

## **2006-2252: ENHANCING AN INTRODUCTORY ENGINEERING GRAPHICS COURSE**

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# Enhancing an Introductory Engineering Graphics Course

## Abstract

In the presented paper, an approach for teaching a freshman level Engineering Graphics course using the solid modeling principles is proposed and discussed. The created model can effectively be utilized by the instructor in the classroom to present various graphics communication principles and techniques to students. Utilizing a variety of special solid modeling tools/commands available in AutoCAD, a three-dimensional representation of the object can be produced with ease. The constructed model can be edited to create other similar solids for further investigation and exploration. This model can be oriented and viewed from various angles to enable the students to better visualize the intricate parts. Standard multiviews, auxiliary views, and sectional views can conveniently and efficiently be created from the created solid model in AutoCAD to better represent the detailed features of the object. A set of other special solid modeling tools available in AutoCAD can further aid in creating a more realistic three-dimensional representation of the studied object. The students can use the produced computer-aided drawings to check the validity of their hand-sketched drawings. Included in the paper are several samples of solid modeling projects that can be used in an introductory Engineering Graphics course to enhance and extend the students' graphical communication skills and visualization capabilities. The presented samples clearly establish the purpose, utility, and advantages of introducing solid modeling in teaching the graphics course.

## I. Introduction

In the past several years the author has published a number of papers<sup>1-7</sup> in the area of application of computers and new technologies in enhancement of teaching. The tools and techniques discussed in these papers were distinctively selected to suit the specific needs and desired outcomes of the course they were used in. The paper presented focuses on the utility of AUTOCAD solid modeling as a tool to enhance the delivery of instruction in an introductory Engineering Graphics course. The utilization of this software tool offers an extra dimension to the delivery of the course, a dimension that is missing in other traditional modes of teaching this type of a course.

In an Engineering Graphics course (ENGR 1133) taught in the Engineering Studies Program at Georgia Southern University, traditional topics related to the graphical communication are explored to enhance the students' manual drafting and computer drafting skills. The author has recently developed a quick reference guide that contained all essential AutoCAD commands needed for working with solid models. The developed guide is organized in three separate categories covering the following operations: (1) Solid modeling fundamentals, (2) Editing Solid models, and (3) Creating two-dimensional views from solid models. The developed guide has a brief description of the utility of the main solid modeling commands, including a page number referring the user to the pages of a comprehensive text which describes the commands in more details<sup>8</sup>. Some examples of the most important operations included the guide have been provided in Table 1. Using such commands, even the most complicated three-dimensional

objects can be created and edited with ease.

| Category 1  | Category 2   | Category 3   |
|---|--|--|
| Solid Modeling Fundamental Operations   | Solid Modeling Editing Operations  | Operations for Creating 2D Views from Solid Models   |
| a. Changing Coordinate Axes<br>b. Changing View Points<br>c. Creating Boxes, Wedges, Cylinders, Cones, Spheres, Toruses<br>d. Creating a Union of Solids<br>e. Subtracting Solids<br>f. Finding the Intersection of Solids<br>g. Creating Solids by Extrusion<br>h. Revolving Solids<br>i. Producing Intersections of planes with Solids<br>j. Slicing Solids<br>k. Presentation of Solids. | a. Aligning Solids<br>b. Rotating Solids<br>c. Mirroring Solids<br>d. Creating Solid Arrays<br>e. Extruding, Moving, Rotating, Deleting, Offsetting, Tapering, Copying, & Coloring Faces<br>f. Imprinting Solids<br>g. Creating Shells of Solids | a. Production Orthographic Projections<br>b. Producing Section Views<br>c. Producing Auxiliary Views |

Table 1. A Summary of Several Important Solid Modeling Operations

The developed reference guide has been provided to all instructors assigned to teach this course in the spring 2006 semester. The instructors can utilize such a guide while teaching in the classroom/laboratory settings to complement their teaching and effectively aid the students with the understanding and visualization of three-dimensional solids. Using this guide, a variety of solid models can be developed and edited with ease through interactions and discussions with students. The constructed models effectively enhance the visualization capabilities of students and provide them with new perspectives. This method of delivery for teaching engineering graphics concepts creates a more active and engaging educational environment, an environment that is more challenging, interesting, interactive, and fun. Using the solid modeling tool, the instructor can also easily generate the solution for the assigned exercises in the classroom to enable students to compare their developed hand-developed solutions against the computer-generated solutions. This process enables the student to locate their errors, and learn the proper procedure needed to correct them.

