

# LECTURE VISUALS FROM A 3-D CAD PROGRAM

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## Introduction

Three-dimensional CAD programs such as SolidWorks, Autodesk Inventor, and Pro/ENGINEER have been developed for the primary purpose of making production drawings. However, the author uses SolidWorks to produce lecture visuals that help students understand complicated three-dimensional objects such as a shell-and-tube heat exchanger, the attachment of turbine blades to turbine wheels, and various metal crystal structures. Using eDrawings for SolidWorks, the author generates stand-alone files that are posted on course Web sites. Students can download these files and explore them without the need to run the SolidWorks program.

This article does not provide instruction in the use of SolidWorks. Rather, it shows how this program can be used to enhance the student learning experience. Although the author is not knowledgeable about Autodesk Inventor and Pro/ENGINEER, it is his impression that similar teaching visuals can be produced with these programs.

## A Word about SolidWorks

Although this article does not discuss details of the use of SolidWorks, a brief discussion of its capabilities is in order. Prismatic solids and bodies of revolution are easily created with the Extruded Boss/Base and Revolved Boss/Base functions. Tetrahedra and pyramids are created by applying Draft (taper) when using Extruded Boss/Base. An octahedron is created by attaching two pyramids base to base.

To create a complicated structure such as a shell-and-tube heat exchanger, the user first creates individual parts and then joins them together in an assembly. The individual parts for the shell-and-tube heat exchanger are: one

tube, one tube-sheet, one baffle plate, one hemispherical end-shell, one cylindrical shell, and the required inlet/outlet pipes. Parts that are used multiple times are easily replicated as required. Once created, the parts are joined together by means of a process called Mates. In this process the geometric relationships between parts are specified. Possibilities include: tangent, coincident, parallel, and perpendicular.

Section and exploded views are easily created from the completed assembly. The orientation and position of the sectioning plane are easily changed. This enables the instructor to conduct a “guided tour” of the interior of the heat exchanger.

A separate program called eDrawings enables the instructor to create a stand-alone file from a SolidWorks part or assembly. This file can either be a data file or an executable file. These files can be emailed or posted on a Web site. If a user possesses the eDrawings viewer, which is a free download, he or she only needs the data file. The executable file contains both the viewer and the data file. Of course the executable file is significantly larger than the data file.

## Lecture Visuals – Materials Science

One of the challenges of teaching materials science is helping students visualize the three-dimensional structure of metal crystals such as body-centered cubic, face-centered cubic, and hexagonal close-packed. Textbooks contain excellent isometric drawings of these structures, but some students still have difficulty grasping the details of the structures. The use of SolidWorks drawings in class is a great help in this regard. It is easy to turn the crystal model to any angle and to section it in any orientation. This is particularly helpful in showing the position and dimensions of interstices.

Figure 1 shows a view of part of a face-centered cubic crystal. The view is from the front, but the front layer of atoms has been removed. Thus the interstice at the center of the cube is clearly displayed. Figure 2 shows a section view of the same crystal, with the section plane cutting through the center of the cube. For purposes of this article, the actual SolidWorks drawings were exported as JPEG files, which are static. However, the eDrawings that are actually used by students are dynamic. They can view the images from any vantage point.

Placement of a carbon atom in the interstice of a body-centered iron crystal structure is important in discussing the properties of steel. Figure 3 shows a section view of this situation. The iron and carbon atoms are drawn to scale in this image. It is quite clear why the presence of carbon causes distortion of the iron structure.

