

# Chapter 1

## The World Class CAD 3D Training Method

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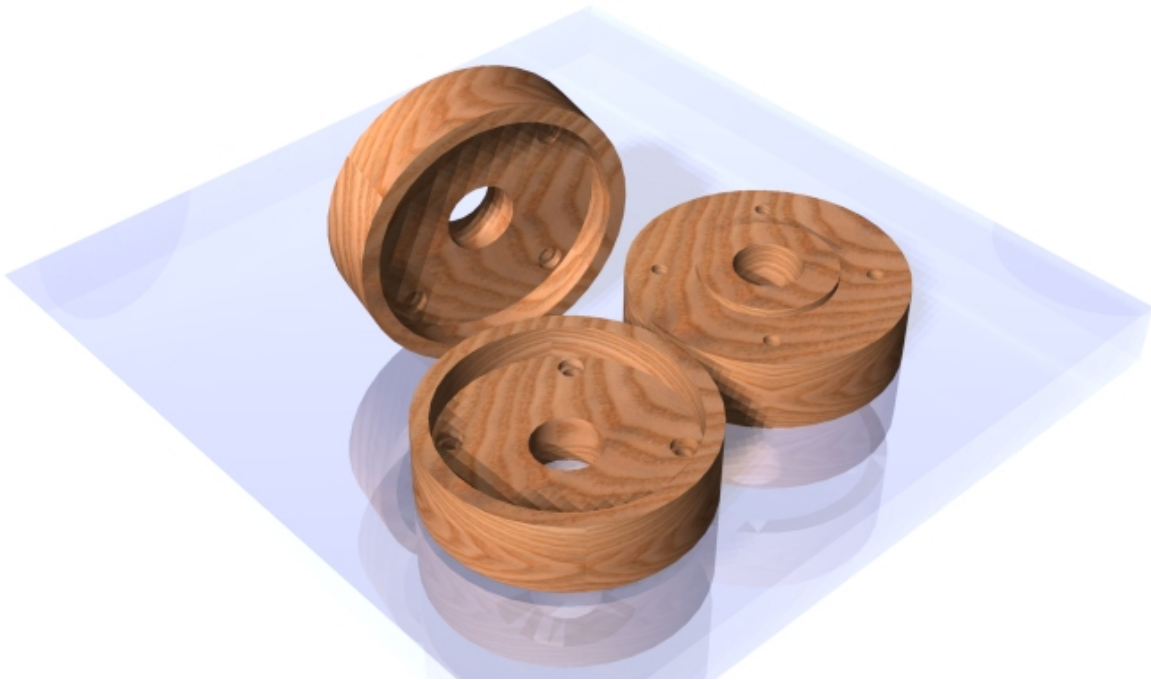
**In this chapter, you will learn the following to World Class standards:**

- **Moving from 2D to 3D Computer Aided Design**
- **Four Steps for Adapting to 3D Computer Aided Design**
  - Step 1 – Ten Basic Problems
  - Step 2 – Three Revolution Problems
  - Step 3 – Transforming 3D Solids to 2D Orthographic Views
  - Step 4 – Making 3D Assembly Drawings
- **Configuring the System for 3D Drawing**
- **Reviewing the World Class CAD Training Method**
- **What comes next?**

## Moving from 2D to 3D Computer Aided Design

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In Fundamentals of 2D Drawing, you examined all the aspects of making an individual part drawing and practiced the skills you require to create a computer aided design project efficiently. Although the engineering drawing is the primary product produced by modern architectural and manufacturing firms, companies have begun to embrace the world of three-dimensional designs. The advantage of 3D modeling over 2D drawing techniques is that the 3D model allows the designer to discover mechanical problems, such as an interference fit or an artistic flaw possibly dealing with texture, curvature or color. In the past, a physical prototype or scaled model of the project would serve as the model for discovering these problems. With present software engines like AutoCAD, Microstation, Pro Engineer, Solid Works and CATIA, designers can examine parts and assemblies in very close detail to determine whether they meet the customer's specification. For the professional of the 21<sup>st</sup> century, 3D design will be the cornerstone to laying a successful foundation in the design process.