Several examples of solid models and their corresponding views are included in this paper to clearly illustrate the power and utility of the discussed approach in delivering instruction in the course. The last three presented examples demonstrate the development of orthographic views, section views, and auxiliary views, the three main important topics typically covered in an introductory Engineering Graphics course.

## II. Creating and Editing Solid Models

The solid model depicted in Figure 1 was constructed using some of the fundamental AutoCAD commands and creating three rectangular prisms, two cylinders, and a wedge element first. These solids were then combined through addition and subtracting procedures to create the resulting models. Commands in AutoCAD can be issued either through selecting the graphical icons from the toolbars, or by directly typing the appropriate text commands at the command prompt provided at the bottom of the screen.

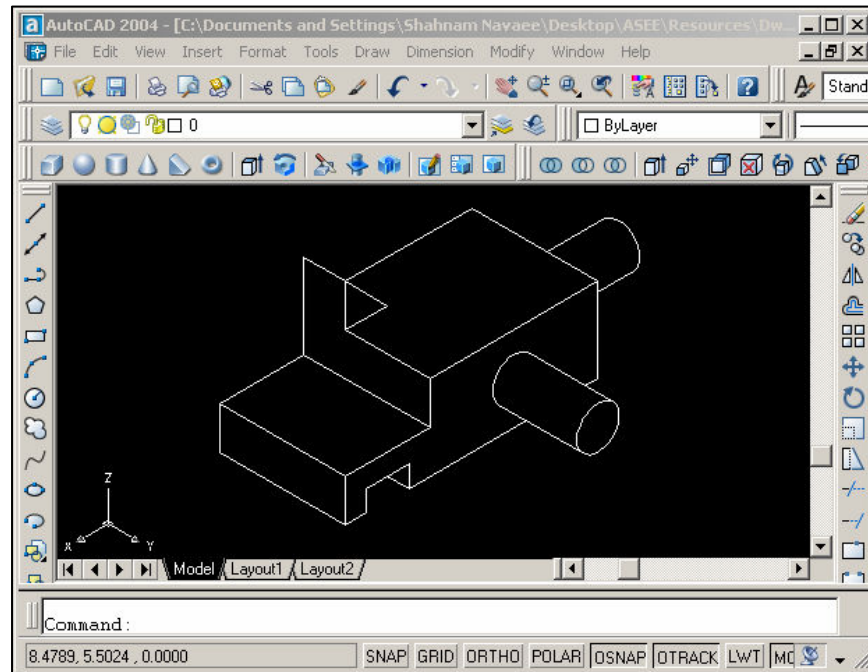


Figure 1. Wireframe Solid Model of an Object Created Using AutoCAD

The orientation of the created model can be adjusted through using the special commands for re-defining the coordinate axes. Additionally, the model itself can also be rotated and viewed from different angles to better examine various body features. The model presented in Figure 1 is rotated in order to add an extra notch at the hidden bottom corner of the solid model as illustrated in Figure 2.

Once a solid model is created, it can further be edited with relative ease utilizing various powerful tools in AutoCAD. The added notes provided in Figure 3 clearly show the commands that were used and the specific actions that were taken to convert the solid model in Figure 1 to the presented model in Figure 3. Some of the operations performed in this example included: aligning, rotating, tapering, extruding, offsetting, deleting, imprinting, and subtracting. To further improve the presentation of the object, colors can also be applied to the solid faces of the model.