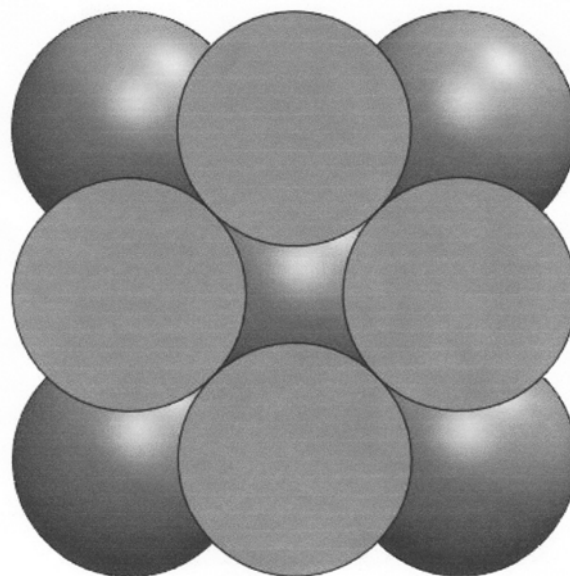


Figure 2 FCC Crystal Section Through Center

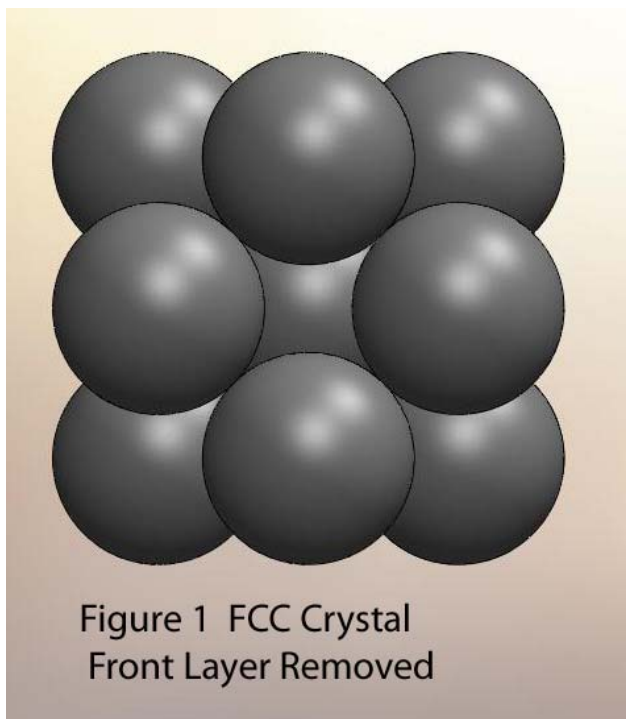


Figure 1 FCC Crystal Front Layer Removed

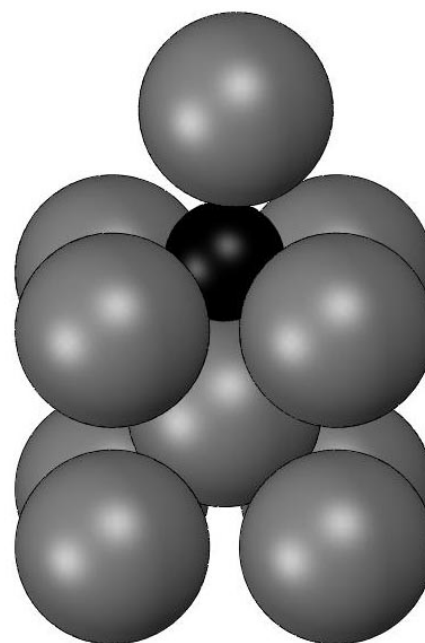


Figure 3 Carbon Atom in Iron

## Lecture Visuals – Dynamics

Students in dynamics may encounter homework problems that involve the Geneva mechanism, and some students have difficulty visualizing the motion of this mechanism. Figure 4 is a SolidWorks drawing of such a mechanism, exported as a JPEG file. In SolidWorks the instructor or the student can click and drag the stepped wheel, causing it to rotate. As it does so, the pin in the slot will cause the cross to rotate in response. Motion can be stopped at any point to illustrate the geometry.

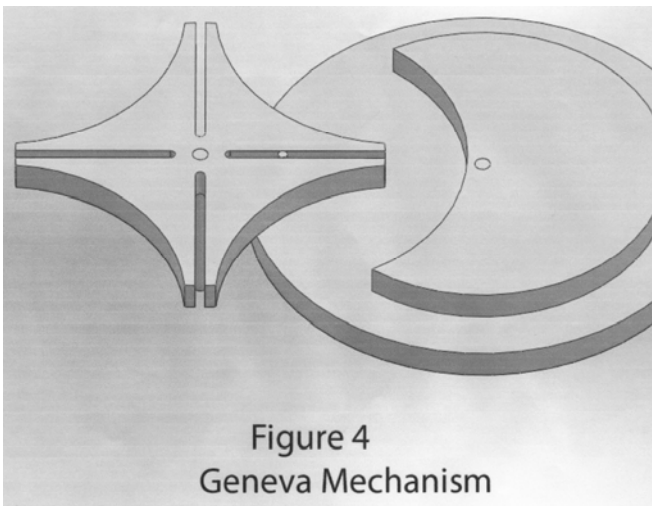


Figure 4  
Geneva Mechanism

## Lecture Visuals – Turbine Design

In one of our junior-level courses, students design the stages of a steam turbine. Figure 5 is used to help students understand the geometry of the turbine. The image shown is easily sectioned in various ways to illustrate the means of attaching the blades to the turbine wheel. Only two turbine wheels are shown, and only three blades are shown on each wheel. While more wheels and blades would be easy to add, this is sufficient for students to gain an understanding of the structure.

