason Lindberg, Dominic Palmer, Molly Pein)*	**Vice-Grips** *(Dave Hallman, Ross McGruder)*

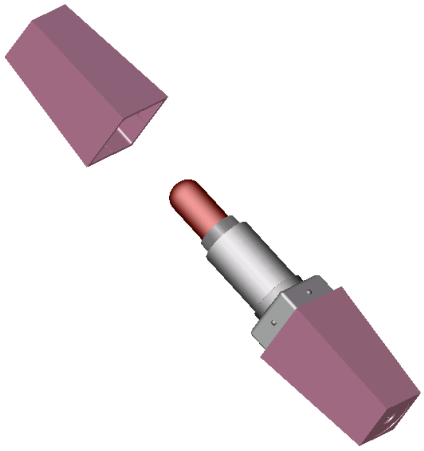
[3] Due to space limitations, the need for variety, and on a rare occasion quality, most but not all student work is showcased.

	
Geneva Wheel *(Brian Skrypek, Ryan Thompson)*	**Musky Fishing *Lure*** *(Michelle Anderson, Vince Fischer)*
	
Hood Linkage *(Adam Spah, Brian Swanson)*	**Computer Mouse** *(Jee Lee, Neng Yang)*
	
CD Case *(Nate Brown, Jim Evanoff)*	**Man** *(Aaron Ames)*

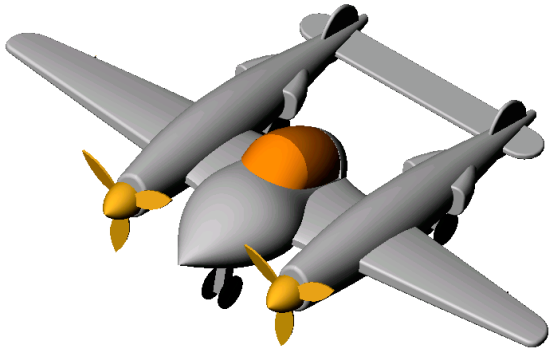
Engineering Graphics Gallery (Fall 2001)

Hand Water Pump *(Jared Davis, Adelle Thomas)*

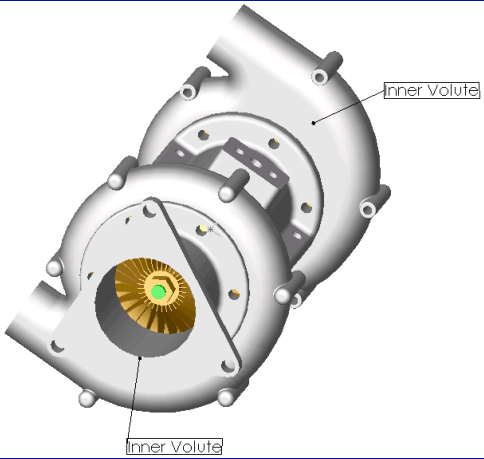
Cox Model Airplane Engine *(Erik Luckjohn, Aaron Spalding)*



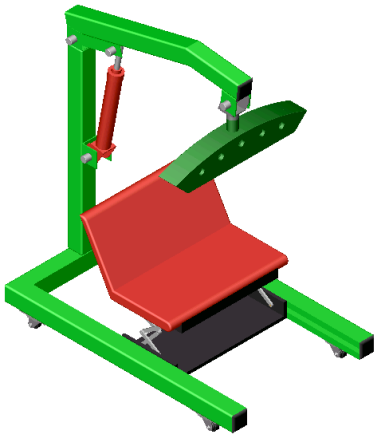
Tube-of-Lipstick *(Farah Friedrich, Kara Torgeson)*