**Figure 1.1 – A Marketing Image of a Simple Three Dimensional Part**

While the Rectangular, Circular, and Bracket problems pushed you both physically and mentally to create orthographic views of an actual part in the shortest period of time, the number of lines, arcs, circles, and text labels among each different perspective allow for a percentage of error in the drawing. In a two-dimensional drawing, the CAD drafter creates every entity in every view. Because the drawing may contain hundreds of entities, a 2D drafter has many opportunities to make a mistake. Even assuming a small percentage in an error calculation, human error may account for ten to twenty mistakes. Since the late 19<sup>th</sup> century, more individuals to participate in the industrial and construction process due to the development of orthographic displays. In the last hundred years, this common language of

engineering has given skilled technicians of every level the ability to understand complex designs; in the past, a master artisan solely executed the entire design process. This strategic use of placing lines, arcs, circles, and dimensions on a plane is responsible for highly accurate parts and assemblies almost perfectly repeatable in the manufacturing process.



**Figure 1.2 – A Marketing Image of a Simple Three Dimensional Assembly**

Although orthographic presentation has brought monumental success to computer-aided design, few individuals in the overall population can read a blueprint intelligently. In the industry today, the equalizer that will allow every member of an organization to participate in viewing technical documents is the availability of 3D software packages, the amount of architectural and engineering companies using 3D presentations, and the push in the multimedia industry for 3D graphics. For example, an architect presenting a new recreational facility at a local town meeting may show a computer model of the design on a large screen. The model could show a pool with life-size human figures in the water, meeting rooms with simulated sessions in progress, restroom facilities with a handicap patron at the sink, and perhaps a weight room displaying each station for exercise and stretching. Each person in the audience can plainly see the outside view of the building, with a lighted parking lot including small, medium and large automobiles to examine flow control and safety. The professional host is able to show every corner of the facility, displaying an infinite number of different viewpoints to the public. Every citizen is then able to comment not just on aspects available from a 2D drawing such as the square footage of the rooms, but also to actually see the structure before construction. This may aide fundraising and promote interest among residents of the community. Three-dimensional models are much more effective in communicating the final product, while orthographic drawings concentrate on technical construction aspects of the job. As the prominence of pure 3D designs increases, the amount of companies using 3D systems will also, leaving classical 2D orthographic drawing techniques in the past.

By the mid 1990's, Autodesk was writing software that really could draw virtual boxes, spheres, cylinders, and cones, along with extrusions and revolutions. The initial attempts to create three-dimensional solids with the early tools proved to be difficult. Autodesk has added more tools and features over time to make the CAD operator more efficient when creating three-dimensional parts. Whether in training or on the job, managers of architectural and engineering departments soon discovered, however, that the limitation lied not in the software, but in the ability of their designers, architects, and engineers to conceptualize and design purely in three dimensions.

You will soon learn that the actual CAD software is not the key element that needs improving to convert a department from two-dimensional to three-dimensional drawings. The process of taking information from the space where you live and converting that data to a flat piece of paper happens daily throughout the world. Because of limitations in technology in the home, work, and school, most people begin managing information two-dimensionally at an early age. What kind of problems does that pose for training?

Instead of converting design information to a flat representation, the student of three-dimensional graphics will need to think in real world spatial form. Model Space becomes a realm where the individual part resides and Paper Space then serves as a region for two-dimensional translation. Paper Space automatically computes the information you see from the Model Space area. Only through a systematic training program can architects, designers, and engineers make the leap to three-dimensional design.

## Four Steps for Adapting to 3D Computer Aided Design

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The World Class CAD method of training 3D computer aided design is accredited by the hundreds of students, who, after completing the exercises to standard, have successfully gone on to be thriving designers at their companies by utilizing a more advanced skill. The graduates of this text will be able to communicate their designs effectively by showing their ideas to anybody at a design review using the 3D images or models created from them. The other professionals in their office may have had very limited or no exposure to 3D training.

