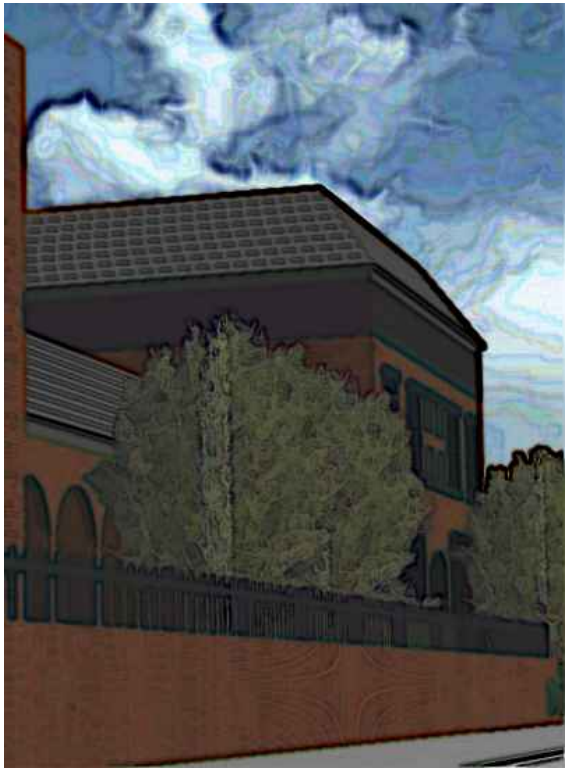
The Language of Drawing

Chapter 1:

History of Construction Documentation



In the early days of civilization, artisans would pictorially depict an object, a dwelling or a fortification to give insight to the customer about the size, shape and color of their product. Artist, such as Leonardo Da Vinci, created very detailed sketches of weapons and forts. Scaled models were used to bring even greater detail to the engineering process by allowing the technicians and junior artisans to determine how to bring the assembly together. By using smaller pieces, the architects could assemble the building, all the while making decisions about special cuts in the masonry, stonework and joists. The model could incorporate the surrounding location and give the construction workers the opportunity to plan how a large structure can come together.

Use of Modeling

Today modern engineers and designers use the same processes and procedures to accomplish similar tasks as their predecessors. Whether we make a physical model using stereo lithography or view a model in 3D Computer Aided Design (CAD), we will use this information to determine whether an assembly will be able to be built. An example of how this is done is when a civil engineering company plans to replace a heavy assembly such as electrical switchgear, where the assembly can weigh thousands of pounds into an existing building. That civil engineering company will use a model to determine how the older assembly can be removed and the newer sections of the design can be moved into position. Experienced workers in construction companies know it is two late to make changes when find that we cannot turn the assembly when moving a multiple ton unit into position. They know that this must be done ahead of time and we need to use either physical or virtual modeling.

Over time, construction workers and small specialty shops needed larger quantities of parts and those parts needed to be replicated exactly in material size and shape. When a worker on the job site only needed one part, they build it. Even 100 years ago, construction workers would make their own doors and windows, bringing the raw material on site and creating the product. Today, that is hardly ever done. Nearly all of windows, doors and cabinets for a building are made in a manufacturing plant. A manufacturing plant will provide an outline drawing showing critical exterior dimensions and contain special notes describing the item. The project architect creates architectural schedules that the purchasing manager uses to acquire manufactured goods for the building. When the construction worker creates a rough opening for the manufactured assembly, and is familiar with the assembly notes provided by the manufacturer then in the majority of the time the manufacturing and assembly is installed with no problem. The challenge at the modern construction site is to have all of these pre-manufactured goods arrive on site just in time, as they are needed. So manufacturers of every type of product are present throughout the world.

The goal of every manufacturer is to create their part efficiently to reduce their standard factor cost, which includes labor all the while their part or assembly needs meet the customer criteria and do so safely. On the drawing of the part, we will see

a multitude of information that describes how to manufacture the item and keep the parts within tolerance. All part drawings must have sufficient information for the factory worker to make the part. That includes one or multiple views, dimensions, notes and title block. There is no possible way that a designer can furnish two much information, but it is possible that designer can furnish confusing or repetitive information that is not needed.

Orthographic Drawings

Gaspard Monge (1746-1812), a French mathematician inventor of Descriptive Geometry is credited with the idea that led to modern orthographic drawing. The idea of a series of perpendicular planes that encase the object and the visible and hidden lines are projected to the flat two dimensional surface.