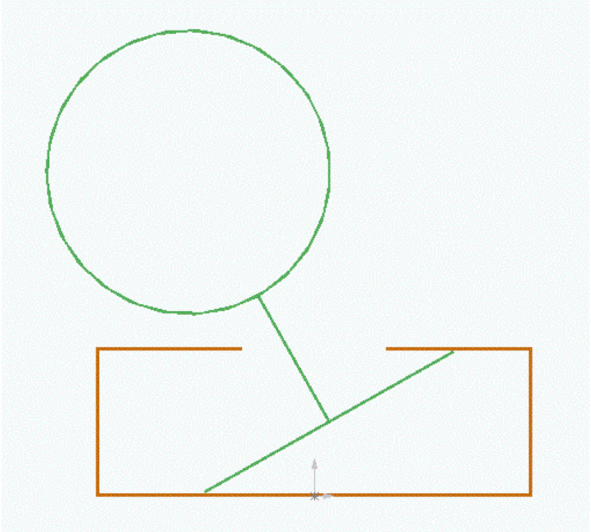
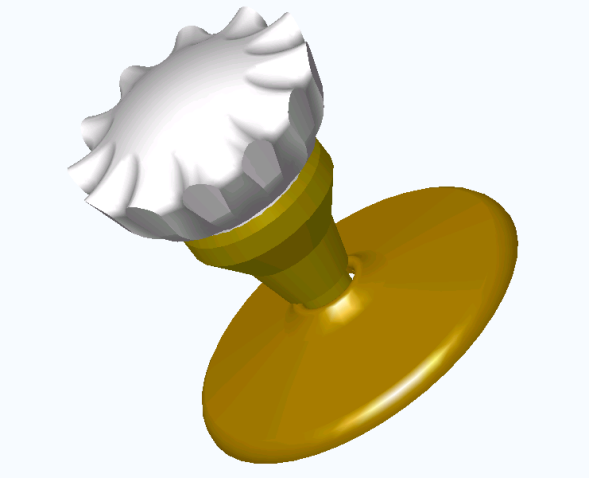
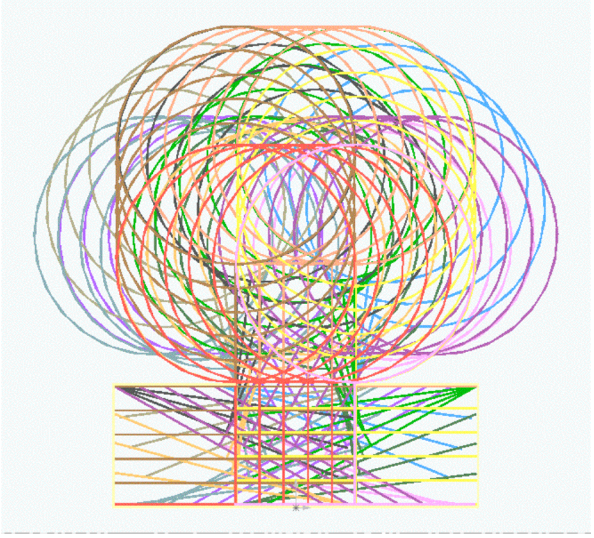
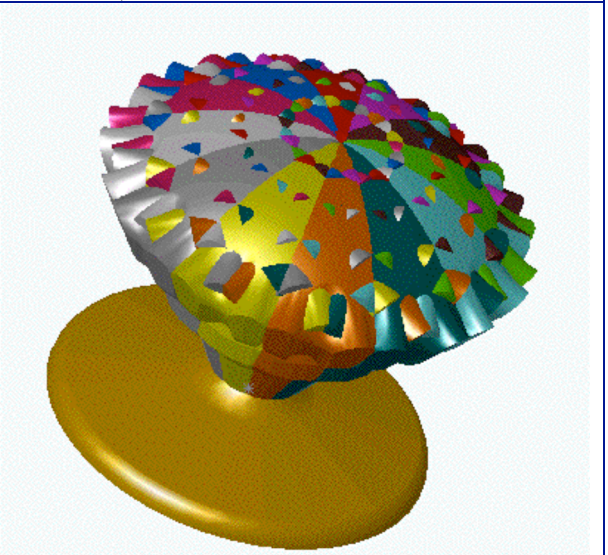
Model Airplane *(Brent Hassler, Chad Hemme)*



Turbocharger *(James Dreher, Jeffrey Novotny)*



Hoyer Lift *(Charbel Bismargi, Tad Klabacha)*

Kinematics and Mechanism Design Gallery (J-term 2002)	
	
2D Doorknob Assembly *(Ryan Beck, Raia Ottman-Rak, Andrew Schwartz)*	**3D Doorknob Assembly** *(Curtis Gross, Scott McClelland)*
	
2D Doorknob t-Sections *(Ryan Beck, Raia Ottman-Rak, Andrew Schwartz)*	**3D Doorknob t-Sections** *(Curtis Gross, Scott McClelland)*

Comments on the Galleries

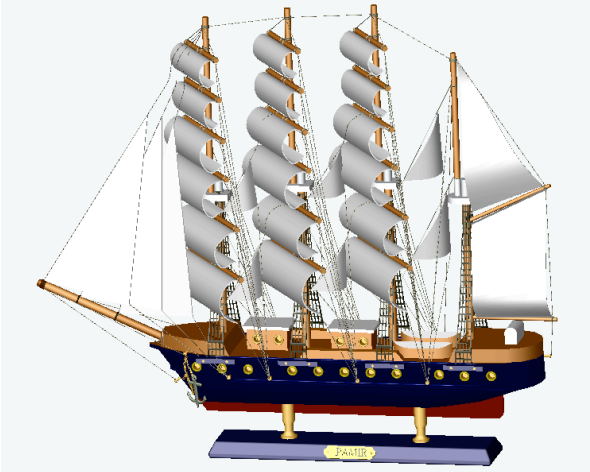
By design, the CAD projects undertaken exercise the student's knowledge of core CAD topics covered, and sometimes even the CAD package![4] Some common CAD topics include: (1) 2D sketching, (2) geometric constraints, (3) extrusions and revolved 3D features (bosses & cuts), (4) patterning, (5) filleting, (6) shelling, (7) ribs, (8) part configurations, (9) sweeping & lofting, (10) basic assembly modeling, (11) assembly configurations, (12) traditional drawings, and (13) viewing and use of color. Aside from the demonstration of specific CAD concepts, perhaps the most important issue concerns the range of projects considered, which is consistent with the ubiquitous nature of CAD in industry today. From a pedagogy point of view this is one the most important concepts learned in the course; the entire class benefits from seeing other projects developed and presented. As a follow-on, during Fall semester 2001 students went well beyond the mere creation of static CAD images. Using the animation

[4] Note: filleting can be sort of notorious in this regard (across various CAD packages).