Step	Task	Problems
1	Basic Solids	10
2	Basic Revolutions	3
3	3D to 2D Conversion	13
4	3D Assembly	1

The first step in the process is to learn the basic building blocks and tools used in 3D modeling, such as Box and Cylinder. You will expand your knowledge throughout this fundamental instruction to include tools such as Wedge and Sphere. The problems use editing tools like the Union and Subtract Boolean commands to add or remove shapes from the model. You can generate finer details using the Extrude, Fillet, and Chamfer tools. By the time you reach the conclusion of the opening set of exercises, you will be surprisingly knowledgeable in 3D part generation.

The second level is to learn revolutions. This technique allows you to create a complex by rotating a closed Polyline detail. You will draw a closed two-dimensional detail in Model Space, convert the feature to a Polyline, and then using Revolve, rotate the sectional outline to gain the desired part. You will need three or more training attempts to learn this method.

To make an orthographic drawing in Paper Space, you can use the Mview or Tenview tools. Many companies that wish to have a true 2D drawing with individual lines, circles, and arcs will use the Tenview tool. Tenview creates Front, Top, Bottom, Right, Left, and Back orthographic observations. The other four views are the northeast, northwest, southeast and southwest. The multiple view command “Mview” will do the same set of perspectives and even more. Both approaches have their own specific uses.

The fourth and final step is learning how to use the XREF system to make a simple assembly drawing. The XREF feature makes AutoCAD a very powerful tool. This tool allows the possibility to make any orthographic drawing using the assembly version of Tenview or the AutoCAD Mview command.

## Step 1 - Ten Basic Problems

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In World Class CAD Fundamentals of 3D, the CAD operator will draw ten 3D solid objects that will introduce him/her to the basics of the AutoCAD three-dimensional drawing system. The first problem will introduce the Box tool. The Union and Subtract tools, which are Boolean commands, will also be used. The training regimen requires that you create the first problem using different tools and strategies, and then complete the exercise within a precise time limit.



Figure 1.3 – Problem 1

The second problem will reinforce the lessons from the first exercise. When you draw a three-dimensional solid in each of the ten basic training sessions, you will have a time limit in which to complete the exercise so you can practice different methods that will achieve the same result. Some designers will draw individual components and then bring together all of the units with the Union tool. Others will create the larger solid and then place elements in position to subtract from the larger entity. 3D solids that are symmetrical can be started by drawing half of the part and finished using the Mirror and Union tools.



Figure 1.4 – Problem 2

The third problem introduces the cylinder tool by inserting a hole with a counterbore into the object. Another tool important to the three-dimensional world is one you are already familiar with: the Fillet tool. You will use this command to round the edges of the solid. The Fillet command is one of the most powerful modifying tools whether you are working in the 2D paper space or 3D model space.



**Figure 1.5 – Problem 3**

The fourth problem will continue to emphasize the cylinder tool. Then you will use the Box, Array and Subtract tools to create the teeth in the spindle. When you are doing a solid part in a computer aided design program, you need to decide whether to build the part from composites, make an extrusion, or revolve a section. All of these strategies have their uses, but usually one will prove more efficient than the rest.



**Figure 1.6 – Problem 4**

The fifth problem uses the Box, Cylinder, Fillet, Union, and Subtract tools to form a composite solid drawn in the metric dimensioning system. It contains similar sections that are ninety degrees apart and the element can be both copied and rotated into the new position using the Array command. Rounding the edges of the part can be done using Cylinders or modifying the box with the Fillet tool. Do not forget to start the problem with the metric template. When completing a template such as “metric” or “architectural”, be wise enough to use them to save yourself time.



**Figure 1.7 – Problem 5**

The sixth problem, also drawn in metric, will introduce you to the Rotate3D command to create a unique part. In AutoCAD, many support tools will allow you to move, copy, rotate, align, or mirror the solid on the two-dimensional plane. Editing tools like Move, Copy, and Align do their jobs outside the 2D plane and are the most flexible in both types of drawing methods. There are special 3D tools useful primarily in 3D modeling, such as Rotate3D, Mirror3D, and 3DArray. Many students find these special commands to be hard to use at first, but with practice the tools can be mastered.