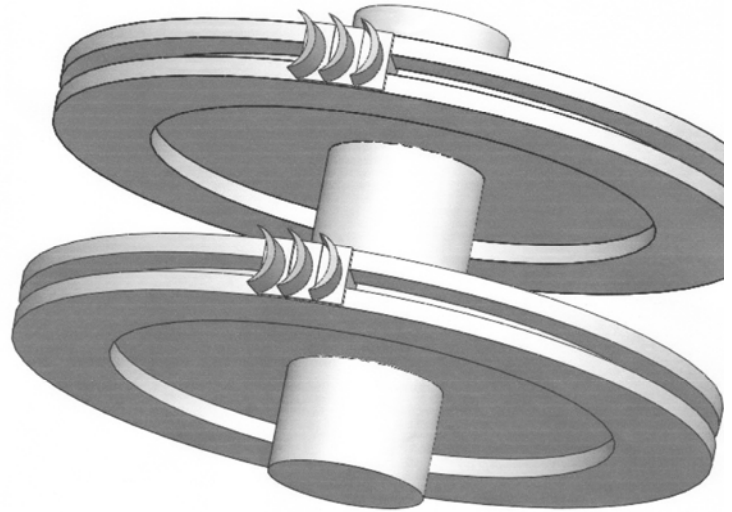
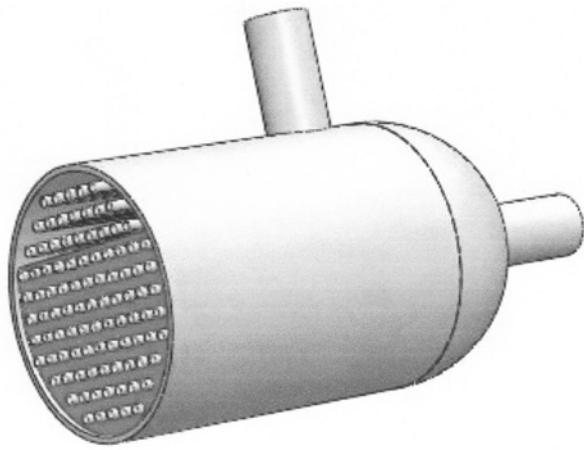


Figure 5  
Steam Turbine Rotor

## Lecture Visuals – Heat Exchanger Design

Webb Institute students also learn to design shell-and-tube heat exchangers. Figure 6 shows a cutaway drawing of such a device. In this image the cutting plane is positioned perpendicular to the tube axis at a location that shows the configuration of the baffle plate. Again, the instructor and the student can rotate and reposition the cutting plane at will. This is very helpful in helping students to understand the geometry.



**Figure 6**  
**Shell-and Tube**  
**Heat Exchanger**

### **Summary**

The point of this article is to illustrate an unconventional use of 3-D CAD software. Instructors in courses that involve complex three-dimensional structures now have a useful tool for the preparation of effective three-dimensional teaching materials. These materials can be used in lecture, and they can be placed in the hands of students for after-class review.

Programs such as SolidWorks, Autodesk Inventor, and Pro/ENGINEER, have significant learning curves. Instructors who are not skilled in the use of these programs may find a colleague who can prepare the visual materials. Because the eDrawings software is a free download, anyone can make effective use of them.

### **Biographical Information**

Edwin G. Wiggins holds BS, MS, and Ph.D. degrees in chemical, nuclear, and mechanical engineering respectively from Purdue University. He is the Mandell and Lester Rosenblatt Professor of Marine Engineering at Webb Institute in Glen Cove, NY. Ed is a past chairman of the New York Metropolitan Section of the Society of Naval Architects and Marine Engineers (SNAME) and a past regional vice president of SNAME. As a representative of SNAME, Ed Wiggins served on the Technology Accreditation Commission, the Engineering Accreditation Commission, and the Board of Directors of the Accreditation Board for Engineering and Technology (ABET). A Centennial Medallion and a Distinguished Service Award recognize his service to SNAME.