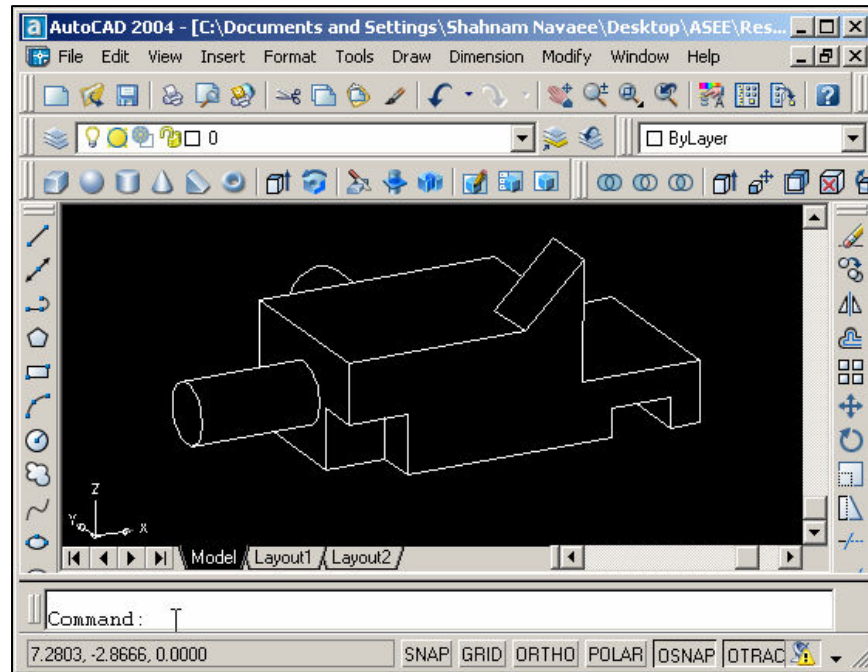


Figure 2. Rotated Solid Model Revealing the Hidden Features

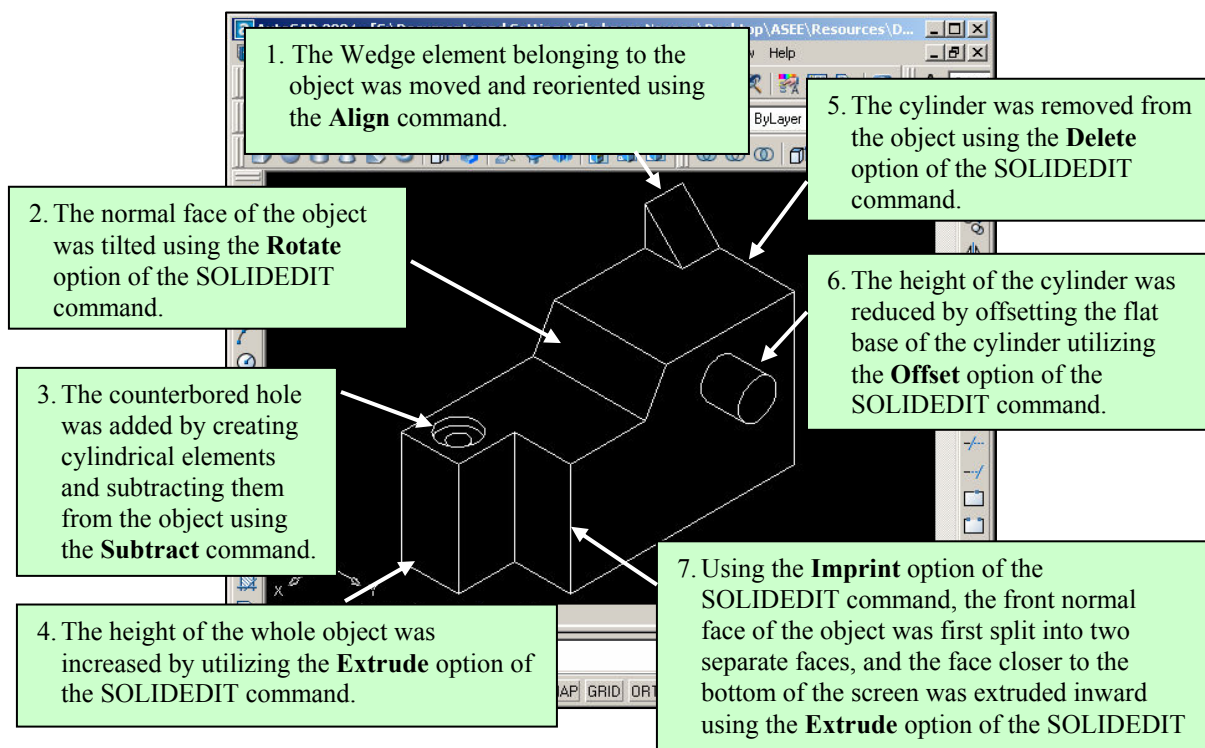


Figure 3. Edited Solid Model Produced Utilizing Several Special AutoCAD Operations