Views

The views that are needed in an orthographic drawing are chosen by a simple criteria which is we see the side of the part or assembly that the work is being done. For example, if a machinist is going to drill a 1/4in. hole in the top of a part, then the top of the part needs to be shown. Orthographic views that do not contain information can be found on a drawing only when they are transitioning the machinist eye from one view to another. This is done when we have that 1/4in. hole on the top of the part; we show the front view of the part in transition, so we can get to the right hand view to show a 1/8 in. hole in the side.

There are six standard orthographic views; top, bottom, right, left, front and back. Other views can be added to the drawing if we add cutting lines that show the separating plane and the direction of view. We can place these special views anywhere on the drawing sheet or in the series of drawings along as they are properly referenced back to their position. We will use special lines on the views to communicate whether the feature is visible or if we are looking at a cross section of the object. So in this textbook, we will introduce different linetypes that are used by architects and engineers to describe their project.

Lines

In a two dimensional sketch, lines, arcs and circles relate to the reader of the drawing what the object looks like, but with experience, the designer can vary the thickness of the lines and give them a pattern to assist the viewer in interpreting the drawing. In the table shown below, we see the most common types of lines used in engineering drawings. In chapters 2 through 9, we will use these linetypes to clearly show every view.

Linestyles	Example	Description
Continuous (visible)		Features that are visible in the view
Hidden (non-visible)		Features that are not visible in the view
Center		Shows symmetry and centers of circles
Dimension and Dimension extension		Dimension extension lines extend from a view and dimension lines show the length of a measurement
Section		Shows areas where cut by a cutting plane. There are different coded patterns for types of materials
Cutting plane (phantom)		Shows the cutting plane on a section drawing

Systems of Measurement

We will use three types of measuring systems on the drawings: U.S. feet and inches, U.S. decimal and metric. On architectural drawings, we will dimension the drawings with feet, then inches along with a fraction just as we show below.

1’ 4½”

In the U.S. decimal system, we will dimension the same measurement as:

16.50

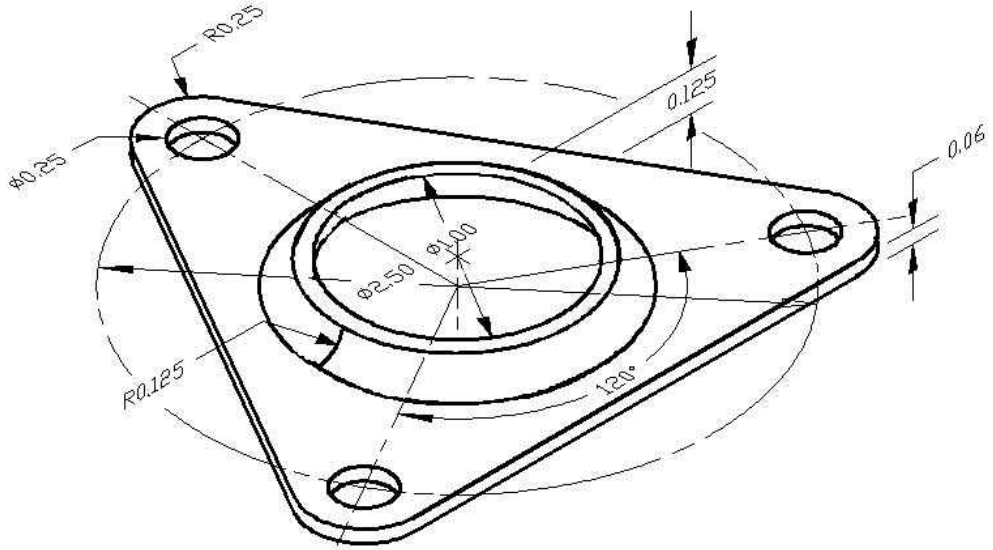
And in the Metric system, we will dimension the same measurement in millimeters as:

419.1

The unit of conversion from feet to inches is

Architectural and Engineering Conversion Chart			
From	**To**		
	Feet - Inches	**Decimal**	**Metric**
Feet - Inches	1	Feet x 12 and add inches, then the decimal , then divide the numerator by denominator to find the decimal	Feet x 12 and add inches, then the decimal , then divide the numerator by denominator to find the decimal . Multiply by 25.4
Decimal	Divide inches by 12 to get feet. Write down the remaining inches. Locate the decimal on the fraction chart to the nearest 16th	1	Multiply by 25.4
Metric	Multiply by 0.03937. Divide inches by 12 to get feet. Write down the remaining inches. Locate the decimal on the fraction chart to the nearest 16th	Multiply by 0.03937	1

Dimensions and Tolerances



Dimensions are measurements that a factory technician uses to locate a feature or another part. In the sketch shown above, we can see linear and angular dimensions. We can view radiuses and diameters. Whether using orthographic or isometric views, dimensioning and determining tolerance on the measurement is crucial to the design of any product or assembly.