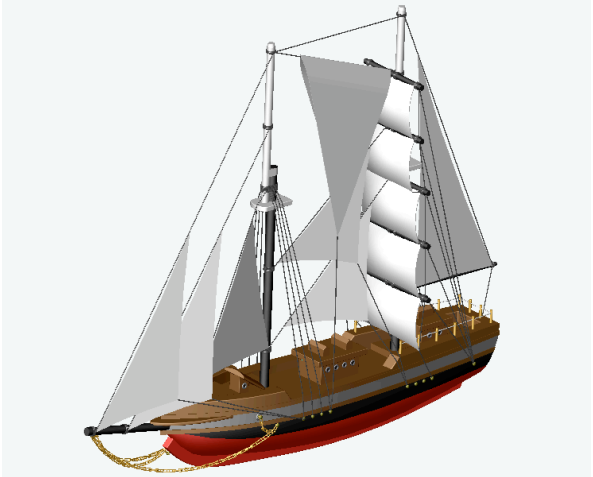
Engineering Graphics Gallery (Spring 2002)

Anakin's Podracer *(Mark Onwuji, Rob Roberts, Holly Wilcox)*

The HUMVEE *(Christi Hoffmann, Thomas Maurtizen, Sean Murname)*



Pamir Sailing Vessel *(Titus Amundson, Jenny Borofka, Jay Brecke, Brian Shovelain)*



Bluenose Sailing Vessel *(Luke Hacker, John Hines, Dan Shinozaki)*

The Original Harley Davidson *(Nick Koivunen, Mitch Malecha, Kasey O'Malley, Will Stipe)*

Vector Scooter *(Brian Murphy, Julie Reed, Derek VanBeusekon)*

M5 Light Tank *(Jason Emiliusen, Thomas Gardner, Apur Mehta)*

King Tiger Tank *(Mark Gambetta)*

feature in SolidWorks™ (called Animator™ [14]), they animated their assemblies creating a ".avi" file which was merged with a ".avi" of their audio selection (typically a song germane to the topic) to create in effect a video which was burned to CD ROM and made available for wide distribution.

Recommendations Regarding CAD Project Implementation

After defining many projects, advising students on CAD project work, and seeing the results of the project effort, a number of specific recommendations have emerged to maximize the learning and project success:

- Project scale and complexity level must be appropriate for the number of students and project time allocated (typically 2-3 students over one month).
- Geometric data (such as features and dimensions) must be readily available to the project team. Inexpensive, clean, durable, hand-held, physical models that can be easily assembled/disassembled next to the computer seem to work the best. Students can then use standard measurement equipment (such as dial calipers, micrometers, and protractors) to easily obtain accurate dimensions that feed directly into the CAD model.
- Construct assemblies with at most 15 or so parts (depending on complexity).
- Mechanisms (versus structures) are preferred since internal motions (or degrees of freedom (DOF)) lend themselves to interesting visualization using animation (a commonly available capability).
- Projects that are truly 3-dimensional in nature are preferred – otherwise why bother using solid modeling?
- Don't be a perfectionist! It is completely acceptable for the student teams to construct approximate models of reasonable fidelity. Having said that, there are some models that aren't that appropriate for a typical first CAD class; e.g. models that possess fairly arbitrary geometry (e.g. sculpted artwork with textured surfaces).
- A low student to faculty ratio is essential since CAD packages are notorious for idiosyncrasies and students often get stuck and they need easy access to the instructor.
- The poster-board concept for displaying the CAD work is a great idea for a number of obvious reasons.
- The projects lend themselves to use of student teams that can be a great learning experience that can be carried into other courses.

Conclusions

Conclusions are as follows:

- With current CAD software, in one semester students can create quite elaborate models of parts, assemblies, even including the possibility of animations and videos. Generally, the entire process can be a fun learning experience for all involved.
- The freshman CAD experience (i.e. *Engineering Graphics*) has wide applicability in other follow-on courses in a BSME program.
- Based on our combined experience of teaching the course many times, a number of specific recommendations have been identified that serve to maximize the fun and the impact of the learning experience.
- The *Engineering Graphics* course has and continues to evolve at a faster pace than other courses, largely because of the ever-changing CAD software.

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