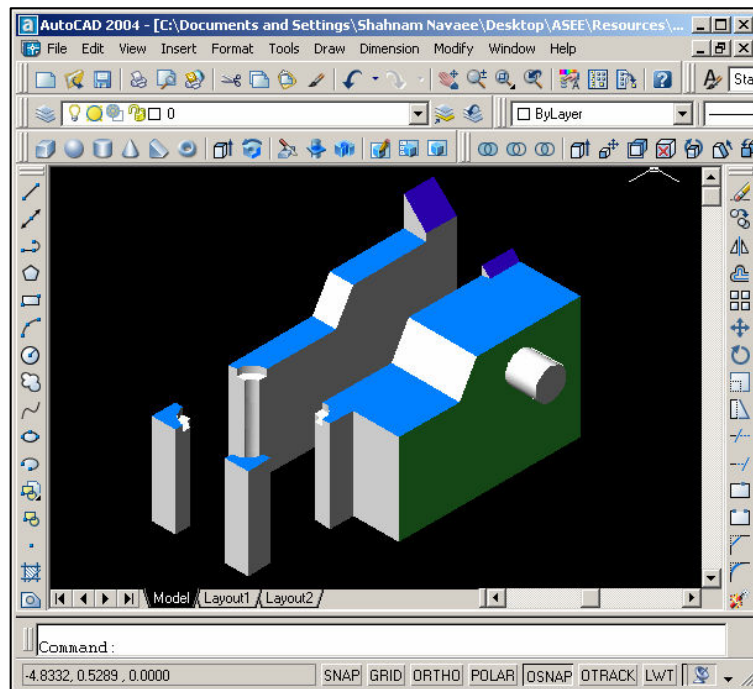


Figure 4. Solid Model Sliced Using Two Perpendicular Planes Revealing the Interior Features

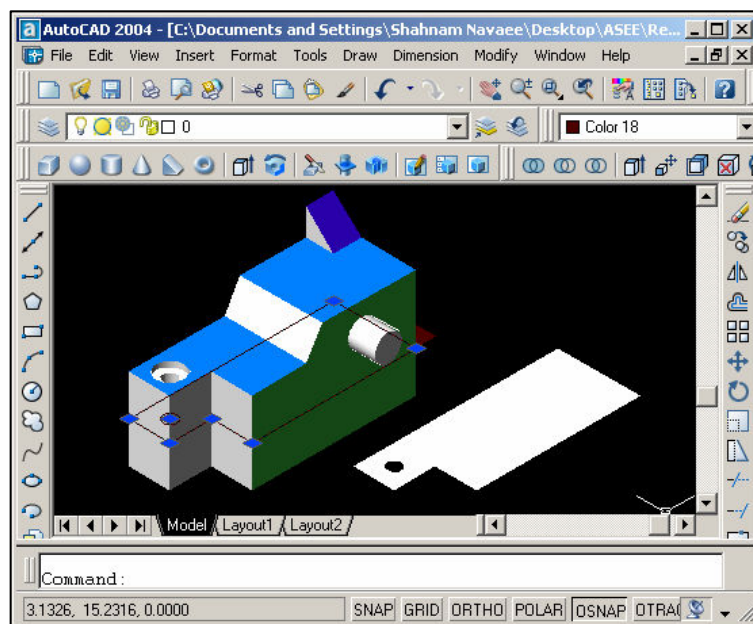


Figure 5. Solid Model Sectioned with a Plane Indicated Parallel to the Base of the Object

Using another useful feature of AutoCAD, solid models can be split in different sections by passing a plane through the solid model and separating the resulting sections to reveal the

interior details. In the solid model presented in Figure 4, the faces of the solid model have been colored, and the body is split into four separate sections using two perpendicular cutting planes.

Another very valuable feature of AutoCAD allows the user to pass a plane through the solid model and determine the intersection of that plane with the boundary of the solid model. The application of this tool is illustrated in Figure 5. In this Figure, the intersection of the solid body with a plane parallel to the horizontal base of the object is indicated.

Utilization of tools similar to the ones discussed above, allow the students to better examine and visualize the object.

### **III. Creating Two-Dimensional Views from Solid Models**

Once a solid model is created, classical two-dimensional views of the objects such as the orthographic view, section views, and auxiliary views can automatically be created from these models using several powerful AutoCAD commands. These are the same important classical views that are traditionally covered in any introductory Engineering Graphics course. One example from each of the three listed views is included in this section to illustrate the utility and usefulness of the AutoCAD tools in producing these view types.