There is no such thing as an absolute dimension. All dimensions have tolerance and it is important that the customer understand the tolerances of their purchase part, and that the manufacture meets the tolerances of their part. For example, a manufacturer of machines screws will meet specifications governing the name of the product. If the manufacturer calls the screw a ¼ -20 UNC -2A Hex Head Screw and declares that they meet a specification for the product, they do not need to tolerance their drawing since that tolerances are on the specification. If the distance across flats on the Hex Head screw is 7/16 in. and the tolerance is +/- 0.002, then the allowable measurement can be a minimum 0.4355 to a maximum 0.4395.

Notes

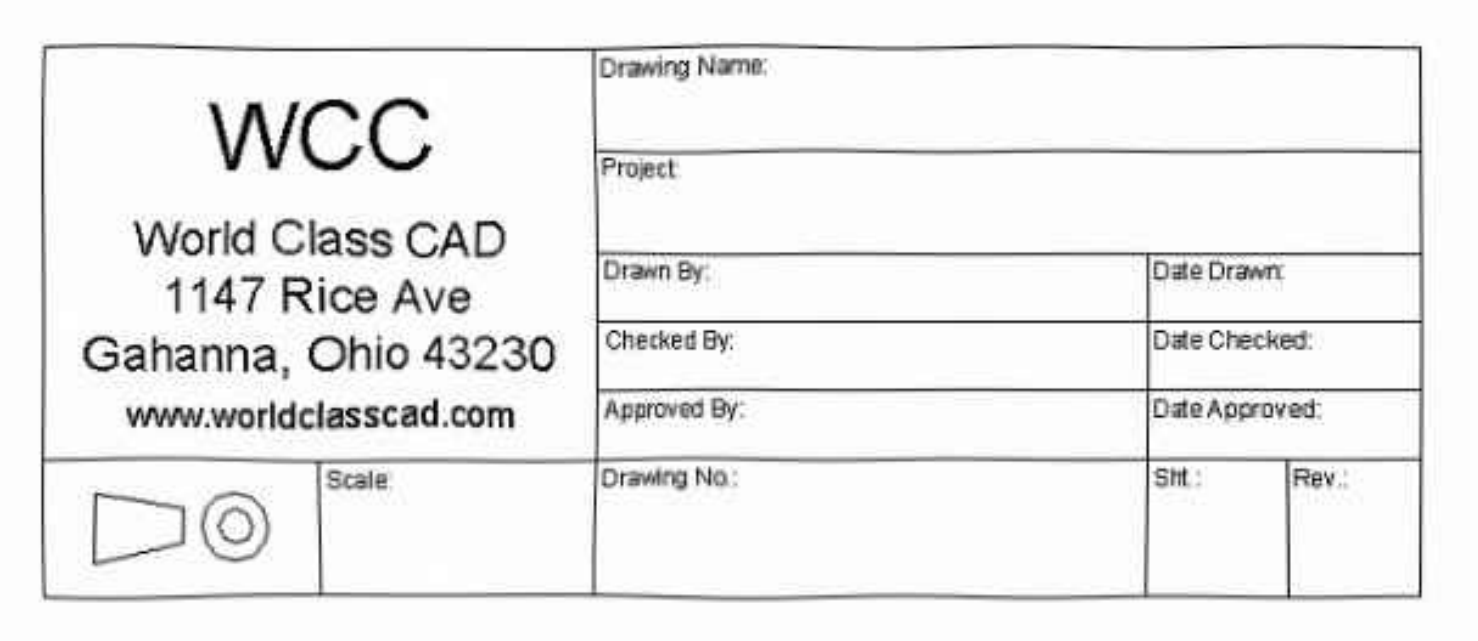
We will learn to manually letter and number, so we can easily place notes on the drawing. The most important notes are material, surface texture after machining, corrosion protection and tolerance control. We will practice capital letters, since they are easier to print. Pay special attention to placing good solid decimal points when they are needed. A lightly drawn decimal point can disappear from a drawing when the print is copied.