**Figure 1.8 – Problem 6**

The seventh and eighth problems continue to add levels of difficulty to the creation of three-dimensional solid components. Although the part may have more features to detail, you will just be practicing the tools that you have all learned already.

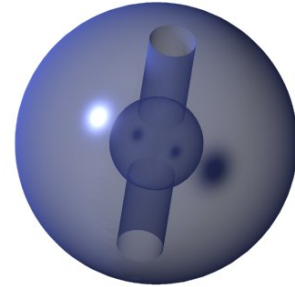
The ninth problem introduces the Sphere tool by creating a smaller concentric sphere inside a larger one. A cylindrical tunnel connects the inner sphere to the outer spherical surface.



**Figure 1.9 – Problem 7**



**Figure 1.10 – Problem 8**



**Figure 1.11 – Problem 9**

The tenth problem finishes the set with a composite of different shapes. Where the first ten parts are rectangular in nature, in the next phase of training, you will do mostly circular solids using the Revolve command. The problems in phase two are different enough in shape to cause most designers to make the majority of the detail using the Revolve command and then remove the finer details using the Subtract tool. When you see a circular problem, consider this method as your first choice to complete the exercise.



**Figure 1.12 – Problem Ten**

## Step 2 - Three Revolution Problems

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The three problems in the circular set all use the Revolve tool on the Solids toolbar. These parts have a hub near the center of the part where the circular entity attaches to a shaft. Parts like this are common in many assemblies. Knobs, wheels, or bases have the hub detail followed by a thinner cross section working towards the outer periphery of the part. Many times, they include clearance holes in the flat area for bolts or screws to pass through onto other connecting devices. There can be an outer lip to counter torque in the design or to add an artistic relief.



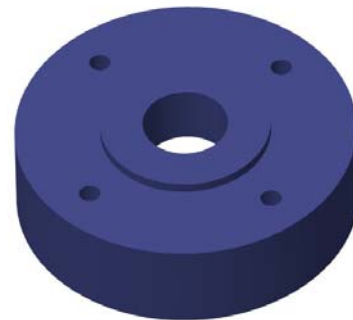
**Figure 1.13 – Revolution 1**

In problem two, the outer section is a much more pronounced area to hold a belt or to make better contact with an object. The second part still shows a hub with an angled taper like one you may see in a cast part. There are more holes in the thinner cross section, which could exist to make the part lighter in the assembly, cheaper with less material, or again to give the detail an artistic characteristic. As in Revolution 1, Revolution 2 has rounded corners where the surfaces meet. You will use the Fillet tool to create a radius at each interface.



**Figure 1.14 – Revolution 2**

The last problem in step two has a smaller hub and less detail for the clearance holes on the side shown. The most complex features are on the opposite side of the part, so you have to decide how to draw the solid. The procedure is not hard in AutoCAD, but the sketch in Revolution 3 is opposite in detail than the first two. Determine whether you wish to draw the part upside down to show the additional textures or continue using the exact same method you used in the first two revolving problems. After saving the thirteen solids, you need to create the thirteen part drawings for each entity in Paper Space.



**Figure 1.15 – Revolution 3**

### **Step 3 – Transforming 3D Solids to 2D Orthographic Views**

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After completing a solid, checking the form, fit, and function in the virtual assembly, most designers make an orthographic layout to dimension and note the part. In AutoCAD, the Paper Space region is the section to do the 2D translation of the 3D entity. Starting back with Problem One, you will open the saved drawings, select the Layout 1 tab, and use the Mview tool to create a front, top and side view. Also you will add an isometric view using the same Mview too. In Figure 1.16, you can see a drawing that has every component required to release the document to production: a drawing border, views, dimensions and notes. You need to do this step for each solid drawn in steps one and two. By the time you finish the last drawing, you should have the skill to draw any solid part, translate the data to Paper Space for 2D documentation, and be prepared to use the parts in an assembly drawing using the XREF system.