The “orthographic views” of a three-dimensional body are basically the projections from the object onto the perpendicular sides of an imaginary glass box that contains the object<sup>9</sup>. The orthographic views of the solid model presented in Figure 3 are provided in Figure 6 together with the isometric sketch of the object.

The “section view” of a body can be created by cutting the body with an imaginary plane perpendicular to the line of sight, removing a segment of the body between the viewer and the body, and obtaining the projection of the remaining portion of body onto the imaginary glass plane<sup>9</sup>. The section views are normally utilized to show the interior details of the object and to reduce the hidden lines in the drawing. In a section view, the area/areas of contact between the imaginary cutting plane and the solid body are hatched using “section lines”. The pattern used for the section lines are prescribed by the American National Standards Institute (ANSI) for various body material types. The front section view for a sample cast iron solid model depicted in Figure 7, is presented in Figure 8 along with its top view and isometric sketch. Note that the special command used for creating the section view also automatically produces the section lines on the drawing. The phantom line and the arrows shown on the top view of the object respectively represent the edge view of the cutting plane and the direction for viewing the object once the front half of the object is removed.

The “auxiliary views” are normally used to determine the true shape and size of the inclined faces of the body by establishing a line of sight perpendicular these faces<sup>9</sup>. The auxiliary view for the solid model shown in Figure 9 is depicted in Figure 10, together with three other related views of the object. The auxiliary view presented in this figure establishes the true shape and size of the inclined faces **A** and **B** indicated on the solid model.

