

Chapter 1

The World Class CAD 3D Training Method

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

- **Moving from 2D to 3D Computer Aided Design**
- **Four Steps to 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 a 3D Assembly Drawings
- **Setting Up the System for 3D Drawing**
- **Reviewing the World Class CAD Training Method**
- **What comes Next?**

Moving from 2D to 3D Computer Aided Design

In the Fundamentals of 2D training, you examined all the aspects of making an individual part drawing and repeatedly practiced the skills that enable you to make a computer aided design project efficiently. Although the engineering drawing is the primary product coming out of the modern Architectural and Manufacturing firms, companies have and are in process of moving towards the world of three-dimensional designs. The advantage of 3D over the 2D technique is that in the past, the intent would be to build a prototype or scaled model of the project to discover mechanical problems, such as an interference fit or an artistic flaw possibly dealing with texture, curvature or color. With the present software engines like AutoCAD, Microstation, Pro Engineer, Solid Works and CATIA, designers can scrutinize parts and assemblies in very close detail to determine whether they meet the customer's specification. For the professional of the 21st 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 phrases allow for a percentage of error in the drawing. The difficulty arises from retaining accuracy from the first view to the second and maybe a third perspective. In a two-dimensional drawing, every entity is a creation of the CAD drafter, and the ability to use the drawing tools or by modifying an existing object. This creates many opportunities for error, since the drawing will contain hundreds of entities. Just using a small percentage in an error calculation, there may be ten to twenty mistakes just from human error. Since the late 19th century, orthographic displays have been responsible for allowing more individuals to participate in the industrial and construction process. In the

last hundred years, this common language of engineering allowed every level of skilled technician to participate, where in the past the design process was executed solely by the master artisan. You could say that the strategic use of placing lines, arcs, circles and dimensions on the x and y-axis is responsible for highly accurate parts and assemblies that can be repeated almost perfectly in the manufacturing process.



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

Although the success of the orthographic presentation in computer-aided design has been monumental, 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, at a local town meeting where an architect presents a new recreational facility, the viewing screen shows a computer model of the pool, with life-size human figures in the water. Meeting rooms can show a simulated session in progress; restroom facilities can be displayed with a handicap patron at the sink; a weight room might be shown displaying each station for exercise and stretching. Seeing the view outside the building, each person in the audience views a lighted parking lot with small, medium and large size automobiles to examine flow control and safety. The professional host shows every corner of the facility displaying an infinite number of different viewpoints to the public. Every citizen of that locality is able to comment not just on the square footage of the rooms, but is able to see the structure before construction, making the prospect of fundraising easier, and promoting interest among the athletically inclined residents of the community. Three-dimensional models are much more effective in communicating the final product, where the old orthographic drawings concentrate on technical construction aspects of the job. As the number of specifications calling for truly pure 3D designs, the amount of companies using 3D systems will evolve, leaving the 2D orthographic views in the past.

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

You will soon learn that the CAD software is not the key element that needs work in converting a department from two-dimensional to three-dimensional drawings. The process of taking information from the space where you live and converting the data to a flat piece of paper is done 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?

The student of three-dimensional graphics will need to think in real world, spatial form, instead of converting the information to a flat representation. Model Space becomes the realm where the individual part resides and Paper Space is the region for two-dimensional translation. The information that you see in the Paper Space is automatically computed from the Model Space area. Presently, most companies do not have this capability, since they take their ideas and place them in a plane. Only through a systematic training program can architects, designers and engineers make the leap to three-dimensional design.

Four Steps to Adapting to 3D Computer Aided Design

The World Class CAD method of training 3D computer aided design is accredited by the hundreds of successful students, who, after completing the exercises to standard, have gone on to be thriving designers at their companies by utilizing a more advanced skill. The graduates of this text can 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 such as Box and Cylinder. You will expand your knowledge throughout the fundamental instruction to include tools such as Wedge and Sphere. The problems use editing tools to add or remove shapes using Union and Subtract Boolean commands. You can generate fine 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, where a closed Polyline detail can be rotated axially resulting in an even more complex circular solid. You will draw a closed two-dimensional detail in Model Space, convert the feature to a Polyline, and using Revolve, rotate the sectional outline any number of degrees to gain the desired part. You will only 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 positive and negative attributes.

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

Step 1 - Ten Basic Problems

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



Figure 1.3 – Problem 1

The second problem will reinforce the lessons from the first exercise, adding a tutorial on the Wedge tool. When you draw a three-dimensional solid in 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 then bring together all of the units with the Union tool. Others will create the larger solid and then place the particles in position to subtract from the larger entity. 3D solids that are symmetrical can be made only on one side the centerline, using the Mirror and Union tools to finish the part.