Some companies may want to have an orthographic drawing containing views with lines that are not permanently associated with the 3D solid. The Tenview code will generate those views in seconds. Each projection is capable of easy modification. Typically, companies with a mixed staff of 2D and 3D designers wish to have this capability.



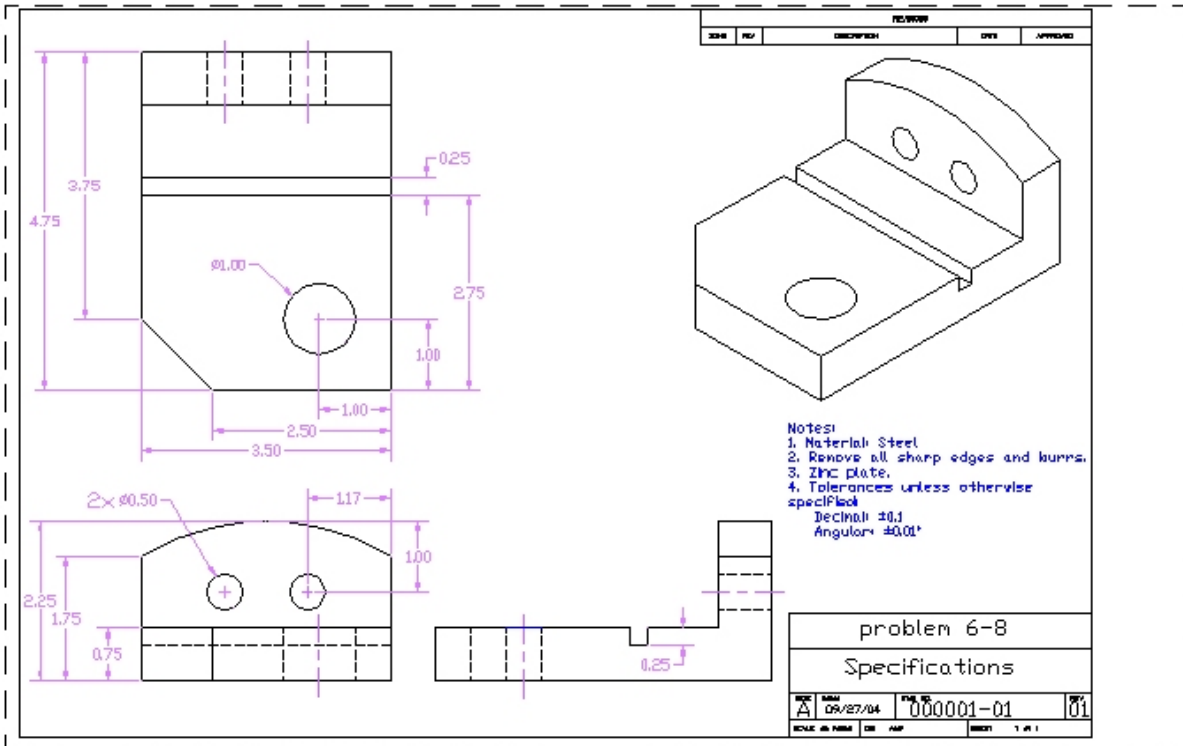


Figure 1.16 – A Sample Orthographic Drawing made from a 3D Part

## Step 4 – Making a 3D Assembly Drawings

The last phase of the training involves making a simple assembly from relatively simple part drawings. Your first XREF assembly will be the footstool shown in Figure 1.17. Students and professionals are amazed at the clarity of the marketing images made from the assembly, the ease of documenting each of the solid parts and orthographic drawings, and the effortlessness of making 3D assembly drawings.