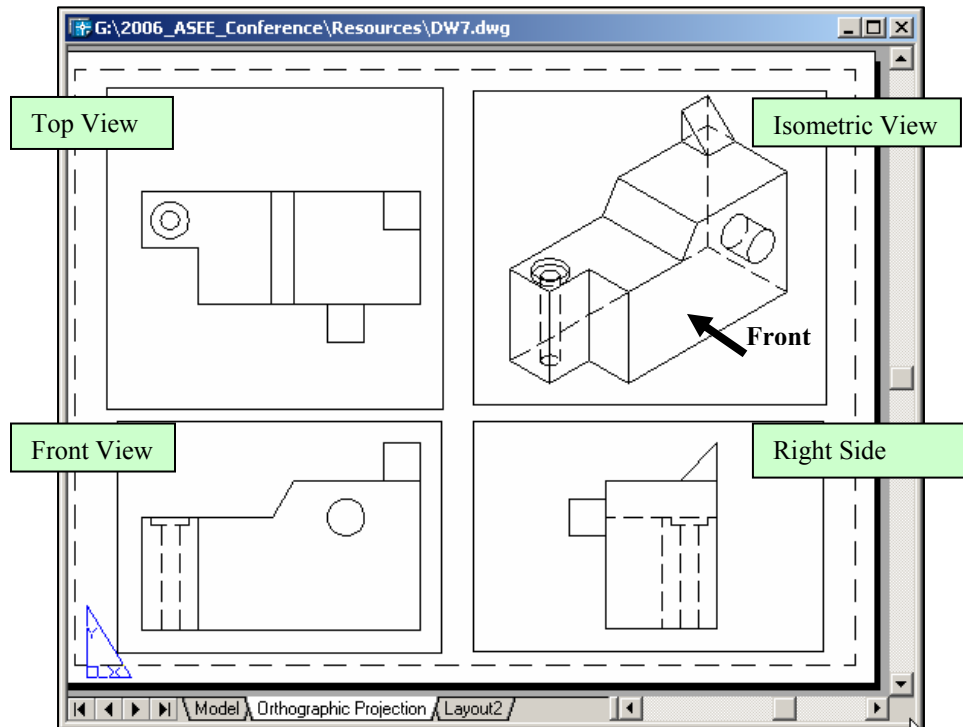


Figure 6. Orthographic Views of the Solid Model Created Using AUTOCAD

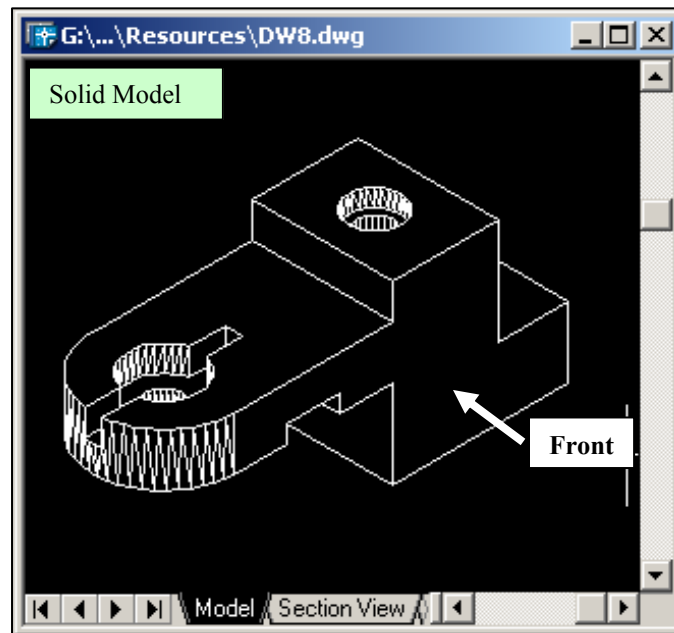


Figure 7. Wireframe of the Solid Model Corresponding to the Views Presented in Figure 8.



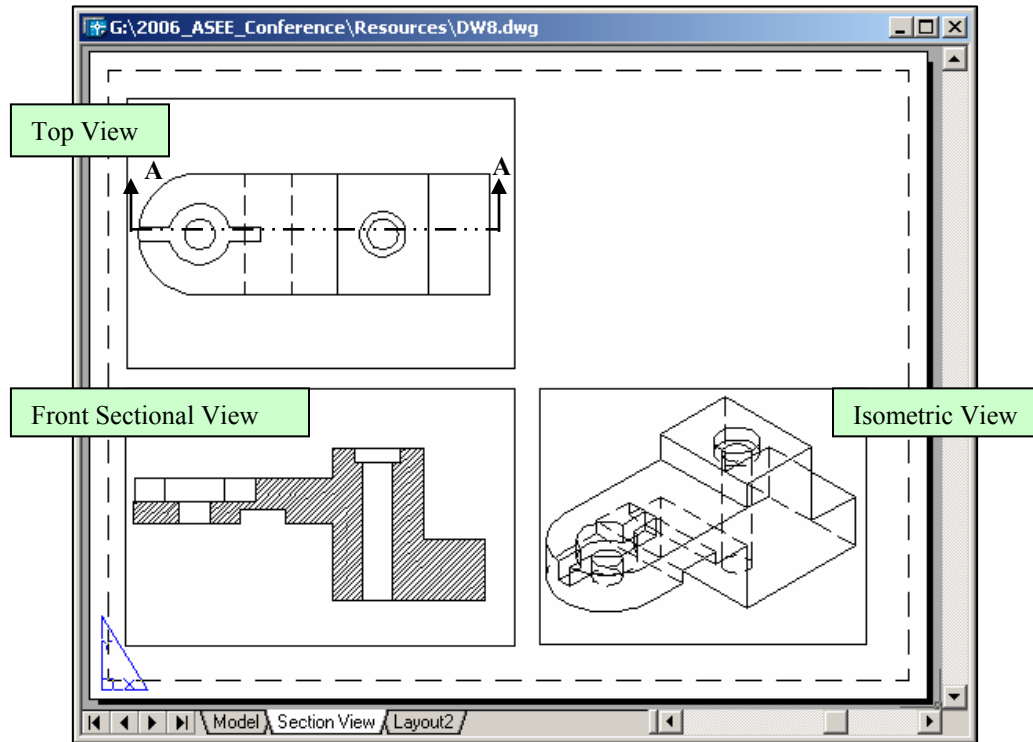


Figure 8. Two-Dimensional Views of the Solid Body Presented in Figure 7.