NOTES:
1. MATERIAL: 0.125 THICK ALUMINUM.
2. REMOVE ALL SHARP EDGES AND BURRS.
3. CLEAR ANODIZE.
4. TOLERANCES UNLESS OTHERWISE SPECIFIED:
   1 DECIMAL: ±0.06
   2 DECIMAL: ±0.010
   3 DECIMAL: ±0.003
   ANGULAR: ±0.5°

In this textbook, we do not have to be perfect when lettering, but our characters have to be neat enough to be read.

Titleblocks

Some organizations still release hand drawings to production, so titleblocks are also added to a sketch. They still need to contain



The first item of information is the "drawing name", which is present on every print. In the field of architecture, the names can be *First Floor Plan* or *Foundation Plan*. In mechanical engineering, the names can look funny, like *Screw, Hex Hd ¼-20 – 2 LG* or *Bracket, Steel Mounting*; the first word of the drawing identifier matches a common list of descriptions, so the organization's drawing database can be sorted easily by their categories, such as *Screw* or *Bracket*.

The project description is also very important. Again, in the field of architecture, the project identification could be the *James Street Steel Bridge*. In mechanical engineering, the project can be the product to which the drawing is associated, like *403/404/406 Vertical Motor Mount Assembly*.

The next block data added to the titleblock is “drawn by” and “date drawn”. In many cases, the person who started and ended the drawing would either type their name or sign the drawing in the “drawn by” section of the titleblock. This will depend on the company’s protocol for releasing drawings to the manufacturing shop or construction site. When a person does not finish the initial attempt, and the drawing is handed over to another drafter or designer, then the individual that completes the entire drawing is considered the drawer. When another individual adds or removes any entities to or from the original drawing, this does not entitle that person to take credit for the design and replace the drawer’s name. The addition or subtraction will be a revision and would be added to the drawing’s revision block, along with the documentation in a file or database explaining the change. When a drawing name is changed, the industry in which you will be working can consider your attempt to take credit for another’s work as plagiarism. Normally this is discovered when drawings are being submitted for patent or an investigation after an accident or product failure. The question is always, “who made the drawing?”

For the “date drawn” section of the titleblock, always put the date the drawing was started. Often design times are somewhat long in their duration, so the initial drawer will be modifying the entities in the drawing while other elements of the project are coming together. The print will not be released to another department or organization without being checked and approved, so anyone can see the date for release from the project manager’s approval date. You will discover over time how significant the drawing start date will become. In a project with hundreds or even thousands of parts and assemblies being documented, having the date drawn, date checked and date approved being the same is almost worthless for project analysis. Just a few simple logical questions could not be answered if these dates are incorrect.

When did a drawing start?

How long did the department take to finish different aspects of the effort?

When did the designer first think of that idea?

Always capture the “drawn by” and “date drawn” information in the first day you create the computer aided design file.

Most companies that either through time or through experience have found that quality is the number one issue in the business of architecture and engineering will enforce a multiple signature rule in their departments, and this will be evident when viewing their titleblock. The “check by” signature, typed name or initial shows when the drawing is 100% inspected for proper form, fit and function. The dimensions and tolerances are checked with corresponding parts and assemblies. Notes will be reviewed to see if they are exhibiting proper material, finish, coating for corrosion control and appearance and other special concerns. The checker becomes one the most important individuals in the design process, eliminating silly mistakes that could cause the project to overrun or terminate. When the drawing is checked, sign and date the print and send the file to the project manager for approval.

The project manager, who probably is a highly experienced designer, engineer or architect, should be the only person able to sign off the “approved by” and “date approved” blocks for release of the drawing. The job supervisor has to have the knowledge to control the entire content in the package of blueprints, but may not check every single item, since the drawer and checker verify every detail in the creation of the drawing. Typically, the project director will have multiple reviews where their team and other invited specialist sorts through the most important details to examine significant portions of the design. The project manager can have reports on file showing calculations and various approvals from other engineers and architects.

You will learn many facets of the building trade and design theory throughout your career, but you must realize that the majority of professionals in your field will eventually take on a level of responsibility sometime during their tenure. Therefore, you must take every opportunity to learn the correct method of detailing object lines, dimensioning, noting and encompassing the views in the correct orthographic presentation. There are laws or codes in nearly every country outlining the methods for constructing a project. In the end, when the drawings are complete and like many qualified technical specialist before you, you will be the individual signing off the package of drawings for release.