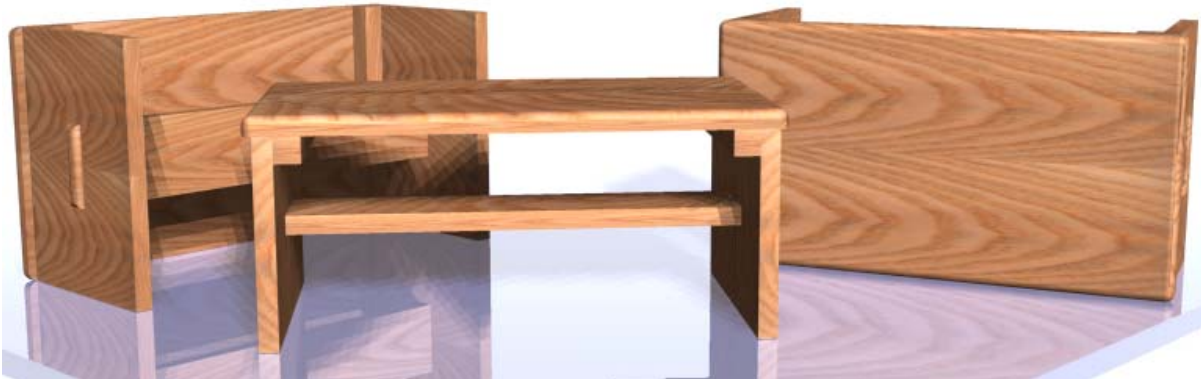


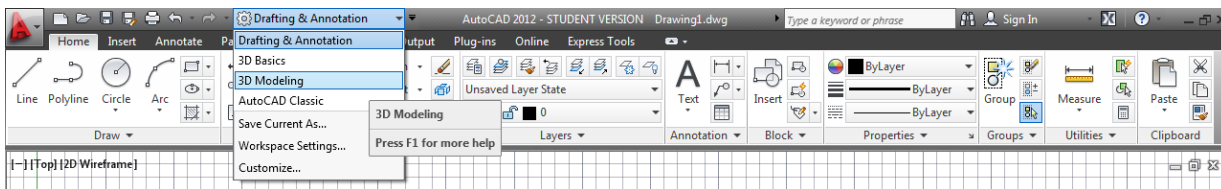
Figure 1.17 – A Marketing Image of your First Simple Three Dimensional Assembly

When you first read the introduction in this chapter, like most technicians, the concept of creating artful designs is usually not considered. As people learn to add material, light, and rendering to their components in the drawing file, the virtual compilation of parts becomes much more than an architectural or engineering drawing. You can show the actual device to a supervisor or customer. When a person learns the material in this text, they find their new knowledge to result in faster drawings, fewer mistakes in the assembly of the components, and that the assembly technicians or customers know what to expect with the completed product. Now that you can see your goal in sight, let us look at the tools you will learn in this textbook.

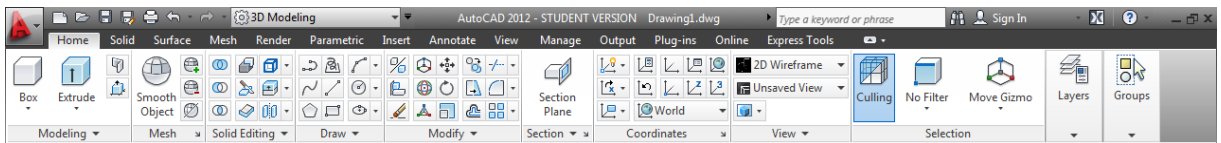
## Setting Up the System for 3D Drawing

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In Fundamentals of 2D Drawing, you learned to use the 2D Drafting and Annotation Ribbon menu as shown in figure 1.18. Above the ribbon next to the Quick Access toolbar is a drop menu that will allow you to choose between a number of different workspaces. Change the workspace from Drafting and Annotation to 3D Modeling.



**Figure 1.18 – Changing the workspace to 3D Modeling**



**Figure 1.19 – The AutoCAD 3D Modeling Ribbon**

You do not have to learn every tool on each of these new panels to create entire series of three-dimensional solids, but you do need to learn the basic primitive solid commands and the modification tools to create 90% of all the parts that workers manufacture or construct in the industrial world.

## Reviewing the World Class CAD Training Method

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The World Class CAD training method has no parallel in any series of instructional booklets in use today. This is modern schooling, like being a pilot of a design computer, and gaining the 2D, 3D, and programming capabilities to provide fast, accurate, and visual solutions to anyone. Thousands of designers know these principles not from memorization but because the exercises in the World Class CAD training series have them built in.