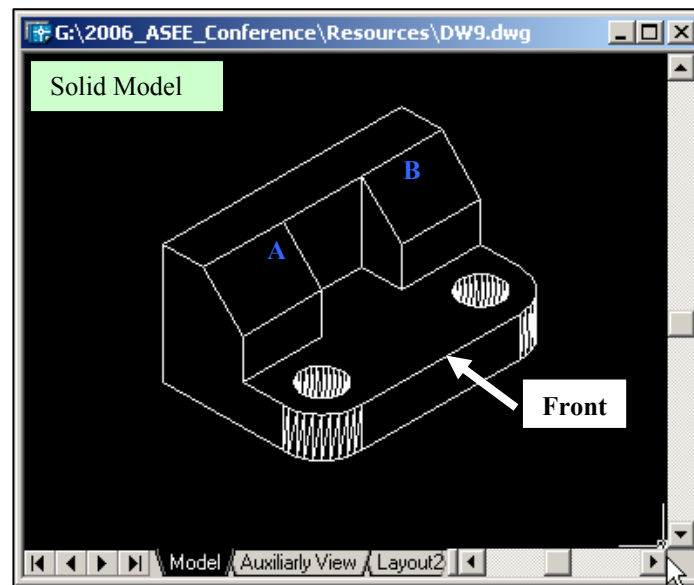


Figure 9. Wireframe of the Solid Model Corresponding to the Views Presented in Figure 10.

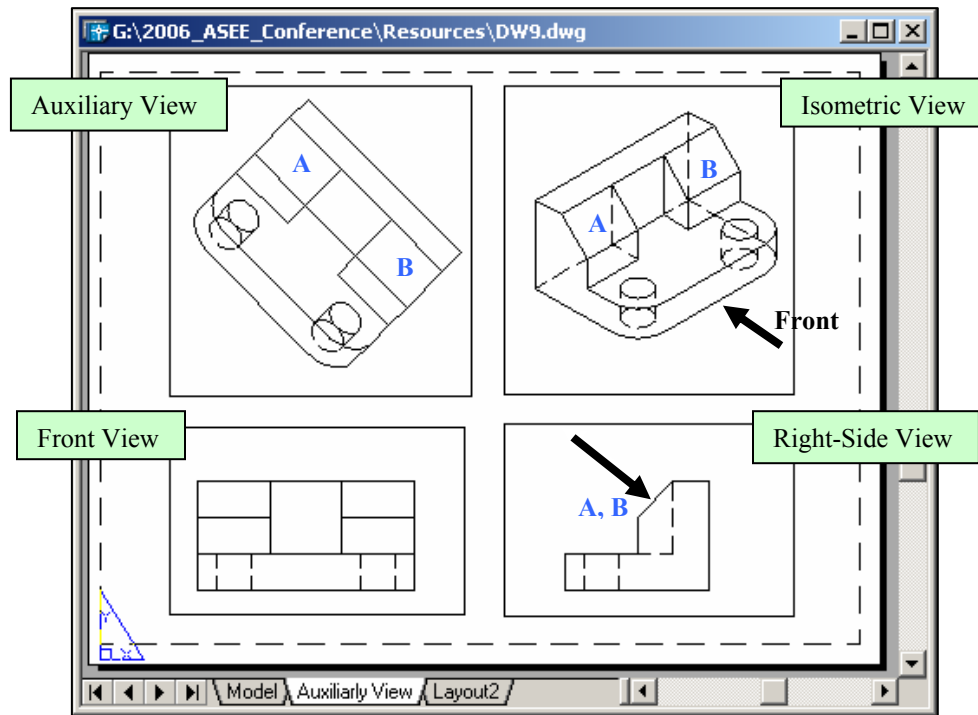


Figure 10. Two-Dimensional Views of the Solid Body Presented in Figure 9.

## VI. Summary & Conclusion

In this paper the utility of AutoCAD Solid Modeling in enhancing an Engineering Graphics course is presented and discussed. This powerful method of course delivery is extremely effective in enhancing the visualization capabilities and graphical communication skills of students. Example problems provided in the paper illustrate the functionality of some of the common solid modeling tools for creating and editing three-dimensional bodies. These tools are particularly suited for covering some of the basic graphical communication concepts and topics covered in an engineering graphics course such as the orthographic views, sectional views, and auxiliary views. The instructor can use some of the solid modeling tools in the classroom or laboratory setting to create a variety of problems for discussion with students. This method of course delivery effectively enhances the student-instructor interaction and creates a richer and more engaging educational environment. Utilization of the solid modeling tools also enables the users to conveniently perform a check on the validity of their hand-sketched drawings. The instructor can use these tools effectively to generate and discuss the correct solutions for the assigned exercises to better guide the students in developing solutions for other problems. This approach to teaching an Engineering Graphics course can be used along-side other traditional instructional techniques to further enhance the students' performance in the course.

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