The drawing number is a serial descriptor identifying the individual blueprint, so that there can be a level of control when discussing, ordering, building or inspecting a part or assembly. Some part numbers are generated from a database that may have existed a decade or even a hundred years before you arrived at the corporation. In this case, when your supervisor asks you to check out fifty drawing numbers for the project, you can enter the data list and capture the next fifty numbers available for distribution. This process of blocking out drawing numbers requires listing the number and project. As each drawing is completed, go back into the organization's catalog of numbers and record the proper name, drawer and date drawn in the database. Your company might have additional fields in their catalog database that they will require you to fill out for documentation of the project.

Other companies use a logical numbering system, like *2005-031-002*, which could mean the part was designed in the year 2005, that the print was in the thirty-first project of the year and the second drawing of the project. Many groups apply logical coding system to identify their drawings. You only need to study the company's drawing number method to learn how to deploy the system.

The block containing the sheet number may be blank or hold a "1" for the first sheet of the group of drawings holding the same drawing number. When an architect completes a package for a residential home with 25 drawings, each print has the same drawing number and has a label with their own sheet number, which is 1, 2, 3, 4, progressing all the way to 25. Some companies will show the text *Sheet 1 of 25*, but this is not a necessary label for every page, since an additional print in the set will cause drafter to change all the numbers from 25 to 26. For ease, just add the additional reference to the package's title print, which is usually the first print, showing the sheet number and name.

The next block that you will create contains the organization's name and mailing address. Businesses that are proud of their product, the package of design prints showing of a building or car will have their company's identification largely displayed in the titleblock.

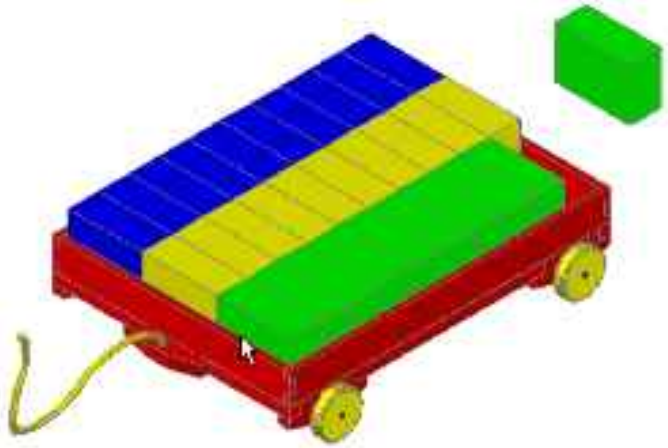
Finally, your titleblock will display a truncated cone with the orthographic view of either one or two circles. When two circles are showing, the orthographic

projections are those familiar in the United States. For countries using the ISO (European) drawing style, their rotation of the part to create the six standard views of Top, Bottom, Right, Left, Front and Back are just the opposite of the US standard. For machinist and construction specialist, the introduction of two standards in the international market causes problems not just with measurements of English or Metric units, but also with how the two systems view the orthographic projections.

The drawing scale can be 1:1 for mechanical drawings or ¼"=1' for architectural prints.

Assemblies

Drawings that contain more than one part require a Bill of Material. In chapter 9 of this text, we will make an assembly drawing and all the part drawings for a project on the www.worldclasscad.com website, the Red Wagon. The assembly has eight parts that will be listed in a table showing item number, part number, description and quantity.



World Class CAD Challenge

World Class CAD Challenges actually assist the student in learning more difficult concepts by breaking them down into smaller segments and setting demanding objectives to increase the student's proficiency. The level of a drafter's confidence and the success rate of problem completion are both increased. When a roadblock is discovered, the individual can train primarily on the difficulty by returning to the specific page in the training manual for reinforcement.

When creating a pencil or pen drawing prior to computer drawing programs, times to complete the work was determined by drawing size, which were set to departmental standards such as:

ANSI Size A (8.5 x 11)	1 hour
ANSI Size B (11 x 17)	2 hours
ANSI Size C (17 x 22)	4 hours
ANSI Size D (22 x 34)	8 hours

The manager made the judgment based upon how much space was on the paper. When creating a drawing, the Department Manager can be much more scientific in their approach to judge drawing speed.

World Class CAD Challenge 01-00 * - Complete this textbook in 40 hours of classroom training.