**The World Class CAD system of learning integrates the following ten principles:**

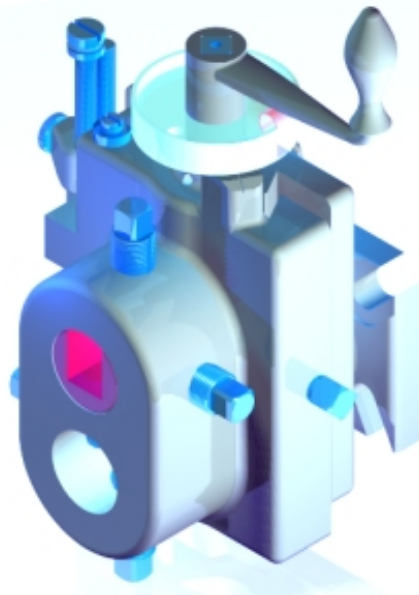
1. Mastering a single tool or concept in conjunction with a believable drawing or problem
2. Grouping a single tool or concept together in logical sequences for like problems
3. Using repetition and coaching to improve drawing techniques and therefore quality
4. Using video gaming techniques of passing through levels or gates before learning new tools
5. Adding competition among the students to challenge them to the next level
6. Returning to a basic tool or concept that is now visually understood at a later time to add complexity
7. Guaranteeing success in like problems when finishing a training problem
8. Guaranteeing drawing speed that are a fraction of those trained by other methods
9. A high percentage of individuals (85%) are able to achieve the World Class CAD standard
10. Providing continual training throughout one's career

As in your previous computer aided design work, the concept of video gaming involves mastering basic techniques in order to advance ahead in the quest and capture a prize or win the match. In everyone's favorite game, Pong, one must master the art of deflecting the ball in such a way so that the computer foe is unable to rebound the ball. As the game goes on, the computer is able to move faster, so that one must make increasingly difficult deflections to defeat the level. World Class CAD periodically employs the same concept in the form of Challenges. These "tests of skill" encourage the student to accomplish a sequence of related tasks consistently in a specified time period.

You can compare your results of World Class CAD Challenges located at the end of a unit to other students and professionals' scores by posting them on the World Class CAD website. You need to submit a copy of the computer file and drawing times to the World Class CAD team. We will calculate your editing time and number of errors, and then the time and score will be posted on the Unit's Results webpage. Having the ability to see your name, organization such as school or company, your score, and you time will allow you to place yourself among our world ranking of CAD drafters, designers, and degreed professionals.

## What comes next?

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**Figure 1.21 – A Marketing Image of a Complex Three Dimensional Assembly**

Architects will move to work on house plans in the Residential Architecture text and mechanical designers and engineers will be working on even more complex assemblies in the Basic Mechanical Design manual. The challenges do not get easier, but your reputation among your colleagues and customers will continue to grow. You can check the list of text in the World Class CAD series of training.

Book	Name of Manual	Time to learn
1	A Complete Introduction to Computer Aided Design (CAD)	10 weeks
2	Fundamental of 2D Drawing	10 weeks
3	Fundamental of 3D Drawing	10 weeks
4	Visual AutoLISP Training Method	10 weeks
5	Visual Basic Applications for AutoCAD	10 weeks
6	Residential Architecture	10 weeks
7	Commercial Architecture	10 weeks
8	Basic Mechanical Design	10 weeks
9	Machine Design (mechanics)	10 weeks
10	Basic Design Concepts (5 rapid design projects)	10 weeks
11	Finite Element Analysis	10 weeks
12	3D Animation	10 weeks
13	Computer Aided Civil Design	10 weeks
14	Computer Aided Electrical Design	10 weeks

**\* World Class CAD Challenge \* - Complete this textbook in 10 weeks or 40 hours of classroom training. Pass your 3D Levels 1, 2, and 3 certification to be ranked among the best in the world.**