Figure 1.4 – Problem 2

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



Figure 1.5 – Problem 3

The fourth problem will show you how to draw a half section of a solid and then convert the entities to a Polyline. This will be your first exposure to revolving a closed Polyline section around an axis. Then you will use the Box, Array and Subtract tools to create the teeth in the spindle. In step two of the training, the Polyline section can be more difficult since the problems are larger and have more detail. 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 deals with the Box, Cylinder, Fillet, Union and Subtract tools to form a composite solid drawn in the metric dimensioning system. There are 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 allow you to use 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 for the 3D solid, such as Rotate3D, Mirror3D and 3dArray. Many students find these special commands to be hard to use at first, but with reference to the UCS icon, 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, but 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 smaller co centric sphere inside the 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 the newer method shown in step two as your first choice to attack the exercise.



Figure 1.12 – Problem Ten

Step 2 - Three Revolution Problems

The three problems in the circular set all deal with 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. There are many parts like this 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 there are 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 just 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 as 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 because of less material or again have the detail to gain an artistic characteristic. As in Revolution 1, Revolution 2 has rounded corners where the surfaces meet. You will use the Fillet tool on the Modify toolbar 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. After saving the thirteen solids, you need to create the thirteen part drawings for each entity in Paper Space.

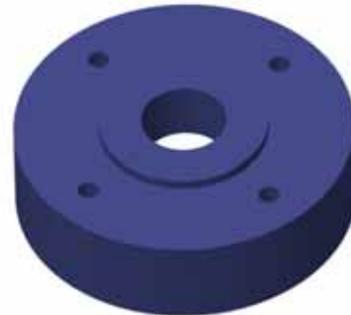


Figure 1.15 – Revolution 3

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

After completing a solid, checking the form, fit and function in the virtual assembly, most designers will go ahead and make an orthographic layout to dimension and note the part. In AutoCAD, the Paper Space region of the software application is the section to do the 2D translation of the 3D entity. Starting back with Problem One, open the saved drawing, select the Layout 1 tab and use the Mview tool to create a front, top and side view. Add an isometric view using the same Mview tool or add an image using Saveimg, capturing a bitmap representation of the most complex sides of the solid. 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 where the views have 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.

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.

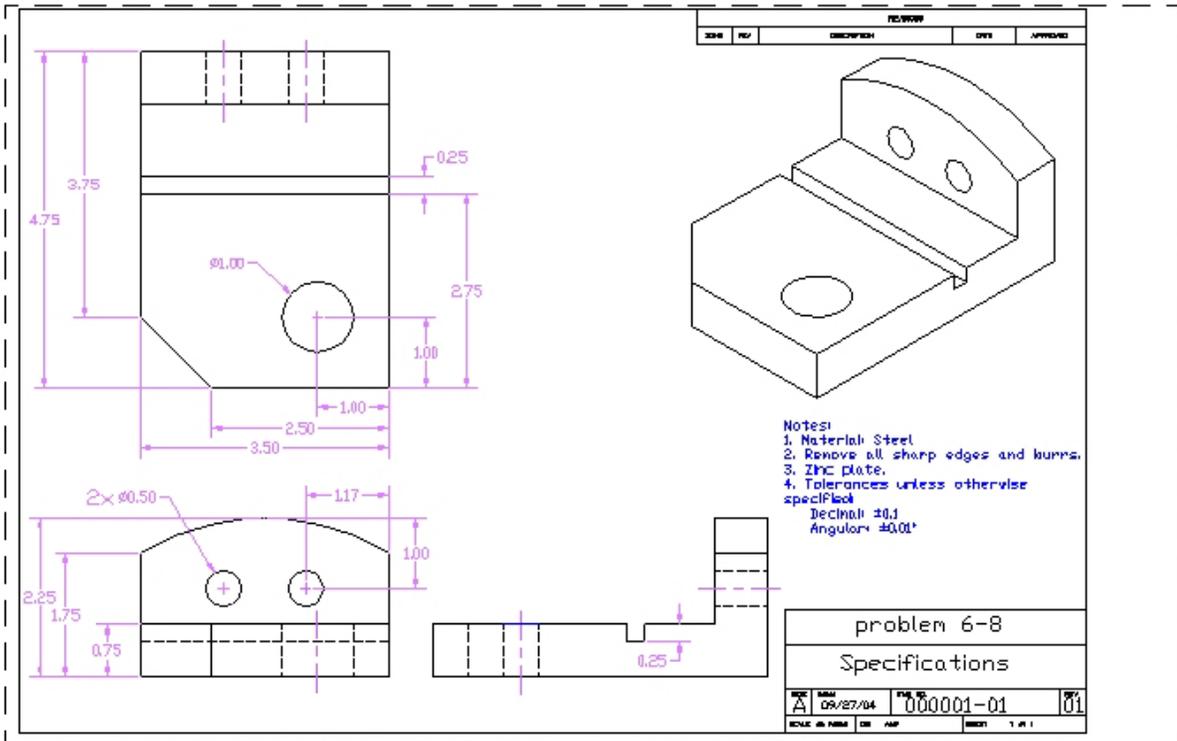


Figure 1.16 – A Sample Orthographic Drawing made from a 3D Part

Step 4 – Making a 3D Assembly Drawings

The last phase of the training involves making simple assemblies for 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 for 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 toolbars you will learn in this textbook.

Setting Up the System for 3D Drawing

In the World Class CAD, Fundamentals of Two Dimensional Drawing, you learned to use the 2D Drafting and Annotation Ribbon menu as shown in figure 1.18. By right clicking on the AutoCAD Ribbon, select Customize and the Customize User Interface window will appear as shown in figure 1.19



Figure 1.18 – The Toolbars for Three Dimensional Work

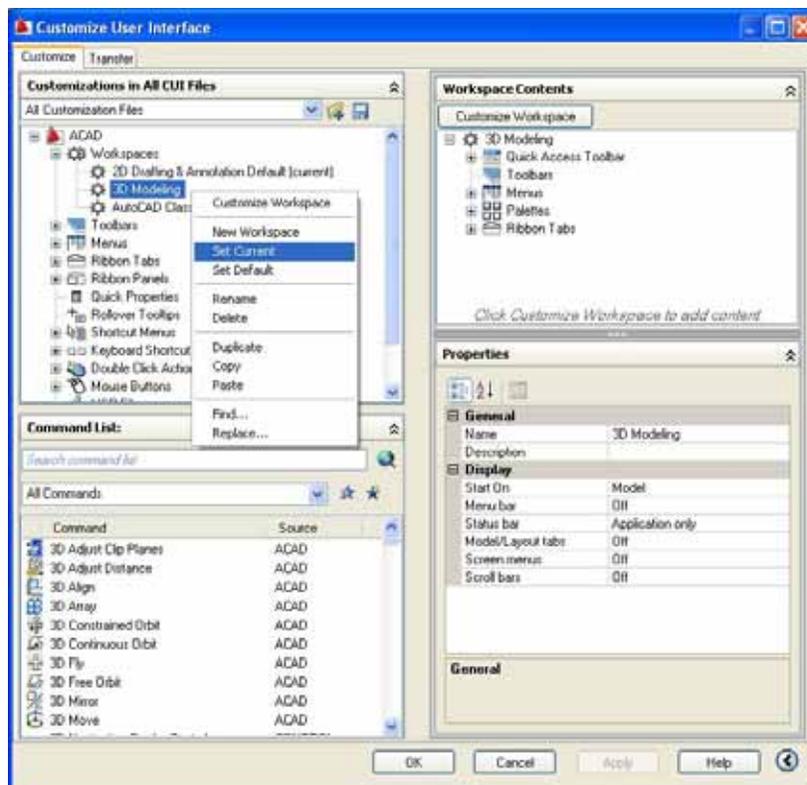


Figure 1.19 – Setting the 3D Modeling Ribbon Menu as Current

Select the 3D Modeling Ribbon as current, apply and close the window. The AutoCAD Ribbon is now ready for 3D operations and a Tool Palette will appear to the right of the graphical display. For your lessons, you can turn off the Tool Palette on the right. The AutoCAD Ribbon appears as shown in figure 1.20.



Figure 1.20 – 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. You can still add the old style toolbars to the graphical display by selecting the large A on the left side of the Ribbon and pick Tools, Toolbars, AutoCAD to see the entire list. Once you insert a toolbar, right click on the toolbar, and select additional toolbars, which you will place around the perimeter of the graphical display.

Reviewing the World Class CAD Training Method

If you need to re-read the ten principles and the reason they exist from the first two books, go ahead. 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 having 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 training material where repetition and coaching improves 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%) that 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 to capture a prize and 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 period of time.

Your results of the World Class CAD Challenge located at the end of a unit can be compared to other students and professionals' scores by posting them on the World Class CAD website. Drawing times and a copy of the computer file need to be submitted to the World Class CAD team. Your editing time and amount of errors will be calculated, 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 time will allow anyone to place themselves among the world ranking of CAD drafters, designers and degreed professionals.

What comes next?



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

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 the 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
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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.**

